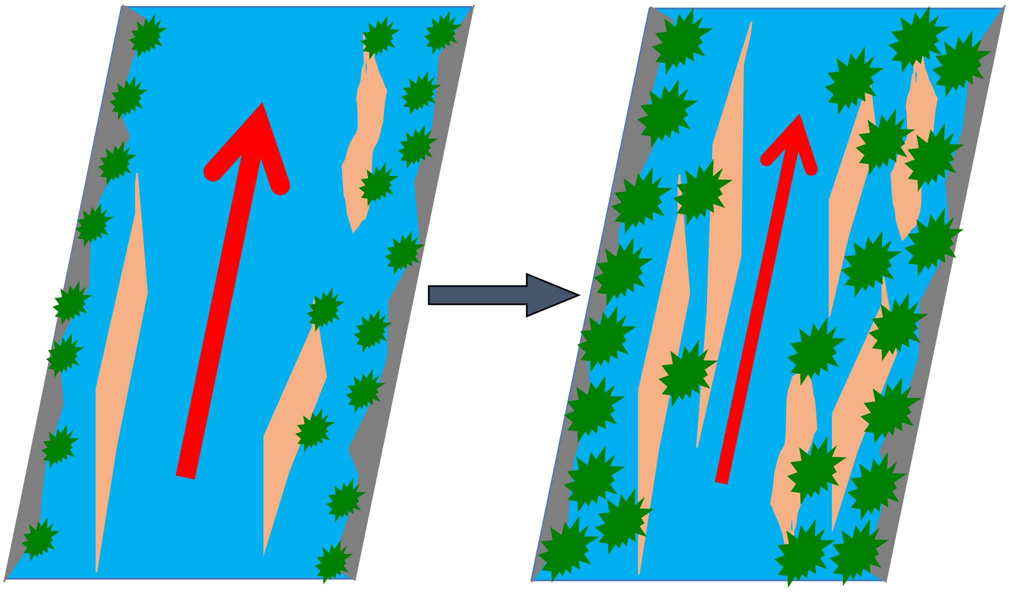
The A.R.I.D. Hypothesis



A River In 'Drought'

Environmental and Cultural Ramifications of Old Kingdom Climate Change

A thesis submitted for the degree of Doctor of Philosophy

by

John William Burn

M.A. (Macquarie University)
Bachelor of Science (University of Wollongong)
Diploma of Education (University of Wollongong)

Department of Ancient History: Faculty of Arts
Macquarie University
Sydney, Australia, 2019

Declaration

I certify that my thesis entitled:

"The A.R.I.D. Hypothesis – A River In 'Drought': Environmental and Cultural Ramifications of Old Kingdom Climate Change"

has not been submitted for a higher degree to any other university or institution other than Macquarie University.

The research within is my own work and the contributions of others is duly acknowledged where it has been used.

Dated this 18th day of September 2019.

John William Burn, Macquarie University, Sydney, Australia

Abstract

During the latter half of the Old Kingdom, Egypt experienced a noticeable decline in the amount of water being delivered by the River Nile. This thesis contends that the way the society responded to this change can be inferred from the tombs' decorations produced during the timeframe in question. Without a regular inundation, nutrients normally lost to the river remained within it. These nutrients changed the ecological balance affecting the local environment. Since less water and less nutrients were available for the land, there was a decline in cultivation, and the development of garden and orchards ceased. Plant life within the river increased, taking advantage of the excess nutrient supply. Fish numbers and varieties increased with new fishing techniques and technologies appearing as tomb decorations. Depictions of water birds increased, presumably as a result of an increasing reliance upon fowl in the daily diet. Cattle depictions also increased as cattle were able to take advantage of the flourishing plants on the riverbanks. Finally, as the ecotone (the boundary between ecosystems) diminished, desert animals ventured closer to the river, integrating themselves with the cattle populations and becoming an increasing part of the animal procession scenes. In conclusion, contrasting to the currently accepted viewpoint of the First Intermediate Period as a time of relapse and retrogression, the artistic narrative produced suggests a responsive, robust and resilient society.

Acknowledgements

There are many wonderful people that helped me on this journey. The fantastic lecturers who inspired me to turn this hobby into an obsession: Professor Naguib Kanawati, Associate Professor Boyo Ockinga, Professor E. Christiana Kohler and Doctor Suzanne Binder. I will be eternally grateful to my supervisors, Professor Kanawati and Doctor Linda Evans who allowed me to develop a research path suited to my training, interest and expertise. Gratitude is directed to my first site supervisors Doctor Sophie Winlaw and Naguib Victor, who helped develop a taste for fieldwork that is still undiminished.

Deep appreciation is directed towards Doctors Mary Hartley and Beth Thompson, who provided never-ending encouragement that there indeed was an end in sight. To the USER crowd for continuing to believe that I would finish, I give thanks. Acknowledgement is also directed towards Associate Professors Yann Tristant and Ronika Powers, and to Leonie Donovan who provided specialist advice when called upon. A special thankyou goes to Natalie Ritchie, whose skilful editing helped turn many disparate documents into one coherent whole, and also to Doctor Joyce Swinton whose insightful comments made this document infinitely better.

And finally, and most importantly, to Doctor Alexandra Woods. Lecturer, tutor, site supervisor, guide and inspiration; who sat beside me during one First Intermediate Period tutorial and asked if I had considered applying for fieldwork……. I will be forever grateful.

Dedicated to my Partner, Peri, my parents, Jan and Bill, and my whole family who have always supported me and allowed me to follow this dream.

For Beth.

TABLE OF CONTENTS

unless stated otherwise, all summary and conceptual diagrams are prepared by the author

FOREWORD AND INTRODUCTORY REMARKS

Thus spake Ankhtify:[1]

> *"I gave life to Hefat and Hermer when the sky was clouded and the land in wind, when every man was dying of hunger under the sandbank of Apophis…*
> *"I rushed this grain southwards to arrive at Wawat. It travelled downstream, it arriving at Abydos while Upper Egypt in its entirety was dying of hunger, all men eating their children.*
> *"Never did I allow death from hunger to occur in this province…*
> *"Ankhtify says that this entire land had become like a grasshopper with emptiness as one goes north, the other going south…"*

According to Ankhtify, nomarch of the third Upper Egyptian nome and overlord of the second, a significant famine had struck Egypt during his time in power. The calamity of which he speaks is thought to have come about as a consequence of steadily declining Nile water levels, which had become a serious concern by the end of the Old Kingdom.[2] In an heroic effort, Ankhtify managed to sustain the lives of his own people and due to his remarkable ability, was even able to provide food for some of his neighbours.[3]

Conversely, in the same autobiography, Ankhtify identifies the spread of the marshlands as a significant problem when he tried to enforce the authority of the king in the region and to impose his own leadership upon those local rulers who appeared somewhat reluctant to embrace it.[4]

[*5*] *gmi͗.n*(*=i͗*) *pr.w ẖww ṯtf*(*.w*) *mi͗ grg.t mkḥ3.n* [*6*] *i͗r.y=f*

"I found the house of Khui inundated like a marsh, abandoned by him who belonged to it"

---

1 Author translation (with apologies to Nietzsche) from Vandier, *Mo'alla*, Ins. 1–12, 161–174.

2 Hassan, *Nile Floods*, 1–23; Said, *River Nile*, 141–143; Lloyd, *State & Society*, 176–177; Stanley et al, *Nile Flow Failure,* 395–402; Parcak, *Physical Context*, 8–10.

3 See also the stele of Merer in Lichtheim, *Literature* I, 87, who makes similar claims. Ankhtify's claims of feeding Wawat and Abydos and the truth may not be related: the veracity of Ankhtify's claims may be challenged, see Vandier, *Mo'alla,* 34–44; Coulon, *Véracité et rhétorique*, 117, 129–132.

4 For the historical overview, Grimal, *A History of Ancient Egypt*, 142; Seidlmayer, *FIP*, 129; Manassa, *El-Mo'alla to El-Deir*. http://escholarship.org/uc/item/4pc0w4hg (March 13, 2016)

Thus, there seemed to have been two competing influences affecting Ankhtify and his contemporaries. The land was in drought while the river had become like a swamp. Are we experiencing narrative hyperbole, or can there exist a situation where both of these events occur simultaneously?

Rationale, Hypotheses and Goals

When a river is expected to flood annually but an inundation does not occur, then the land bordering the river experiences a so-called ‘drought’. In the cultural exemplar of many Western countries, a drought, usually defined as “*a prolonged period of abnormally low rainfall, leading to a shortage of water,*”[5] is what happens to the land, and its associated affects are usually applied to the impact that it has upon that land. In discussion of the Old Kingdom, a drought is usually seen as a dramatically low or absent Nile River inundation, and, similarly, most commentators considered the drought’s effects on the land and the implications a low flood had for the society.

Yet a critical aspect of investigations into this era appears to have been left out by the scholarship so far: scientific analyses of the ecological changes that would have taken place within the river itself during times of drought. From an ecological standpoint, when a river floods, it loses sediments and nutrients to the surrounding landscape. By contrast, a river that does NOT flood retains these nutrients. This organic bounty remains within the river and should significantly alter the normal biological networks of the river. Few investigations into how the Nile’s ecology and its related ecosystems changed in response to a changing climate have been undertaken.[6] Changing ecological conditions would have changed the environmental circumstances of the river and, therefore, should have impacted upon the culture that developed along its banks have been undertaken. Just how the river may have been affected by drought and how this may have impacted upon the surrounding culture is the basis for this investigation. In this examination, the consequences to the river itself of an insufficient or dramatically low inundation will be investigated.

---

5 Oxford English Dictionary, https://en.oxforddictionaries.com/definition/drought (Nov. 11, 2016).

6 Beyond three seminal texts: Butzer, *Early Hydraulic Civilization in Egypt: A Study in Cultural Ecology* (1976), Rzóska, *The Nile, Biology of an Ancient River* (1976) and Said, *The River Nile: Geology, Hydrology and Utilization* (1993).

The rationale for the investigation is as follows:

1. *A weakened river (that is, one with less ability to deliver the expected and desired flood levels necessary to sustain the annual Egyptian agricultural cycle) presumably carried a lower volume of water. The resultant inundation would have deposited fewer nutrients onto the land. Consequently, the amount of nutrients remaining in the river should have increased, thereby affecting the Nile's ecology and its immediate environment.*

2. *Because the river was so important to the society, any changes to it would have had an impact upon that society. This ought to have left an impression upon the visual culture produced by that society. It is expected that changes in the tomb decorations would enable this impact to be identified. It should be possible to identify changing influences in the artwork produced by observing the variances in the tomb decoration patterns over the time frame under investigation.*

From the above rationale, the following hypotheses were developed:

1. *If Egypt experienced an environmental change at the end of the Old Kingdom, then this must have impacted upon the river.*

2. *A changing river that normally flooded annually, and then did not, should have impacted upon the society, and this impact may be manifested in the associated tomb scenes produced.*

The A.R.I.D. Hypothesis – an outline

The overall aim of this investigation, therefore, is to suggest what may have happened to the river Nile when the land was in drought and to attempt to identify signs of a societal response. By attempting to identify the potential physical implications of the phenomenon of a declining river, this investigation will seek to identify how ancient Egyptian society responded to the phenomenon of A River In 'Drought' (A.R.I.D.).

To investigate the hypotheses stated above, the project has been planned to follow two pathways of consideration, environmental and social. In order to investigate any environmental change within the river, an examination of the ecological processes that could have been occurring is needed. In order to identify any subsequent cultural change, then an examination of the changing compositions of tomb scenes needed to be traced. As the data used in this study covers two broad fields, the goals of this investigation, therefore, may be stated in the following manner:

1. *To suggest, using consideration based on the ecological sciences, possible variations to the Nile and its associated biology that may have occurred as a result of a weakened river.*

2. *To identify potential cultural changes, as identified in tomb scenes, that may have arisen as a consequence of a river in 'drought'.*

Part A will provide a palaeo-climatic overview, summarising and emphasising the importance that climate played in the developing riverine civilisation that came to be ancient Egypt. It will identify the role that art, specifically tomb wall scenes, had to play in the transmission of the culture from one generation to the next, and also attempt to ascertain the ways that late Old Kingdom and early First Intermediate Period art may have indicated these environmental changes.

Part B will present a summary of basic ecological terms and will introduce the central principles of riverine ecology that have to be applied to the present investigation. Because of the need to fundamentally understand the potential consequences of a river in drought, by necessity, this section presents its data and conclusions in a strongly science-based analysis of riverine properties. This scientific exposition is important because the application of these principles allows for the prediction of how riverine properties would have been affected by variations in the total water flow. From there, modern ecological examinations of current waterways experiencing similar irregular or unnaturally low water flows will then be applied to the situation that may have existed in ancient Egypt. From these, the potential habitat changes that may have occurred to the Nilotic system at the end of the Old Kingdom will be suggested.

Part C will attempt to identify if any perceived cultural response to this environmental change can be detected through changes to the decoration repertoire as depicted in tombs from the period in question. The progression of tomb scenes produced in the Old Kingdom and into the First Intermediate Period will be analysed for any apparent change in the patterns of representation. Significant changes to the regular forms of representation will be examined in more detail, with an attempt to identify any environmental influence that may have been behind these changes.

Part D will discuss the results and summarise the findings. It will suggest potential directions for future examination. Finally, a conclusion will be presented.

Part A

Environment, Society and Culture

CHAPTER ONE:

CLIMATE AND SOCIETY IN THE OLD KINGDOM

1.0 – INTRODUCTION

This chapter outlines the development of the two main issues of the study, the riverine system of the Nile and the human culture of the inhabitants of the Nile valley. The primary goal of this study is to identify any possible changes that may have occurred to the Nile river ecosystem which may have subsequently affected its environment and associated surroundings. In order to identify any evidence of potential change, it is necessary to firstly establish the significance of the original riverine system to the society and subsequent culture of ancient Egypt.

To the ancient Egyptians, oases, swamps and marshlands provided important wetlands, while the eastern and western deserts formed natural borders to their everyday world. The traditional name in ancient Egypt for the fertile valley with its alluvial soil, *Kemet*, meaning 'black land', related directly to the rich sediment 'gifted' by the river. This contrasted significantly to the remainder of the country: *Desheret,* the 'red land' of the desert. The moist and fertile soil of the valley was dedicated to agriculture, animal husbandry and the living; none of it was wasted on the dead. Cemeteries, up and down the Nile, were either constructed on desert escarpments or hewn into mountain rock; this land being agriculturally unproductive. It was, however, very productive in terms of its characteristics being conducive to the preservation of the body: an interesting paradox. From the deserts to the arable lands to the river, from the inundation to the harvest, each component of the surrounding environment had an impact upon the culture of the ancient Egyptians. Any change to these basic characteristics would have had a noticeable impact upon the traditions of the society.

1.1 – Egypt and the Nile

As the formation of the Nile valley began only about 25 million years ago; in geological terms, the Nile River may be regarded as relatively young.[7] The river carried water all the way from the Ethiopian highlands and the lakes of Central Africa, over time carving its way through the northeast corner of Africa to reach the Mediterranean Sea. The river branched before reaching the coast in the locality of modern-day Cairo, with several tributaries forming a region now called the Delta. As the sea-level of the Mediterranean fell, about 100,000–120,000 years ago, the speed of the Nile flow increased, as did the rate of erosion, digging ever deeper into the landscape to form the Nile valley.[8]

Each year, the river peaked in an annual flood as a result of the monsoonal rains in the south, swelling the normally placid flow into a mighty surge. These waters carried masses of rich silt, which were deposited as they flowed over the banks and spread across much of the Nile valley. After the annual Nile floods, natural high points, known as *gaziras*, produced areas that were safe to occupy and close to areas fertilised by a build-up of alluvial soil; these *gaziras* could also serve as natural dam walls.[9]

Sometimes, along the length of a river, secondary channels formed.[10] These secondary channels were a natural part of the river system and formed as the river branched as it moved onwards winding its way downstream to the sea.[11] Along the Nile these secondary channels are known as '*khors'*,[12] and they represented economic and ecological benefits to the local population – a potential for exploitation that still exists in the modern age.[13]

By the time of the Dynastic era, alluvium and marshlands were present along both flanks of the river and a number of secondary channels probably existed (see Figure 1: Simplified cross section of the Nile valley).

---

7 For a broad overview, see Said, *River Nile Evolution*; Bunbury, et al., *Memphite Floodplain Landscape*, 74–76, Hassan et al., *Memphite Floodplain Alluvium*.

8 Williams & Williams, *Nile Basin Evolution*; 207–224; Salama, *River Nile Evolution*, 899–913; Salama, *African Basins*, 105–149.

9 Bunbury, et al., *Memphite Floodplain Landscape*, 74; Ghilardi et al, *Nile River Evolution,* 13; Vermeersch & Van Neer, *Late Pleistocene Nile,* 162; Holz, *Man-made Landforms,* 253–269.

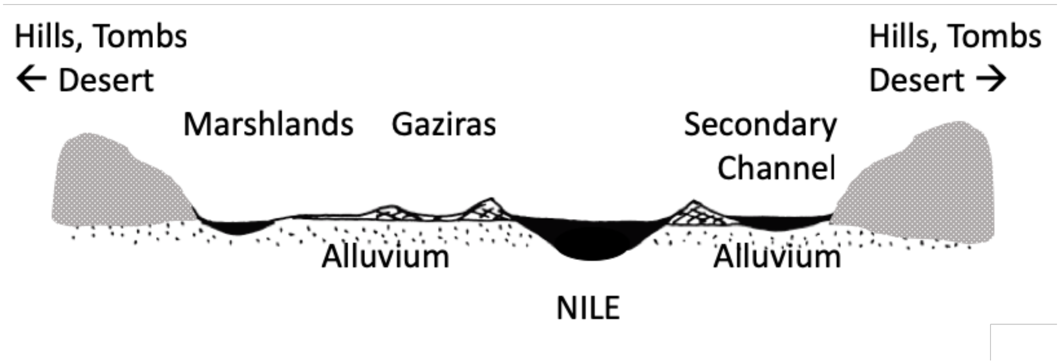
10 Butzer, *Hydraulic Egypt,* 16–18, 33–34,.

11 Hassan et al., *Nile Floodplain Alluvium*, 65–67; Vermeersch & Van Neer, *Late Pleistocene Nile,* 162.

12 Dumont, *Nile*, 127; Shahin, *Hydrology*, 37; Sallam & El-Barbary, *Secondary Channels*, 489.

13 Macklin et al., *River Dynamics*, 110–114; Sallam & El-Barbary, *Secondary Channels*, 498.

Figure 1: Simplified cross section of the Nile valley



1.2 – A Developing Riverine Civilisation

About 10,000 years ago, the Sahara plateau was a place that was much more appealing than is generally understood today. As equatorial monsoons reached that far north,[14] grasslands were common, and herds of migratory animals regularly crossed it. Animals thought of as typically southern African today, such as the giraffe, elephant and even rhinoceros, were common sights and recorded in the rock art of the prehistoric inhabitants of the region[15] (see Figure 2: Rock art depicting giraffe and barbary sheep).

Figure 2: Rock art depicting giraffe and barbary sheep

Adapted from Riemer et al., *Desert Animals*, 114.

Between 7500 and 5500 years ago, as the monsoons retreated southwards,[16] northern Africa began to dry out. As the number of available watering sites decreased[17] and the quantity and quality of available resources diminished,[18] the variety displayed within the distribution and abundance of flora and fauna began to decline.[19] Due to increasing aridity, partly as a consequence of human activity,[20] regions once relatively fertile, began to deteriorate.

---

14 Kröpelin et al., *Ecosystem Succession in the Sahara*, 765–768.
15 See also Hendrickx et al., *Western Desert Rock Art*, figs. 6, 17; Köln University, *Project A1*.
16 White & Mattingly, *Ancient Lakes of the Sahara*, 58–65.
17 Said, *River Nile,* 88–91, Midant-Reynes, *Prehistoric Cultures*, 3.
18 Manning & Timpson, *Saharan Holocene Demographics,* 30.
19 Pollath, *Prehistoric Gamebag*, 93; Riemer, *Risks & Resources*, 145–147.
20 Wright, *Humans as Agents*, 1–14; Brierley, et al., *Green Sahara Pastoralism*.

Hunter-gatherer societies became less successful and were forced to adjust their lifestyle by moving nearer to more predictable and consistent supplies of water.[21] The culture appeared to have transitioned from a community of hunter-gatherers into one resembling more a society of herder-foragers.[22] As large inland water deposits diminished, pastoralists, once able to survive in the marginal lands, in their turn, narrowed the range of their nomadic wanderings and moved closer to more dependable water sources.[23] Populations occupying these areas appear to have become less like herder-foragers and more like agriculturalists, living within a narrower range of the landscape; with the time of most rapid population growth seeming to coincide with that of an increasingly arid environment.[24] Perhaps a decline in near-to-hand resources stimulated a westward expansion of the Egyptian civilisation onto the oases.[25] Perhaps agriculture was adopted in response to a changing climate that was limiting available resources suggesting that the population did not have to adapt to agriculture, but did so out of "*choice rather than necessity*."[26] Cereal production did not replace previous practices but supplemented them,[27] eventually becoming a major force for stability in the valley.[28]

All these groups gravitated towards the major unvarying sources of water in the region: the oases and, more significantly, the River Nile.[29] Villages developed around these areas not affected by the rising floodwaters. The distribution of these villages was not geometrical, because the sites of occupation were simply a consequence of that site's ability to endure the annual flood.[30] Ancient cemeteries and village remnants all along the river suggest a continuous occupation history of more than 8000 years.[31]

---

21 Hambrecht & Gielen, *Hunter-gatherer to Sedentary*, 60–61. Connor & Marks, *High Water Adaptations*, 171–199, outlines the gradual process from hunter-gatherer to agricultural lifestyles.

22 Hughes, *Sustainable Agriculture*, 20; Midant-Reynes, *Prehistoric Cultures,* 2. Pennington et al., *Saharan Aridification,* 2, fig. 1, discuss the changing ratio of water versus wind-borne sediments shown up at this time.

23 Hély and Lézine, *Holocene African Vegetation*, 681–686; Pennington et al., *Saharan Aridification,* fig 5b.

24 Butzer, *Hydraulic Egypt*, 85; Park, *Class Stratification,* 102; Pennington et al., *Saharan Aridification,* 9; Williams & Hill, *Meat & Evolution,* fig. 16.

25 Ayyad, *Vegetation & Environment 1*, 509–523. Furthermore, it has been argued that sophisticated communities moved eastwards from the desert to the Nile valley as a consequence of the gradual drying of the Sahara: e.g., Wilkinson, *Political Unification,* 377–395; Midant-Reynes, *Egyptian Prehistory*, 137–138. Professor Colin Hope (personal communication July 22, 2011) believes evidence from his findings in the Dakhleh Oasis supports this notion.

26 Midant-Reynes, *Egyptian Prehistory*, 137–138.

27 Williams & Hill, *Meat & Evolution,* 9–11.

28 Murray, *Cereal Production*, 505–507.

29 Riemer, *Risks & Resources*, 152–153; Hassan et al., *Nile Floodplain Alluvium*, 52.

30 Butzer, *Hydraulic Egypt*, 85; Park, *Class Stratification*, 90–92; Butzer, *Archaeology & Geology*, 621.

31 Church & Bell, *Settlement Patterns*, 701–714.

Figure 3: Simplified Nile valley cross section

Figure 3 removed due to copyright restrictions

Bunbury, J., & Jeffreys, D. (2011). Real and Literary Landscapes in Ancient Egypt. Cambridge Archaeological Journal, 21(1), 65-76. doi:10.1017/S0959774311000047

Adapted from Bunbury & Jeffreys, *Ancient Landscapes,* fig.3.

Over time, the meandering of the river caused the riverbed to gradually shift position as it migrated from the west to the east.[32] Some settlements became covered by this inexorable movement, while others were made uninhabitable due to their ever-increasing remoteness from the river,[33] (see Figure 3: Simplified Nile valley cross section). Buto, for example, appears to have been abandoned, not for political reasons, but primarily due to its increasing remoteness from the nearby waterway.[34]

Some of these villages grew into major towns, eventually developing into centres of administration, trade and religion, with emerging cultures unique to themselves.[35] Upper and Lower Egypt, had similar lifestyles but different religious beliefs.[36] The great variety of creation myths and the myriad local gods worshipped by particular regions and towns also suggests that for much of their formative periods, the cultural development that occurred did so in a decentralised, non-directed manner.[37] Spatial efficiency of population centres appears to have developed early on, though not all important towns had begun as administrative hubs.[38] The significance of Hierakonpolis, for example, was primarily cultural, not industrial nor agricultural.[39]

32 Said, *River Nile*, 53–55; Bunbury & Jeffreys, *Ancient Landscapes,* 66–68*;* Bunbury, et al., *Memphite Floodplain Landscape*, 75–78, figs. 5, 6.

33 Bunbury & Lutley, *Nile on the move*, 3–5; Said, *River Nile*, 149–152; Wilkinson & Stevens, *Environmental Archaeology,* 277.

34 Müller-Wollermann,, *End of the Old Kingdom*, 5.

35 Chew, *Harappa to Mesopotamia*, 109–112, contrasting Egyptian developments to those further east.

36 Midant-Reynes, *Prehistoric Cultures,* 6–8.

37 Wilkinson, *Gods & Goddesses,* 6–15.

38 Church & Bell, *Settlement Patterns*, 701–714.

39 Note that Hierakonpolis, despite having no resources of note, had still developed into an important cultural centre by Predynastic times; see Hoffman, *Before the Pharaohs,* 160–161.

Certain centres had other attributes that led them to develop into significant centres, as they progressively (aggressively?)[40] absorbed politically weaker adjacent centres or amalgamated with centres of similar power and influence. Not all centres developed along the same lines or for the same reasons, but by a certain stage, all had begun to perform similar administrative functions for the Egyptian state.[41] The uneven distribution of the nomes suggests that this process was haphazard. Government became increasingly regional.[42] Eventually, a common culture, based around the exploitation of the resources of the river, as well as encouraged by its natural geographical isolation,[43] led to centralised government control and these localised cultures blended to form the state that we know as ancient Egypt.

Egypt is the Nile

The hydrology of Egypt is unique because almost all of the water that flows through the country comes from external sources, initially falling as snow and rainfall in locales much further south. Ancient Egypt has been described as a '*Hydraulic Society*',[44] its civilisation developing as a direct consequence of the large-scale manipulation of water.[45] It is difficult to envisage the development of the complex ancient Egyptian civilisation without the adoption of irrigation, something recognised by historians of old: Herodotus, in his *Histories*, recognised the land of Egypt as a "gift from the Nile", while Pliny the Elder claimed it was the river that did the farming.[46]

Trees were not plentiful, but sycamore and acacia were available for small boats, furniture, chests and other items. Swamps and marshlands bordering the waterways, oases and natural levees provided important wetlands, with abundant fish, birds, animals and plant life, including papyrus and lotus. Large herds of cattle thrived on the grazing found in the Delta where many estates were established. Small trees and shrubs in the marginal lands of the valley and the deserts perhaps also provided pasturage for a variety of animals, including sheep and goats.

---

40 Bard, *Encyclopaedia*, 30.
41 Seidlmayer, *OK Elephantine*, 108–111.
42 Baines & Malek, *Atlas*, 14–19.
43 Morris, *Art of Not Collapsing*, 63.
44 Butzer, *Hydraulic Egypt*, 7–10.
45 Wittfogel, *Oriental Despotism*, 19, 311; For a more complete description of 'hydraulic' cultures, their development and their significance to history, see Wörster, *Rivers of Empire*; Wittfogel, *op. cit.*; Butzer, *Hydraulic Egypt*.
46 Herodotus, *Histories* 2.5; Pliny the Elder, *Natural History*, 18, 47 & 167.

Since climatic conditions have an important impact upon the fertility of the land, it seems logical that agricultural societies developed a keen awareness of the environmental conditions around them.[47] With the flood arriving at a (mostly) predictable time every year, the most significant technological advance, the calendar, has been applied to agricultural circumstances from well before written history.[48]

Figure 4: Mereruka painting the seasons

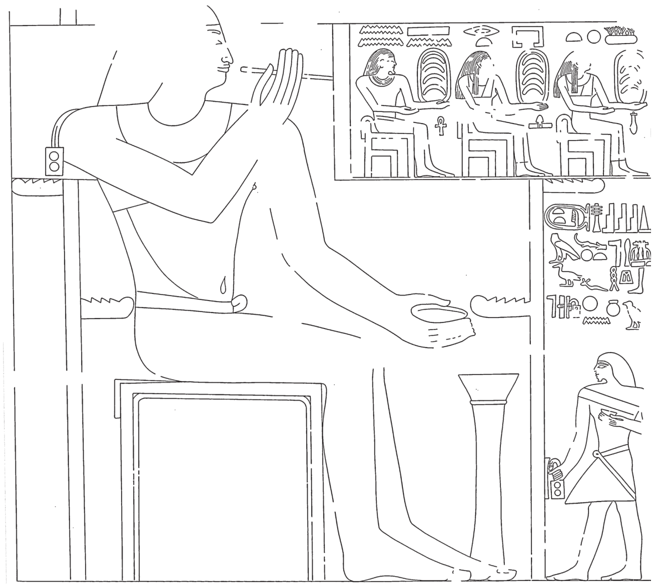


Image from Kanawati et al., *Mereruka,* pl. 66a

The passage of the seasons was such a significant event in Egyptian life that it was recorded by several Fifth Dynasty kings on the walls of their temples.[49] At the beginning of the Sixth Dynasty, a very rare scene of an important official depicted painting the seasons is preserved in the tombs of two viziers at Saqqara (see Figure 4: Mereruka painting the seasons).[50]

The Egyptian calendar year had three seasons, and their names and timings derived from the river and the associated agricultural production. The start of the calendar coincided with the arrival of the floodwater, known as the time of *akhet*, 'the inundation' (of water). When the flood occurred, it discharged nutrients carried by the river onto the surrounding countryside, these nutrients,[51] therefore being lost to the river. *Peret,* 'the emergence' (of land), is the period when water started to recede, leaving rich and fertile alluvial soils ready for planting, while the season known as *shemu,* 'the deficiency' (of water), was the time when harvests began.

---

47 Erman, *Life in Egypt*, 425; Bard, *Archaeology of Ancient Egypt*, 45–54. Said, *River Nile*, 132–142.

48 see Butzer, *Hydraulic Egypt,* 4–11, Table 1. Hoffman, *Before the Pharaohs*, 311; Butzer, *Discontinuity*, 106

49 Edel & Wenig, *Sonnenheiligtum des Ne-User-Re*, 250, 252, pls. 14, 16; Borchardt, *Grabdenkmal des Sahu-re,* 2, pl. 17.

50 For a similar depiction, see James, *Khentika,* pl. 10, a contemporary of Mereruka.

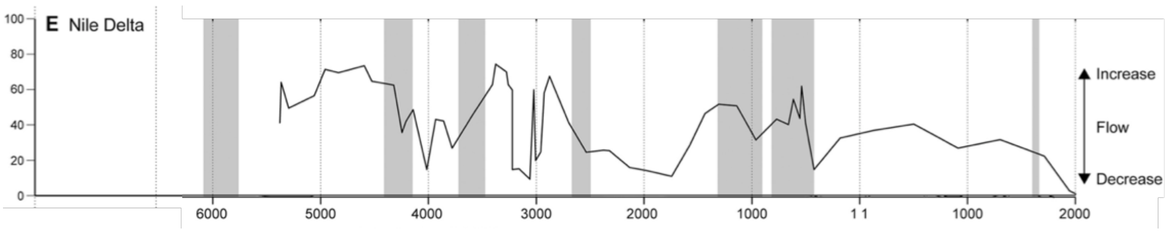
51 Said, *River Nile*, 131–135.

This regular cycle underpinned the society that developed in the Nile valley.[52] To ensure a successful harvest, the height of the Nile floods was crucial, and it was measured each year. Nilometers, stone steps leading from the riverbank down into the water, registered the level and, during the Old Kingdom, the heights of 63 annual floods were recorded by 11 different kings. Before the floods arrived every season, the land needed to be repaired and prepared: natural dams were improved and extended, old water channels needed to be repaired and new channels dug.[53]

Agricultural success … and its consequences

The Egyptians developed an agricultural system thought to be one of the most productive in the ancient world. Good quality, fertile land was a prerequisite for successful economic development.[54] Field crops such as wheat, barley, flax, vegetables and fruits provided food, drink and fabric. With increased control of water, agricultural surplus could develop.[55] Agricultural success was then followed by rapid population growth. As long as resources were available, overpopulation was not a significant problem.[56] However, though the annual flood was mostly reliable, it could sometimes appear lower than expected.[57]

Figure 5: Summary: Relative floods over time



Modified from Macklin et al, *River Dynamics*, fig. 7.

Regular lower-than-average floods led to an onset of lean times with numerous accounts of famine recorded in Egypt's past, with evidence from objects such as the Palermo Stone suggesting short-term fluctuations,[58] (see Figure 5: Summary: Relative floods over time). It seems, however, that during the Old Kingdom, the power of the river and the inundation

52 Hildebrand & Schilling, *Early Nile Agriculture*, 81–95.
53 Butzer, *Hydraulic Egypt*, 41–47.
54 Soroush & Mordechai, *Short-term Cataclysm*, 1, 8–10.
55 Said, *River Nile,* 188–208.
56 Hely, et al., *Climate Water Tradeoff*, 681–686.
57 Said, *River Nile*, 131–133, 141–142, 149–152.
58 Said, *River Nile*, 134–138; for archaeological evidence see Hamdan et al., *Climate & Collapse*, 89-100.

associated with its annual flood was gradually weakening (see Figure 6: Fluvial history of the Memphite floodplain). The Nilometer, while indicating the river height, could not take into consideration the relative thickness of the amount of sediment below the river, on the river floor. This meant the actual depth of the river was unknown so indications of the real volume of the river was also unreliable.

Without the benefits of alluvial deposits from the flood, the capability and productive capacity of the land would be severely diminished. It was difficult to adequately store sufficient surplus food and while the deficits caused by an occasional low flood might be overcome by compensating surpluses in more productive flood years.[59] Increasing aridity is thought to have encouraged the adoption of more efficient production by the Egyptian population.[60] However, as hinted earlier, it may not have been climatic conditions that drove the gradual change from a herder-forager society to one with an increasing emphasis upon cultivation.[61] It appears that agriculture began in prehistoric Egypt in areas with the narrowest floodplain, those areas of substandard fertility, those areas receiving less of the flood's gifts.[62] In fact it seems that the establishment of dynastic Egypt coincided with a time of increased variability in riverine flows, with increased aridity and lower average flow volumes.[63] This suggests that the less water that was available, the more organisation was required in order to utilise it most effectively.[64] The inference that an increasing aridity should have been an impetus to have driven an update of increasingly complex technology does not seem supported by evidence.[65]

As a consequence of the success of agriculture, so too did the environment in ancient Egypt change.[66] Despite the repeated floods continually regenerating the land in an unchanging cycle, the cultural experience did change.[67]

---

59 Hamdan, *Nile Floodplain Sediments*, 286, outlines these changes; Macklin et al., *River Dynamics*, fig. 7 and Qianli et al., *Climate-induced Variations*, fig. 7, identify the cycles; with Hassan et al., *Nile Floodplain Alluvium*, Figs. 7–8, provides a recent summary.

60 Midant-Reynes, *Egyptian Prehistory*, 253.

61 Midant-Reynes, *Egyptian Prehistory*, 59–63, 137–138. See also Butzer, *Pleistocene Nile;* Connor & Marks, *Terminal Pleistocene.*

62 Macklin et al., *River Dynamics*, 118.

63 Macklin, et al., *River Dynamics*, 118–120; Hassan et al., *Nile Floodplain Alluvium*, 65–66.

64 Said, *River Nile,* 187.

65 Brewer, *Predynastic Temperatures*, 299–300; Weiskel, *Environmental Lessons*, 99.

66 Said, *River Nile*, 201; Soroush & Mordechai, *Short-term Cataclysm*, 2.

67 Butzer, *Quaternary Nile Problems*, 162; Butzer et al, *Urban Geoarchaeology*, 3365; Butzer, *Desert in Flood*, 3–5.

Figure 6: Fluvial history of the Memphite floodplain

Figure 6 removed due to copyright restrictions

F.A. Hassan, M.A. Hamdan, R.J. Flower, N.A. Shallaly, E. Ebrahem (2017) Holocene alluvial history and archaeological significance of the Nile floodplain in the Saqqara-Memphis region, Egypt, *Quaternary Science Reviews*, Vol. 176, pp. 51-70, https://doi.org/10.1016/j.quascirev.2017.09.016.

Modified from Hassan et al., *Memphite Floodplain Alluvium*, fig. 7.

Notwithstanding the cultivation being well-managed, in the long term all extensive agricultural systems change their environment in fundamental ways.[68] Despite these regular inundations, land management practices categorised as "*aggravated by collective and cumulative human behaviour*"[69] eventually resulted in increasing salinity of the land around the river. Deforestation, for example, removed the protection afforded to the soil by permanent deeply rooted plants and became a factor in the raising of the water table and an increase in salinity.[70] Overgrazing, for another example, resulted in the removal of valuable nutrients from the soil.[71] Removal of non-agricultural vegetation and its replacement by an annual crop is a significant factor in raising the water table over time.[72] Waterlogged soils are not as productive as well-aerated soil.[73]

---

68 Uprety, et al., *Climate Change & Agriculture*, 7–29.

69 Weiskel, *Ecological Lessons*, 98–99, identifies this as the most significant factor in the vast majority of examples of historical environmental degradation.

70 For example, as commented upon by Harpur, *Miscellaneous Scenes*, 40–41, fig. 10. For a description of how irrigation leads to the development of salinity problems in cultivation, see Pitman & Läuchli, *Salinity & Agriculture*, 3–12; Butzer, *Hydraulic Egypt*, 90, outlines its development in Egypt as a consequence of long-term irrigation.

71 Steward et al., *River Runs Dry,* 207.

72 Vermeersch & Van Neer, *Late Pleistocene Nile,* 162, figs. 1, 11.

73 Butzer, *Hydraulic Egypt*, 19, 48.

1.3 – IMPACT OF CLIMATE ON OLD KINGDOM SOCIETY

The surroundings in which the ancient Egyptians found themselves significantly influenced their outlook towards life, their art and their religion. Many religious festivals were linked to the annual recurrence of natural events: for example, Utterance #581 of the Pyramid Texts praises the river for its role in ensuring the continued fertility of the land.[74] While it is difficult to accurately measure the agricultural productivity of past societies, some basic understanding can be derived by 'reverse engineering' from what is known of modern societies that still follow simple agricultural practices. There seems to have been a positive correlation between normal flood levels and the attainment of national prosperity and government stability,[75] since "*without reasonable floods, there were no reasonable harvests*."[76] In traditional Egyptological terminology, the term 'drought' equates to the lack of the regular annual flood.[77] With the presumed failure of these regular floods, the resultant lack of reliable water interfered with the production of abundant food, the land could not be re-invigorated and so could not deliver the agricultural excess necessary for a highly stratified and well-ordered society supporting artisans and administrators.[78]

Egyptian versus Mesopotamian Irrigation

"*Water drives the world*":[79] whoever controls the water controls the territory.[80] As in other parts of the Middle East, complex human societies developed as the agricultural revolution encouraged people to come together to exploit water as an agricultural resource.[81] While irrigation practices began at roughly the same time, the timing of the flood meant that farmers in Mesopotamia needed to work to make the soil rich, and they needed to store water until the appropriate season for its use arrived.[82]

---

74 Allen, *Pyramid Texts*, 110.
75 Hughes, *Sustainable Agriculture*, 14; O'Connor, *Political Systems*, 15–38.
76 Said, *River Nile*, 149–152; Bárta, *Collapse Hidden in Success*, 26.
77 Baines & Malek, *Encyclopaedia,* 18.
78 Said, *River Nile*, 88–108; Macklin et al., *River Dynamics*, fig. 1.
79 Beinart & Hughes, *Environment & Empire,* 130.
80 Wittfogel, *Oriental Despotism*, 19, 311; Willcocks, *Irrigation*, xvi; Bard, *Archaeology of Ancient Egypt*, 52–53.
81 Renfrew & Bahn, *Archaeology,* 285–288; Weiss, *Akkadian Collapse*, 94–95.
82 Soroush & Mordechai, *Short-term Cataclysm*, 4–7.

People worked collectively to build canals and storage areas for the water flowing down the Tigris and Euphrates Rivers.[83] The logistical skills needed for this achievement required a complex bureaucracy, which is why organised agriculture developed much earlier in Mesopotamia than Egypt.[84] Large-scale agriculture allowed civilisations to grow and flourish and the city-states of Mesopotamia developed into huge administrative and trade centres.[85]

Egypt's situation was somewhat different to Mesopotamia's, since irrigation and agricultural cooperation appears to have been proceeding well before unification.[86] There appears to be minimal evidence suggesting central government control of irrigation in early Egyptian history,[87] since naturally occurring dams already existed, meaning extensive irrigation works like those undertaken in Mesopotamia were not needed.[88] Small flood basins were occupied first as they were easier to manage with small numbers. Because fewer participants were needed, the logistical demands were not as significant, so the organisation of this fieldwork remained localised, not centrally organised as in Mesopotamia.[89] Technological 'advances' that led to the eventual decline in agricultural productivity within the Fertile Crescent do not seem to have been practised in the Old Kingdom.[90]

The Egyptian population centres were an integral part of the surrounding landscape, arising in response to the need to help manage the resources of the land,[91] rather than acting as overlords upon it. No heavily fortified city-states developed along the Nile because there was no conflict over water usage and storage.[92] The spontaneous evolution of significant

---

83 Approximately 6000BCE, see Van De Mieroop, *History Ancient Near East*, 8–13; Powell, *Sumerian Agriculture,* 291–299; Soroush & Mordechai, *Short-term Cataclysm*, 1–2.

84 Said, *River Nile*, 175; Jursa & Moreno García, *Near East & Egypt*, 119–120, 144–146.; Soroush & Mordechai, *Short-term Cataclysm*, 7–9.

85 Leick, *Invention of the City*, 43–53; Midant-Reynes, *Prehistoric Cultures*, 4–5.

86 Butzer, *Hydraulic*, 7. Collon, *Ancient Near Eastern Art*, 13–16, provides an overview of the cultural differences between Mesopotamia and Egypt. Maisels, *Early Civilisations*, 60–69, 152–169, 336–338, contrasts the social and logistical aspects of agriculture and irrigation in the Nile valley with those of the Fertile Crescent. Also, Midant-Reynes, *Egyptian Prehistory*, 46; Soroush & Mordechai, *Short-term Cataclysm*, 1, 8–9.

87 Hassan, *Riverine Civilisations*, 52–54; Butzer, *Human Ecology*, 147.

88 Soroush & Mordechai, *Adaptation to Cataclysm*, 351–356.

89 Butzer, *Human Ecology*, 261; Peréz Largacha, *Hydraulic Relation*, 82; Soroush & Mordechai, *Short-term Cataclysm*, 1, 8–9.

90 Weiskel, *Environmental Lessons*, 99. See Lawton & Wilke, *Ancient Agriculture*, 1–44 and McAdams, *Heartland of Cities*, 19–21, 243–247, describing the different rates adoption of agricultural technological innovation, identifies Egyptian technology as being less sophisticated.

91 Hassan, *Riverine Civilisations*, 69; Midant-Reynes, *Egyptian Prehistory*, 46.

92 Hassan, *Riverine Civilisations*, 6; Butzer, *Human Ecology*, 261.

population centres all along the river explains the simultaneous emergence of multiple major centres of regional administration and helps us understand why the city-state phenomenon as experienced in Mesopotamia did not evolve within the Nile valley.[93]

The End of the Old Kingdom

The ending of the Holocene Wet phase (from about 7500–7000 BCE to about 3500–3000 BCE)[94] appeared to coincide with the dislocation of a number of communities around the Aegean.[95] These climatic events are supposed to have brought about the decline of the first urban centres in the Levant,[96] the fall of the Akkadian Empire,[97] as well as the deterioration in the Palatial Culture of the islands in the Mediterranean.[98] It is believed that, during this time, the Old Kingdom declined and 'fell' as Egypt experienced a series of poorer-than-average inundation events, resulting in a number of significant drought-like episodes.[99]

Despite indications of increasing aridity from as early as the 3rd Dynasty,[100] the late Old Kingdom 'drought' was thought to have led to a severe and enduring crisis in food supply causing Egypt to experience a long-term famine, affecting society in a debilitating manner, perhaps initiating a 'dark age' in Egyptian history.[101] Many have attempted to discuss the societal changes that may have occurred and to explain administrative and other governmental reforms in the light of this understanding of a 'drought'. The calamity of drought would have impacted upon the stability of the society as a whole,[102] and in association with an incapacitated government,[103] has been suggested as a direct cause of the end of the Old Kingdom.[104]

---

93 Van den Brink, *Settlement Patterns*, 301–302; Butzer, *Archaeology as Human Ecology*, 51.
94 Bloszies, et al., *Lake Turkana Transition*, 64–76.
95 Said, *River Nile*, 138; Bell, *Dark Age Egypt*, 1–26; Höflmayer's overview in *Dating Catastrophes*.
96 Fiorentino et al., *3rd Millennium Syrian Climate Change,* 51–58, summarising their findings, suggest significant climate events in that region over a similar time frame to that under examination here.
97 Höflmayer, *Dating Catastrophes*, 118; Weiss, *Akkadian Collapse*, 93, 101–104.
98 Drake, *Greek Dark Ages*, 1862–1870. For recent overviews, see Finné et al., *Late Bronze Age Climate Change*; Weiss*, Akkadian Collapse.*
99 Weiss, *Akkadian Collapse*, 100–102; David, *Pyramid Builders*, 25–27.
100 Bell, *Oldest Nile Floods*, 569–573, suggests that the evidence indicates a decline in average flood level and a decline in resource availability from as early as the 1st Dynasty.
101 Hassan, *Historical Nile Floods* and *Nile Floods & Political Disorder;* Bell, *Dark Age Egypt.*
102 Hassan, *Re-reading Ipuwer*.
103 Butzer, *Discontinuity,* 102–112*;* Malek, *Old Kingdom*, 118.
104 Hassan, *Re-reading Ipuwer,* 357–377. Moeller, *FIP Drought?* 153–168, does not see the absolute link.

One theory is that the disorder and disruption so weakened the fabric of Old Kingdom administration[105] that the society was rendered paralysed and unable to cope.[106] It is thought by some Egyptologists that the developing societal unrest that began at the end of the Sixth Dynasty and lasted throughout the First Intermediate Period was a direct consequence of this extended drought.[107] Others hold that they cannot see direct evidence of this in the archaeology they have studied.[108] Some suggest that it was weak government that exacerbated the negative impacts of weaker food surpluses.[109] Perhaps, it was a combination of all these factors magnifying one another's negative effects.[110]

The consequences of this dislocation of culture has excited the imagination of many scholars.[111] This has led to commentary describing the negative consequences such famine would have had upon Egyptian culture and the types of changes that may have occurred.[112] However, despite the suggestion of significant impact, Vandier identified some texts related to famines experienced during the Old Kingdom but found very few direct references to great suffering.[113] This seems odd considering the supposed severity of the calamity in question.[114] It is to be expected, therefore, that the negative environmental conditions of that era would have presented a challenging time for local societies.[115] It is suspected that, with such a change, enough time would have existed for the society (even if only subconsciously) to adapt to the new circumstances: a form of 'resilience' perhaps?[116]

---

105 For an excellent overview of the research on this subject, see Priglinger, Elisa. '*Historiographie der Ersten Zwischenzeit einst und heute*.' PhD, university Wien, 2010. To see the current thinking of the subject, see Müller-Wollermann, *End of the Old Kingdom*.

106 Romem, *Unravelling Prolonged Stability,* suggests that the major decline was the inability of the government to counter the growing power of the elite. Lawler, *Collapse Revisited,* 908, speculates similarly that the changes at this time derived more from a redistribution of power than a failure of resources.

107 Bell, *Dark Age Egypt*; Negus, *A Great African Drought.*

108 Moeller, *FIP Drought*? and Willems, *FIP*, for example. However, as Höflmayer, *Dating Catastrophes*, 123 and Contardi, *Rhythm of the Nile*, 14, point out, it seems the idea of a famine is still widely accepted in the scholarship.

109 Lawler, *Collapse Revisited,* 908; Bard, *Archaeology of Ancient Egypt*, 176–177, speculating that the changes at this time derived more from weakness in administration than a failure of resources.

110 As outlined in Hall, *A Perfect Storm?* 75–86.

111 O'Brien, *Boredom with Apocalypse*, 296. Soroush & Mordechai, *Short-term Cataclysm*, 9–10, identify that government ineptitude existed before the environmental stressors impacted upon the society.

112 Said, *River Nile* 176–178; Hassan, *Re-reading Ipuwer,* 357–377; Büntgen et al., *Climate & Human Susceptibility*, 578–582; Weiss, *Akkadian Collapse*, 105–106.

113 Vandier, *La Famine*, 2–3, 100–114; added to by Moreno García, *Études sur l'administration*, 88–92.

114 Schneider, *First Intermediate Period*, 315 and Gee, *Old Kingdom Collapse?* 68–72, on the role of Middle Kingdom propaganda in the dissemination of this idea.

115 Nana-Sinkam, *Degradation*, 15–16.

116 O'Brien, *Boredom with Apocalypse*, 296–297; Renfrew, *Collapse as Social Transformation*, 481–506.

The debate could be said to have become one where the causes of breakdown have distilled into socio-political versus climatic causes.[117] Perhaps other societal factors were significant in the changes also, with a gradual decline in administrative efficiency observed as a political failure on the part of the government to control the growing regional power of the local elites.[118] Ankhtify, nomarch of the 2nd and 3rd Upper Egyptian nomes during the latter stages of the period under examination, experienced hardships during his time in charge of his provinces but, according to his testimony, nobody starved.[119] Ankhtify also experienced disruption in the form of warfare:[120] warfare is never good for an agricultural system, or for society or the environment.[121]

Whether or not the people were actively aware of the wider changes, a population as intimately connected to its surrounding environment would have adjusted its behaviours.[122] As more evidence arises, it appears more likely that the decline of the Old Kingdom should be recognised as a series of negative factors exacerbating one another.[123] As to whether the decline was as significant as some contend,[124] some areas of Egypt appeared to thrive during the time frame in question.[125]

Scientific Evidence of a Drought

A large amount of corroborating scientific evidence identifies the timing and significance of the drought experienced at the end of the Old Kingdom and the consequent famine.[126] According to current scientific opinion, the drought reached its nadir 4200 years ago.[127] Scientific evidence supporting this date includes analyses of ancient rainfall precipitation,[128]

---

117 Dee, *Dating the Decline*, 323; Gee, *Old Kingdom Collapse?* 64.

118 Grimal, *History*, 88–93; Malek, *Old Kingdom,* 114–117; Lawler, *Collapse Revisited*, 908; Romem, *Unraveling Prolonged Stability*, 1–3.

119 Manassa, *El-Mo'alla to El-Deir*, 5.

120 Bard, *Archaeology of Ancient Egypt*, 177–178.

121 Nana-Sinkam, *Degradation*, 1, states: "*Chronic localised food shortages caused by war and drought are the most visible aspects of Africa's food and agricultural crisis*." This observation, though describing Africa's modern history, may also be applied to Ankhtify's time.

122 Butzer, *Archaeology & Geology,* 1620–1621.

123 Gee, *Old Kingdom Collapse?* 60–61; Müller-Wollermann, *End of the Old Kingdom*, 5; Seidlmayer, *First Intermediate Period*, 129.

124 Greenberg, *No Collapse: Transmutation*, 33, distinguishing between the terms: 'decline' and 'collapse'.

125 Lawler, *Die or Fade Away*? 3, 7; Snape, *Of Life and Death*, 106–107.

126 Rzóska, *Palaeo-Ecology*, 35–36.

127 See, for example, Krom et al., *Nile Sediment Fluctuations*; Stanley et al., *Nile Flow Failure*; Ducassou et al., *Nile Floods.*

128 Williams & Nottage, *Extreme Rainfall Impacts*; Butzer, *Discontinuity;* Bárta, *In Mud Forgotten*.

Nile delta sediment studies,[129] Mediterranean seabed silt deposit investigations,[130] Isotopic examination of fish bone remains,[131] chemical residue analyses of a variety of lakebed sediments;[132] as well as pollen deposit variances from various Nilotic plants[133] and radiocarbon examination of miscellaneous genetic material found in ancient remains.[134] The conformity of 'agreement' amongst the findings could make a cynical person suspicious, but there does seem to be a vast amount of evidence from many branches of science supporting the assertion of a significant environmental event taking place over the time in question: this time frame identified as approximately 4,200 years before the present. [4200 BP].

Recently, however, it has begun to appear that to some scholars that the idea of a long-term drought seems perhaps a little too simplified to explain all of the observations and interpretations that have been made.[135] These disruptive events may be indicators of a climate changing more gradually over the long term. Current climate change modelling suggests that extremes of weather will become more 'regular'; longer droughts, wetter rainy seasons, cooler cold days and warmer hot days. Rather than a predictable climate (climate being what you expect over a period of time), the world would seem to be entering a phase where the weather (weather being what you get day to day) experienced appears more unsettled.[136]

The same phenomenon may have been experienced in Ancient Egypt with an 'oscillating' pattern of uneven weather displaying more irregular behaviours than previously experienced.[137] Developing geomorphological technologies have allowed scientists to improve the understanding of the nature of the historical Egyptian environment.[138]

---

129 Arz et al., *Red Sea Dry Event*; Marriner et al., *Nile Delta's Sinking Past*; Shaltout & Azzazi, *Nile Delta Climate Change.*

130 Ducassou et al., *Nile Floods in Sediments*; Krom et al., *Nile Sediment Fluctuations.*

131 Brewer, *Predynastic Temperatures*.

132 El-Wakeel, *Lake Qarun Deposits*; Touzeau et al., *Nile Valley Aridity*.

133 Langutt et al., *Mediterranean Climate Change*.

134 Butzer et al., *East African Lake Levels*; Buzon & Simonetti, *Strontium Isotope Variability*; Zanchetta, *Tephrostratigraphy;* Williams et al., *Late Quaternary Floods & Droughts*.

135 Bard, *Archaeology of Ancient Egypt*, 176–180, Müller-Wollermann, *End of the Old Kingdom*, 5.

136 See Stocker & Qin, *Climate Change 2013.* Currently, the earth is experiencing significant climate change. Simplifying the science to a two-word phrase, 'global warming', does not cover the range of scenarios suggested by the most recent modelling. See the 'Summary paper from the first session of the United Nations Environment Assembly of the United Nations Environment Programme, held in Nairobi, 23–27 June 2014'. It is similarly important that researchers into the climate of Egypt at the end of the Old Kingdom do not conflate the terms '*weather'* and '*climate'*.

137 Bunbury et al., *Memphite Floodplain Landscape*, 89–90; Steward et al, *River Runs Dry*, 202–203.

138 For example, see Butzer, *Archaeology & Geology,* 1617–1624; Welc & Marks, *Old Kingdom Climate Change*, 1–10.

Kilimanjaro ice core analyses, for example, have identified stages in Egypt's recent past, with the most recent example dating from 5000–3500 BCE, when so much water would have been available for cultivation that irrigation should *not* have been necessary.[139] The annual regeneration of the soil and the subsequent abundant natural yield allowed for the retention of a herder-forager lifestyle to remain as effective cultural behaviours for many prehistoric Egyptians. This notion is at first glance counter-intuitive, but it is feasible to look on the river as a natural provider rather than the source of labour-intensive agriculture-based sustenance.[140] It was possible that the natural growth of pasture/vegetable greens/vines meant the Egyptians did not have to farm. Perhaps the continued practice of a herder-forager lifestyle in many parts of the country was as a consequence of unpredictable river behaviour, with the adoption of agriculture as an option adopted in response (i.e. choosing to) to a changing climate and not as a consequence of it (i.e. being forced to).[141]

---

139 Macklin et al., *Nile Floodwater Farming*, 696, fig. 3.

140 A similar lifestyle was being practiced in the 'fringe-dwelling' populations of the Mesopotamian marshlands, see http://www.clw.csiro.au/publications/consultancy/2004/Mesopotamian-marshlands-soil.pdf (Mar. 22, 2018)

141 Midant-Reynes, *Egyptian Prehistory*, 137–138.

1.4 – The Effect of Drought upon the River

"*A society is circumscribed by its environment.*"[142] To help us understand ancient Egyptians, we first need to develop an understanding of their environment.[143] Analysis of the long-term environment of a site or region allows for the investigation of a number of inferences that may arise based upon current scientific considerations.[144] This should improve the understanding of the cultural development of that site or region, as opposed to it being a centre for redistribution.[145] Hierakonpolis, as an example noted earlier, had developed into an important cultural centre by Predynastic times despite having no resources of note.[146]

Since reliable agriculture has been linked to the prosperity and stability of the society[147] a continuous slow decline in water levels[148] and a corresponding increase in aridity should have been noticed at the end of the Old Kingdom.[149] It has been suggested that the drought had a major impact upon the culture of ancient Egypt – in some cases, the fall of kings.[150] Evidence suggesting a continuous drying out of the country from the Predynastic era onwards implies that famine and drought were at least a regular occurrence,[151] one that perhaps should not have had as significant an impact upon the civilisation as many claim.[152]

---

142 Butzer, *Discontinuity*, 102.

143 Butzer, quoting Keimer, *Ecological Archaeology,* 106–111.

144 Hassan & Stucki, *Nile Floods & Climatic Change*, 37–46; Crumley, *Historic Ecotonal Shifts*, 377–384; Downing et al., *African Climate Change*, 19–44. See also Talling, *History of Nile Research*. Höflmayer, *Dating Catastrophes*, 133, points out that, including himself, many scholars still see no *direct* evidence that shows dramatic changes in flood levels at the time under investigation.

145 See, for example, Butzer, *Hydraulic Egypt* and *Environment & Human Ecology*. Seidlmayer, *OK Elephantine*, 108–111, suggests that not all centres developed along the same lines or for the same reasons, but by a certain stage, all had begun to perform similar administrative functions for the Egyptian state.

146 Hoffman, *Before the Pharaohs*, 160–161; see also Butzer, *Archaeology & Geology,* 1620–21.

147 Bard, *Archaeology of Ancient Egypt*, 51–53. Lawler, *Collapse Revisited,* 907–908*,* suggests the fall was neither sudden nor disastrous. Santoro et al., *1000 Years of Famine*, shows extremes of flood and drought following an unpredictable but semi-regular pattern.

148 Hoffman, *Before the Pharaohs,* 311; Butzer, *Discontinuity*, 106. Park, *Class Stratification,* fig. 3, 103*,* infers that a gradual decline in flood levels had begun before the Old Kingdom.

149 Bárta, *Long or Short Term?* disputes the role of climate alone as the cause of the decline of the Old Kingdom. Said, *River Nile*, 131–133, identifies Pre- and Early Dynastic droughts.

150 Schneider, *First Intermediate Period,* 311.

151 Brewer, *Predynastic Temperatures*, 299–300; Midant-Reynes, *Egyptian Prehistory*, 46.

152 Said, *River Nile*, 7–91; Phillips et al., *Mid-Holocene Egypt*, 64–74; Butzer, *Collapse, Environment & Society*, 3634; Bárta, *Collapse Hidden in Success*, 18–28. For a modern equivalent, see, for example, Stocker et al., *Climate Change 2013*, 33–115 and Edenhofer et al., *IPCC, 2014 Summary,* 1–21.

As noted earlier, the developing aridity of this time may have encouraged improved production methods.[153] If the current modelling is correct, however, and if ancient Egypt was experiencing climate change, then, in addition to regular droughts, it might also have experienced regular above-average floods. Said, in describing the various fluctuations that the River Nile has experienced over its history, comments on the vagaries of its flow.[154]

However, high water levels do not automatically equate to a positive environment. At this time in history, high rainfall events causing large scale erosion in wadis was followed by instances of dry sand entering the Nile Valley.[155] Excessive siltation can produce dense, compacted and poorly aerated soils; this saturated soil is less productive than well-worked land.[156] High volumes of water can result in severe weathering and rapid erosion as large amounts of fertile soil, laid down in preceding years, are washed away.[157]

Extreme water levels could wash away years of careful planning and preparations; canal and boundary markers were lost, field fences washed away and the organised sharing of excess water severely disrupted.[158] The loss of infrastructure would have had significant negative consequences to ineffective governments.[159] Thus, excessive floods may have interfered with the development of agriculture and the maintenance of cultivation in the region.[160] A problem almost as significant as lower than usual flood heights was the occurrence of higher-than-average flood levels. Potential cultural responses to the environmental impact of variable flood levels have been proposed by Butzer and Bárta,[161] with others having suggested that higher-than-average floods in the Nile valley may have hindered the adoption of agriculture in the region.[162]

---

153 Midant-Reynes, *Egyptian Prehistory*, 253 – contra Weiskel, *Environmental Lessons*, 99, stating that the inference that this increasing aridity should have driven the update of increasingly complex technology does not seem supported by evidence.

154 Said, *River Nile*, 129, 143–148, 176.

155 Hassan, *A River Runs Through*, 22–25; Bunbury et al., *Water Historical Perspective*, 52–71; Bunbury et al., *Memphite Floodplain Landscape,* 80–81; Butzer, *Quaternary Nile Problems*, 161–162, 171.

156 Butzer, *Hydraulic Egypt*, 17–18; Said, *River Nile*, 143–148.

157 Butzer, *Hydraulic Egypt,* 15–17, 51–53; Sampsell, *Traveller's Geology*, 12.

158 Said, *River Nile*, 7–91; Butzer et al., *Urban Geoarchaeology*, 3361–3364, fig. 19; Morris, *Art of Not Collapsing*, 80-81.

159 Butzer, *Pleistocene Nile*, 253–280; Nicholson & Shaw, *Materials & Technology,* 514.

160 Butzer & Hansen, *Desert & River*, 115, 129, 278; Butzer et al., *East African Lake Levels,* 1069–76.

161 Butzer, *Discontinuity*, 254–257; Bárta, *Collapse Hidden in Success*, 23–25.

162 Hassan, *Food Security*, 321–334; Butzer, *Hydraulic Egypt*, 9.

Relating Science and Environment to Art and Culture

As all major civilisations began on or near wetlands, the importance of wetlands to world history can be seen as highly significant.[163] Historically, the marshlands associated with them have been often represented as wastelands,[164] with this attitude perhaps affecting scholars' interpretations concerning the importance of the marshlands of the River Nile.[165] In ancient Egypt, when the river did not flow 'as expected', it did not flood over its banks, and the surrounding land was not submerged. This investigation will attempt to identify environmental changes that may have occurred as a consequence of a drought where the inundation did not occur. Modern investigations of this phenomenon from other places around the globe will be utilised in order to make some valid assumptions about the nature of 'a river in drought' when the Nile did not flow as expected.

---

163 Hendrickx & Vermeersch, 33–40; Renfrew & Bahn, *Archaeology,* 239; Wilkinson & Stevens, *Environmental Archaeology,* 66–67.

164 Allen & Pye, *Saltmarsh Morphodynamics*, 1–18.

165 Rzóska, *The Nile*, 5–9; Malby, *Waterlogged Wealth,* 11.

1.5 – Ecological Principles Applied to History

When an object's environment is discussed, it encompasses that object's natural surroundings.[166] As a consequence of a weak or negligent flood event, the inundation would not have occurred, and nutrients and sediments normally 'lost' to the Nile would have remained within. This would have changed the natural environmental circumstances of the river. Since the primary goal of this study is to identify potential environmental changes that would have developed in the river in times of drought, an ecological overview is needed. Ecology is the science that attempts to explain how nature interacts with itself:[167] it is the study of how organisms interact with one another and with their surroundings (i.e. their environment). Ecologists investigate a region by working to recognise the various features, aspects or factors, that characterise an environment. These characteristics can be broken down into measurable and observable factors that, when added together, identify a particular environment with a unique and distinctive character. An environment can then be described and, if need be, classified according to the many characteristics that it possesses. From those attributes, ecologists can apply this awareness to the situation under investigation.[168]

Modern environmental studies apply the principles of ecological science to contemporary situations in order to make predictions about conceivable hazards or vulnerabilities brought about by a changing or newly developing environmental situation. These principles are well set out and can be applied to many circumstances. The world is currently experiencing rapid climate change with some areas in the modern world experiencing significant shifts in their normal weather patterns. As well as unexpected temperature ranges, many parts of the world are experiencing drought or floods in times of the year where the arrival of (or lack of) these phenomena is atypical, and the intensity of the event is abnormal. It is assumed that these principles would also apply to past situations. By using observations from these modern situations, we may be able to identify similar responses that have occurred in the past. The application of rudimentary ecological principles to the example of an Egyptian drought should enable us to speculate upon the nature of the ecology that developed in response to a gradual drying out of the river.–

---

166 Riemer, *Risks & Resources*, 124.

167 In 1869, German biologist Ernst Haeckel coined the term ecology from two Greek words: *oikos*, meaning 'house' or 'place to live' and *logos*, meaning 'study'.

168 Wilkinson & Stevens, *Environmental Archaeology*, 31–33.

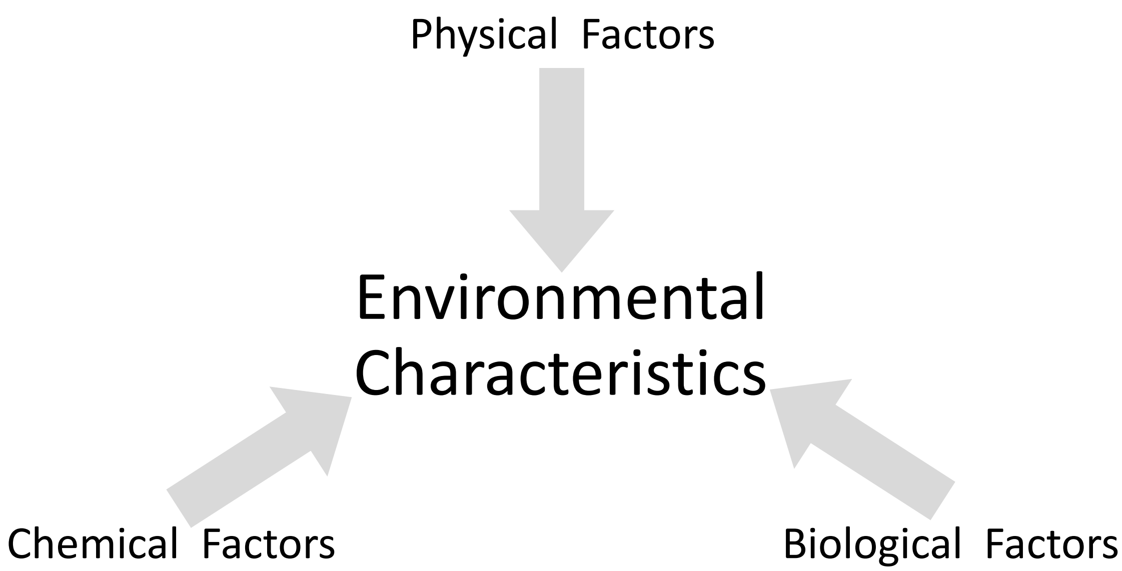
Introducing Ecosystems

A.G. Tansley first defined the concept of an ecosystem in 1935:

> "*Simply defined, an ecosystem is the interacting assemblage of living things and their non-living environment*."[169]

Ecosystems display environmental characteristics that are a result of the interacting *abiotic* (non-living) and *biotic* (living) features found within.[170] The abiotic components include various physical and chemical factors, or properties. The biotic components encompass the living things within that environment; these are commonly known as the biological factors. This usually involves the food webs that have arisen; from the producers to the herbivores to the carnivores and their attendant scavengers and decomposer. The final appearance of an ecosystem is a result of the interaction between these three main factors – physical, chemical and biological (see Figure 7: Influences on environmental characteristics).

Figure 7: Influences on environmental characteristics



[169] Tansley, *Terms & Concepts*, 299–302.
[170] Campbell, *Concepts & Connections*, 2–3.

Egypt itself is located in the northeast corner of Africa and consists of a few characteristic ecosystems. The ecosystem types can be broadly divided into Delta, Riverine, Oasis and Desert.[171] Each of these regions displays their own unique characteristics. The major focus of this investigation are the ecosystems that developed along the Nile – with a particular emphasis upon those areas mostly associated with the society and culture of the Old Kingdom, lying north of the cataracts up to the region of the Delta. The time frame in question encompasses the Fourth to the Eighth Dynasties.

Changes to Ecosystems

Thienemann, another pioneer of ecology, elucidated the basic principles of ecosystem response to changing ecological situations.[172] His *Grundprinzip*, or 'Basic Principles', has formed the basis for expressing ecosystem response to ecological change for almost a century.[173] They can be paraphrased as follows:

1. *The greater the diversity of conditions in a habitat, the greater the variety of species in that habitat.*
2. *The more the conditions deviate from the normal, the smaller the variety of species and the greater the numbers of these individual species becomes.*
3. *The longer a habitat has been in the same condition, the richer and more varied the species in the habitat, and the more stable that habitat is.*

Simply put, as the variability of the habitat increases, so should the biodiversity.[174] Therefore, the converse principle should apply: as the circumstances stray from the 'normal' situation, it is expected that some species would flourish while others may flounder.[175] Excess or sparse water supply impacts upon the behaviour of a river. Excess sunlight, in a drought, for example, may speed up decomposition of dead organisms, building a toxic overload or undesirable chemicals in a habitat. Other factors that could change an ecosystem are related to the way that an ecosystem is utilised or exploited.

---

171 Butzer, *Hydraulic Egypt,* 26–38; David, *Pyramid Builders*, 13–19; Zahran & Willis, *Vegetation of Egypt*, 255–256.

172 Thienemann, *Grundprinzip*, 421–422.

173 Perhaps even seen as "*dogma*" as suggested in McIntosh, *Ecology*, 141.

174 Solimen et al., *Nile Island Plant Species*, 81, n. 82.

175 See, for example, Al-Hassan & Ofori-Danson, *Plankton Abundance Factors*, 2; Okuku et al., *Plankton Response to Damming*, 114–132; Steward et al, *River Runs Dry*, 205–206.

Changes occur naturally to all ecosystems over time.[176] Seasonal changes producing a regular cycle of change, and ecosystems contain within them organisms that have adapted to this progression.

Fundamental to any ecosystem is the human impact upon it.[177] While some ecologists choose in their study of ecosystems to exclude the human species, and some humans think of themselves as somehow separate from ecosystems,[178] this is inappropriate for our study, since humans are an interacting and integral component of ecosystems at many levels, and both contribute to, and impact upon, the system of environmental balance.[179] Ever since the application of fire as a tool, humans have been impacting upon the environment, changing the landscape; altering the configuration of 'space' within their environments.[180] The most significant impact upon the planetary environment has been the adoption of agriculture as the primary source of food supply.[181] Since then, vast swathes of woodland have been cleared; waterways have been dammed, diverted and polluted; and human-induced weathering and erosion has occurred, all leading to rapid changes in the landscape.[182] Compared to the rapid changes experienced in the current climate, however, in historical times, the rate or speed of impact was presumably less.

Succession: Tracing Ecosystem Change

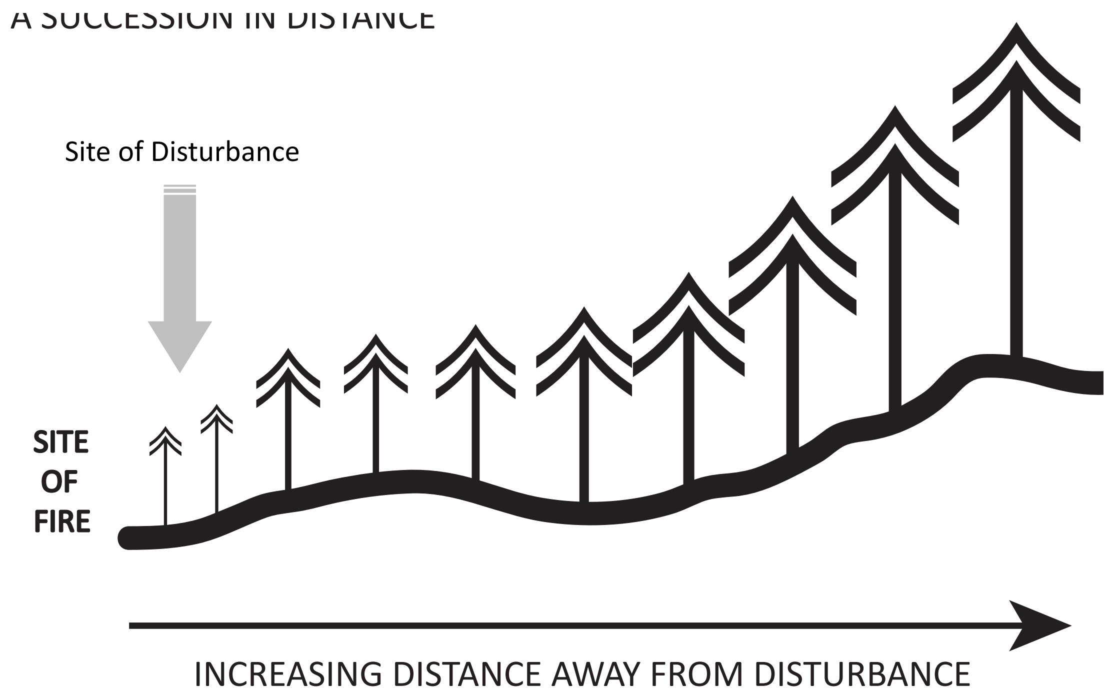
In ecological terms, a 'succession' may be defined as "*the observed process of change in the species structure of an ecological community over time*."[183] Within any community, some species may become less abundant over some interval, or they may even vanish from the ecosystem altogether.[184] Usually, changes occur as a result of some form of disturbance to the natural pattern within the environment.[185] In an ecological context, changes to the distribution and abundance of organisms within an environment usually suggest the influence of some new stimulus upon that environment.

---

176 Bunbury, *Geographical Development,* 1–12, outlining Nile floodplain changes during the Dynastic era.
177 Wilkinson & Stevens, *Environmental Archaeology*, 253–262.
178 Lyle, *Human Ecosystem Design*, 657.
179 Lyle, *Human Ecosystem Design*, 657–660.
180 Riemer, *Risks & Resources*, 124.
181 Wright, *Humans as Agents*, 1–14.
182 Reynolds & Stafford Smith, *Do humans cause deserts*? 1–21.
183 Tansley, *Terms & Concepts*, 286–287.
184 Tansley, *Terms & Concepts*, 288–299.
185 Krebs, *Ecology*, 32–39.

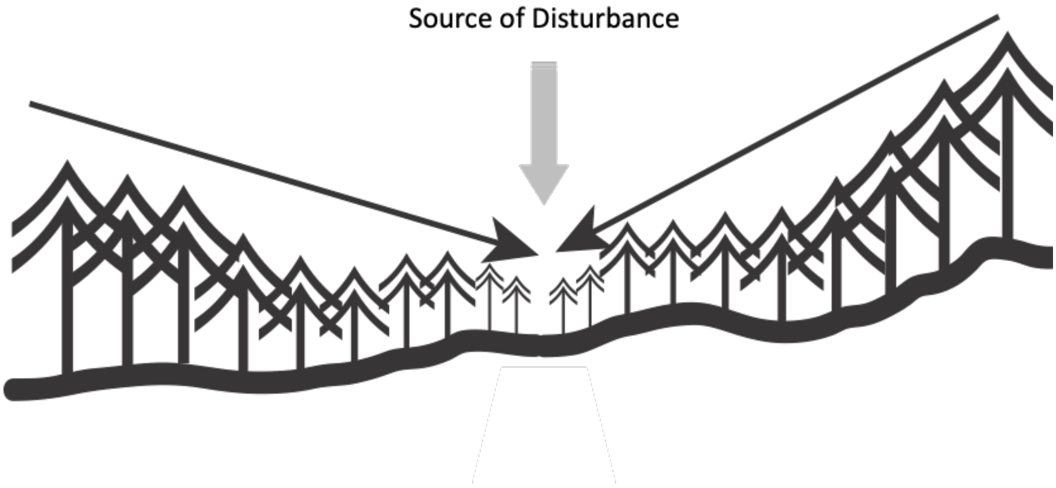
In a wildfire, for example, the further from the source of fire, the less damage to the trees can be observed (see Figure 8: A succession in distance). The further from the fire the greater the proportion of mature trees that should be present.

Figure 8: A succession in distance



Measuring the abundance and distribution of a tree species and adding the knowledge of tree growth rates can allow for the time frame of the disturbance to be calculated (see Figure 9: Identifying the source of the disturbance).

Figure 9: Identifying the source of the disturbance



Identifying these changes allows the disturbance to be traced backwards, both in time and in space. This is a 'succession in time' and a well-known ecological principle: the further from a disruption in time and distance, the longer this disturbance takes to manifest itself, and the likelihood that it is observable decreases.[186] The further away from a site in time and distance, the less the noticeable effect. If this disturbance was measured in reverse, then, as well as where the disturbance took place, it is also possible to identify when it occurred, a common enough ecological practice.

Within the ecological field, potential errors and ambiguities can develop due to a misinterpretation of the data or when particular data is looked for to the exclusion of other evidence. Similarly, when looking for patterns within the decorations that humans produce, the cultural context is vital. Too often, ecology and environmental studies take place independent of the human species and its cultural impact. Among these living things that make up an ecosystem are human beings, and the built environment becomes an important part of the ecosystem.[187] During this investigation, interpretations or suggestions that arise from interpretations of the data will be tested against the archaeological record and other scientific evaluations that would aid in our understanding.

---

186 Krebs, *Ecology*, 485–510.

187 Lyle, *Design for Human Ecosystems,* 656*,* recognises that humans are continually interacting with and are integral to ecosystems at many levels and 657, where he suggests that many humans think of themselves as separate from ecosystems. See also 658–660, where he identifies that the 'built' environment humans have fabricated has become an important part of ecosystems

Applying Ecological Succession to Art

In earlier studies, the author has applied ecologically based succession-style analyses to tomb decoration programmes to see if changing patterns within the progression of the decorations could be detected.[188] The assumption made in these studies was that societal disturbances, or influences, would have had a similarly observable impact upon the cultural representations of a society. In these studies, the distribution and abundance of certain tomb scenes over particular periods of time have been analysed to seek to identify developmental changes. Particular changes to the tomb decoration programme have been identified by observing when the changes occurred and linking this time to a cultural disturbance.

Butzer identified how the study of changes to Egypt's early ecology should be used to help develop understanding of how a changing climate may have impacted upon the developing Egyptian culture.[189] Our interpretation of their society may be influenced by the way they responded to the calamity, or how they described its impact.[190] An understanding of the cultural development of any one site or region is necessary, since a culture's environmental interaction was, and is, a significant component charting the development of human societies.[191] If changes to a society can be related to the geo-archaeological history of the region,[192] then it should be possible to relate the cultural history of a region to its environmental history in a similar manner. It should be possible to trace the development of the cultural progression at a particular site or within a particular region.[193] If the ecological analogy outlined above were to be applied to tomb decorations toward the end of the Old Kingdom and into the First Intermediate Period, then it would be logical to assume that the distribution of decorations within tombs would be different before and after the occurrence of the drought, and to pinpoint with some precision when this change occurred.[194] Without

---

188 Burn, *Mehu* and *Pyramid Texts*.
189 Butzer, *Hydraulic Egypt*, xiii–xv.
190 Pierssené, *Explaining Our World*, 20–22; O'Brien, *Boredom with Apocalypse*, 296–297.
191 Butzer, *Ecological Archaeology*, 106–11, argues for the recognition that a culture's environmental interaction was, and is, a significant component charting the development of human societies; see also Butzer, *Context,* 417–422.
192 Midant-Reynes, *Egyptian Prehistory,* 16–17.
193 Church & Bell, *Settlement Patterns*, 701–714, identify sites that had developed into important administrative centres despite having no resources of note.
194 To see how succession patterns in art may allow ecological and environmental inferences to be made, see Burn, *Marshlands and OK Famine* and *Fishing and OK Climate Change*.

a significant merging of the historical and scientific data, key factors that influenced the development of the civilisation may be overlooked.[195]

[195] Butzer, *Ecological Archaeology*, 106–11; see also Butzer, *Context,* 417–422.

SUMMATION: CHAPTER ONE

A Changing Environment Changes Society

The basic points of this chapter include:

⇒ The enduring success of the Egyptian culture indicates its resilience.

⇒ The geo-archaeological history of the region should enable the relationship between the environmental history and the cultural history of a society.

⇒ The culture that developed was influenced by the climate in which it developed.

⇒ A culture's environmental interaction was a significant factor in the charting of the development of that society.

Considering the pivotal role of the river to the long-term success of the society, a significant influence on that success must have been the riverine environment. A changing river would have had some impact upon the surrounding environments and that would have impacted upon the local population. It has been identified, in the discourse of the fall of the Old Kingdom due to the impact of a long-term drought, that the impact of drought upon the river itself has been left out of our reckoning.

Chapter Two:

Art, Society and the Environment

Note: Sections of this chapter have been previously published:
Burn, J. 2012. 'The Land and its Environment.' In McFarlane, A. and A. Mourad, (eds.), *Behind the Scenes: Daily Life in Old Kingdom Egypt, 1–12, Oxford.*

2.0 – Introduction

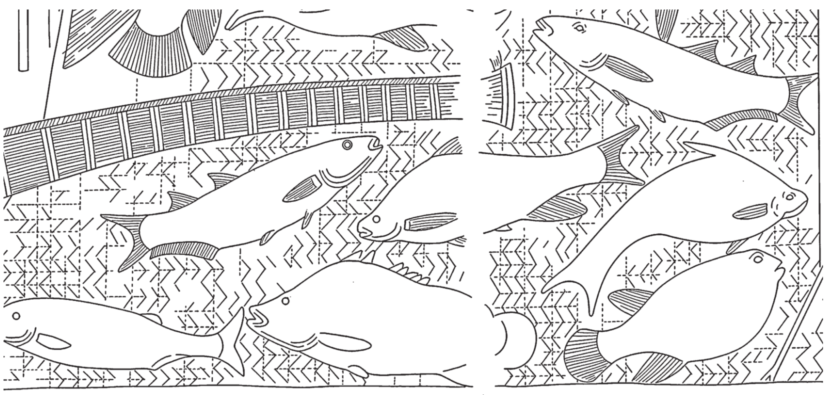
The secondary goal of this study is to identify if any correlation exists between the hypothetical ecological conditions at the end of the Old Kingdom, as suggested by the scientific analysis of the riverine ecology; and the tomb decorations that were produced at the same time. If changing environmental conditions were impacting upon the society, as many Egyptologists claim, then it follows that the tomb scenes produced concurrently should yield some evidence of this influence. As changing climate impacted upon the daily life of the ancient Egyptian, it could be possible that it influenced the culture as well. While it may seem to the cursory visitor or the casual observer that the culture of ancient Egypt remained stagnant, the society actually existed in an almost continuous state of change and adaptation. Changes in the way that ancient Egyptians saw themselves and their society should be recognisable in their art.

In this chapter, examples of how a society's environment influences its art will be identified and discussed. The chapter will outline how art, especially tomb decorations, may be used to make inferences about the impact of a changing environment upon the culture. The methodology employed in this study to identify how changing environmental river conditions could have affected the society and the visual culture of ancient Egypt at the end of the Old Kingdom will be presented. A case for the use of tomb wall scenes as indicators of Egyptian society will be made and, finally, a strategy for the utilisation of these tomb decorations as environmental markers will be outlined.

2.1 – Egyptian Representations of The Environment

A culture and society so attuned to the river flowing through its heartland, one so wedded to the regular cycle of inundation, and one so reliant upon its bounty, must have become aware of changes that interfered with this rhythm. The long-term success of the ancient Egyptian culture suggests an ability to adapt to their immediate surroundings. The art of the Old Kingdom reveals a deep understanding and detailed knowledge of the environment and illustrates the influence of the physical world on the evolution of Egyptian culture and on the lives and activities of its inhabitants.[196] The clarity, detail and precision of the wall decorations and their various themes suggest that the Egyptians had a great awareness of and interest in their natural surroundings. The creative use of both human and natural resources produced one of the world's greatest civilisations and is reflected in the many themes of wall scenes decorating the tombs of officials.

Figure 10: Water and fishes from the tomb of Mereruka



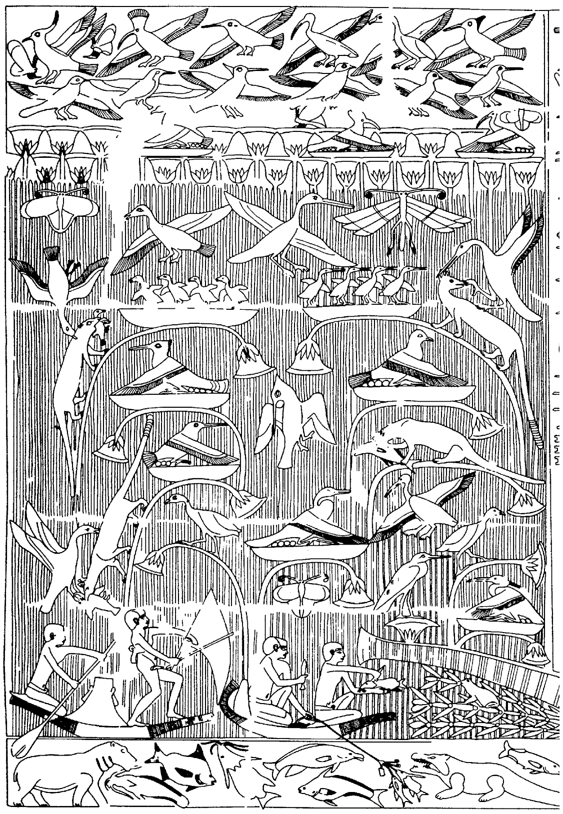
Adapted from Kanawati et al., *Mereruka III,* pl. 68

Artists took great care to keenly observe and to accurately represent the natural world in which they lived. Water, for example, was represented by a series of zig-zag lines portraying its liquid nature and was often filled with fish, flora and aquatic animals (see Figure 10: Water and fishes from the tomb of Mereruka). The waters of the Nile and its bountiful marshlands on which the Egyptian depended for transport, fish and fowl, constitute a significant component of the wall decorations produced during the Old Kingdom. The numerous types of fish depicted in the water are rendered so clearly, and in such detail, that the various species can easily be identified.

196 Schäfer, *Principles*, 45, in quoting Goethe, identifying nature as the "eternal spring" of influence, outlines his belief that the 'imitation of nature' is closely related to the essence of artistic creation.

Representations of dense papyrus marshes together with their attendant water birds, fauna and insects were illustrated in great detail (see, for example, Figure 11: Marsh scene from the tomb of Hesi).

Figure 11: Marsh scene from the tomb of Hesi



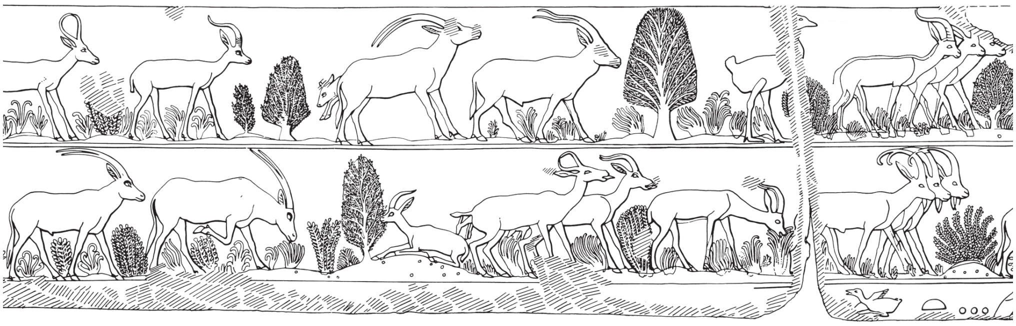
Modified from Kanawati & Abder-Raziq, Hesi, pl. 54

As well as fish, the water holds dangerous aquatic mammals and reptiles, such as the hippopotamus and crocodile, and even the odd turtle.[197] Frequently, very small animals are also depicted in the marsh scenes, such as frogs, and a wide variety of insects; including a praying mantis, some grasshoppers, butterflies and dragonflies.[198] Illustrated both in and above the papyrus marshlands are many varieties of water birds, such as geese, egrets, hoopoes, pied kingfishers, herons, turtle doves and lapwings. Some are shown within vegetation or in papyrus marshes, while others are portrayed flying above the papyrus.

The desert landscape was also represented, depicted as wavy lines above the register baseline suggesting the mobility of the sand (see Figure 12: Desert landscape from the sun-temple of Niuserra). In a scene in Niuserra's temple, for example, the desert is represented by an undulating landscape and the fauna and flora of the desert itself is represented by succulents, small shrubs and stunted trees; as well as many animals, including a few birds and a rare ostrich. The presence of shrubs and succulents suggests an area between the arid desert and the fertile land where water was available and sparse vegetation provided grazing. Desert animals in the scene include an oryx, a gazelle, an ibex, two jerboas, two hedgehogs and a young gazelle hiding behind a shrub. As well as desert prey, numerous large desert animals were depicted, for example, aurochs, lions and leopards.

197 Kanawati & Abder-Raziq, *Hesi*, pl. 53. Apparently, this scene depicting turtles mating is unique.
198 For example, frogs and mantis in the tomb of Hesi: Kanawati & Abder-Raziq, *Hesi*, pl. 54.

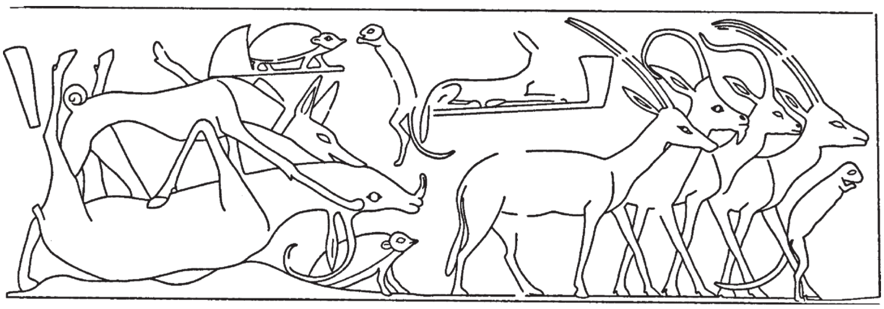
Figure 12: Desert landscape from the sun-temple of Niuserra



Adapted from Edel & Wenig, *Sonnenheiligtum des Ne-User-Re*, pl. 14.

The great variety of desert animals provided a rich resource and were hunted both for food and for recreational purposes.[199] As such, they were regularly depicted on tomb walls (see Figure 13: Desert hunt from the tomb of Inumin), including a scene depicting a hunting dog attacking an ibex.

Figure 13: Desert hunt from the tomb of Inumin



Adapted from Kanawati, *Inumin*, pl. 47.

The environment, including flora, and fauna such as mammals, birds, reptiles, amphibians, fishes and invertebrates such as insects and arachnids, was also a source of a large number of Egyptian hieroglyphs. While the river was the lifeblood of the country, the culture also relied on resources from both the desert and the ecotone regions at the edge of the floodplain. The hieroglyphic determinative for Lower Egypt was a clump of the papyrus that grows in the marshlands, while the determinative for desert lands is composed of two or three adjacent hills, often with red dots to indicate their sandy nature, beyond the fertile Nile.

199 Herb & Förster, *From Desert to Town*, 24–33.

2.2 – Art, Society and Culture

Ancient Egypt, as a society existed in an almost continuous state of gradual cultural evolution.[200] Despite the impression Egypt gives of a conservative civilisation, the culture was never in an inert state.[201] Rather, its art exhibited an almost continuous state of change,[202] whether in regard to depicting administration,[203] societal manners,[204] or in religion.[205] While a "*continuity of culture*," was evident,[206] art was not static;[207] it being "*no more unchanging than the institutions and beliefs that it served*."[208]

It seems better to see ancient Egypt not as a series of one king following another, in a seemingly never-ending repetitive cycle, but perhaps as in some form of cycle of 'Interrupted Stability,'[209] in which some rulers had the fortunate (or unfortunate?) experience of ruling when significant changes to the society were taking place. Over the time frame in question, changes occurred to both the variety and frequency of decorations displayed in tombs.[210] Within the context of an endlessly evolving cultural milieu, the decorations produced for the elite of the society generally reveal, sub-consciously at least, the current concerns, cultural atmosphere, beliefs and mores of the society.[211]

---

200 Vassilika & Bourriau, *Egyptian Art*, 1, suggest that Egyptian art, though evocative, was almost the most conservative of middle Eastern cultures.

201 For example, Malek, *Old Kingdom*, 23–33. Bard, *Archaeology of Ancient Egypt*, 84–87.

202 Smith & Simpson, *Art & Architecture*, 74; Robins, *Art of Ancient Egypt,* 57. Tiradritti, *Art, Architecture and History*, 20, suggests artistic 'maturity' as having been reached by the 3rd Dynasty, with Robins, *Art of Ancient Egypt*, 78, identifying the art of Dynasties 4 to early 6 as of the highest quality.

203 Smith & Simpson, *Art & Architecture*, 62 and 75, discuss the 'Biography of Weni' in this context. Malek, *Egyptian Art*, 26, identifies mechanisms of elite control of the peasant class. See also Robins, *Art of Ancient Egypt*, 252, on the role of art in reinforcing social structure; Donovan & McCorquodale, *Principles and Themes*, 1.

204 Donovan & McCorquodale, *Principles and Themes*, 1, note that styles that changed did so as a reflection of changes within that society. Smith & Simpson, *Art & Architecture*, 3, recognise the increasing development of Egyptian manners in the artistic representations of their surroundings.

205 Bard, *Archaeology of Ancient Egypt,* 84–87; Grimal, *History.*

206 Smith & Simpson, *Art & Architecture*, 1.

207 Smith & Simpson, *Art & Architecture*, 74. Robins, *Proportion,* 228–248, outlines how the process of representation of humans changed over the Old Kingdom. Binder, *The Physical World*, 29–34, links the idea of 'stasis' in interpretation to our inability to see the reality in two-dimensional representations.

208 Robins, *Art of Ancient Egypt*, 255.

209 See Bárta, *Punctuated Equilibrium*.

210 Harpur, *Decorations,* traces the development and evolution of Old Kingdom tomb decoration.

211 Schäfer, *Principles of Egyptian Art*, 14–18, on the role of symbolism; Malek, *Egyptian Art,* 16–18. See also Harrington, *Art & Social Theory,* 63–65, explaining the evolution of art in response to changing social structures. The conclusions drawn by Mysliwiec, *Decoration Schemes,* Michalowski, *Art of Ancient Egypt,* Shirai, *Ideal & Reality, and* Hagen & Hagen*, Egyptian Art,* serve as examples of interpretation of what is being represented.

After times of disruption, disturbance or upheaval had faded, the artwork presented appeared regularly to have reverted to original, more 'traditional', forms.[212] While not disregarding 'aspirational' themes that influenced many of the decorations,[213] it is hoped that this study will identify some instances where tomb scenes suggest that, as well as symbolic influences, an environment influence was insinuating itself upon the society. Socio-political breakdown may be evidenced by observing changes to the decorative programmes provided by the artists who decorated the chapels of the Old Kingdom elite, perhaps applying the 'insider information'[214] they had acquired in their association with the elite of society.

Art as Evidence

Some have asked if we can justify the use of art, in this case tomb wall scenes, as a guide to the society that produced it.[215] Art existed before writing so we should be entitled to see it as some form of symbolic representation,[216] an illustration of the basic concerns of the culture that was producing it.[217] Egyptian "*art was not produced for its own sake,*"[218] but had a role in the culture, and was a significant factor in enforcing the character of the elite within that society.[219] Much of ancient Egyptian culture has been gleaned from the examination and interpretation of its art.[220] While it is important to study art in a systematic manner,[221] new thematic and scientific approaches (a new 'lens', perhaps?) may enable the addition of new interpretations to old opinions.[222]

---

212 Robins, *Art of Ancient Egypt,* 109; Donovan & McCorquodale, *Principles and Themes*, 3. Shirai, *Ideal & Reality*, 333, suggests that an increase in 'ancestor worship' or linkages to previous times was attempted in order to shore up a current ruler's legitimacy. See Hope, *Libya and the Dakhleh Oasis*, 409, as evidence, perhaps, for a change in the rhetoric regarding 'foreigners.'

213 Quirke & Spencer, *Ancient Egypt*, 98; Hornung, *Afterlife*, 1–5, 14, 26–27, 30; Allen, *Middle Egyptian*, 315–317; David, *Religion & Magic*, 93; Taylor, *Death & Afterlife*, 194–95; Wilkinson, *Gods & Goddesses*, 42–44.

214 Butzer & Enfield, *Critical Perspectives,* 3630.

215 Seidlmayer, *Beni Hassan People*, 351, asked this question. Vasiljević, *Hierarchy of Women*, 146, has made hypotheses from tomb decoration data and then tested these on tombs from different sites.

216 Aldred, *Old Kingdom,* 30–32; Wilkinson, *Reading Egyptian Art*, 9; Donovan & McCorquodale, *Principles and Themes*, 2.

217 Knudsen et al, *Cultural Interpretation*, 303.

218 Aldred, *Days of the Pharaohs*, 11–12.

219 Hendrickx & Eyckerman, *State Development*, 63–64.

220 Aldred, *Old Kingdom*, 29; Knudsen et al, *Cultural Interpretation*, 58. Malek, *Egyptian Art*, 3, state that despite not being wholly 'realistic', it has enabled us to build our understanding of the culture – for example, religious art has improved our understanding of the development of religion, 21–22.

221 Schäfer, *Principles*, xxv.

222 Schäfer, *Principles*, 5–7, on the importance of a scholarly approach and the role of an academic over an artistic response to the decorations. Donohue & Fullerton, *Ancient Art & Historiography*, 1–3. Donovan & McCorquodale, *Principles & Themes*, 1, identify the significance of the interdependence of the picture and the script in a decoration.

Because art contains a multi-layered web of ideas, allusion and symbols,[223] art should not be studied in isolation but in conjunction with other fields. While some may question the validity of relying on the artistic evidence as data of its own accord, exactly what is produced allows for the utilisation of the artwork as pieces of archaeological data.[224] A good case in point is the representation of barley and flax harvesting to be found in most provincial tombs. For the production of linen, flax needed to be harvested 'green' whereas barley was harvested 'dry' in order to facilitate the ease of removal of the crop.[225] Most tombs display the harvesting sequence in the correct order, in some form of visual narrative.[226] The correct sequence is shown in Old Kingdom tombs at Sheikh Said,[227] Meir,[228] Deir el-Gebrawi[229] and at El-Hawawish.[230] Since the artists were careful to indicate the correct order of harvesting, then it lends support to the idea that it is reasonable to trust that their renditions of other events and phenomena were similarly accurate.[231] Using accuracy of identity and depiction of the chronology of the harvest may help justify the use of decorations as some form of historical data.[232]

Art as a Branch of Archaeology

Smith and Simpson see art as the "*re-creation of life*",[233] with the artists attempting to reproduce reality as vividly as possible[234] using the resources available, despite some representations that would appear unlikely to have occurred in real life.[235] Interpretations about the whole of society that are made separately from corroborating evidence should be

---

223 Malek, *Egyptian Art*, 27, identifies art in this manner.

224 Woods, *Art as Data*, (in preparation).

225 Siebels, *Agriculture*, 118–119.

226 See, for example, the commentary in Davies, *Sheikh Saïd*, 19–23. See also, Vogelsang-Eastwood, *Textiles*, 270–271.

227 Davies, *Sheikh Saïd*, pl. 16.

228 For the tomb of Pepyankh the Black, see Blackman & Apted, *Meir V*, pl. 22, updated in *Kanawati & Evans*, *Meir II*, pls. 83–84. For the tomb of Pepyankh the Middle, see Blackman, *Meir IV*, pl. 14v, updated in Kanawati, *Meir I*, pl. 84.

229 For the tomb of Ibi, see Kanawati, *Deir El-Gebrawi II*, 42–43 (though the image in Davies, *Deir El Gebrawi II*, pl. 6, is less damaged). For the tomb of Djau/Shemai, see Kanawati, *Deir el-Gebrawi III*, pl. 14–15, where the colour photography indicates the artist has depicted the stalks green.

230 For the tomb of Hesi-Min, see Kanawati, *El-Hawawish IV,* fig. 18.

231 Kanawati, *Tomb & Beyond*, 97.

232 Schäfer, *Principles*, identifies that images, in order to give the understanding of what is needed, may be seen as a transition from one place to another, see fig. 151; a sequence of actions, see fig. 244; or as a representation but not a copy of what was seen, see fig. 263.

233 Smith & Simpson, *Art & Architecture*, 1.

234 Tiradritti, *Art, Architecture & History*, 8.

235 Robins, *Proportion,* 1

deemed as more likely invalid and flawed.[236] For example, in his attempted construction of a parallel between the pictorial and archaeological records from Beni Hassan, Seidlmayer found it easier to identify parallels for the higher stratum of society than for the lower.[237] While tombs decorated within a royal context may have been produced under stricter, perhaps more religiously motivated, ideals,[238] those tombs produced by individuals beyond the immediate royal family may have been designed with more artistic licence,[239] with some elite adopting royal prerogative during the latter parts of the Old Kingdom.[240]

Art was not wholly derivative;[241] one artist may have been more 'creative' than another in the area,[242] or the scene may have been regarded as an 'informal' decoration, allowing greater scope for freedom and experimentation.[243] Consequently, the tombs of the non-royal elites may be seen as representing a more accurate 'historical' representation of everyday life[244] at that level of society. However, even allowing for conventionalism, in some situations, perhaps in circumstances where the artist was untrained or inexperienced,[245] the artist often drew from what they knew instead of what they saw,[246] so some images may not be realistic.[247] Schäfer first cautioned against this as some images may be concerned…. "*more with the essential character of objects than with their appearance*."[248]

---

236 Donohue & Fullerton, *Ancient Art & Historiography*, 3–6. Knudsen et al, *Cultural Interpretation*, 303, counsel against 'emotional' responses to art as opposed to rational ones.

237 Seidlmayer, *Beni Hassan People*, 365. For interpretation of these parallels from a more southerly locale, see Seidlmayer, *Early Old Kingdom Elephantine,* 108–127.

238 Baines, *Schäfer & Egyptian Art,* 10, where not all representations are accurate but more likely 'ideal'.

239 For a general discussion, see Davis, *Canonical Tradition,* 199–201 and Hartwig, *Painting & Identity*, 49–50; on the role of 'prestige' in representations, see Baines, *Communication & Display*, 476–7.

240 Bárta, *Old Kingdom Kingship*, 267–269

241 Smith & Simpson, *Art & Architecture*, 75, identifying new themes compared to older 'formulaic' ones. See also Lorand, *Four Schools of Art*, 52, identifying examples where the same subject resulted in many varied outcomes.

242 Schäfer, *Principles*, 36–45, gives many examples of variations upon a similar theme. Tiradritti, *Art, Architecture & History*, 8, contrasts the greater sense of freedom displayed on non-elite fragments compared to those that made up the more comprehensive tomb decoration programmes of the elite. Tiradritti identifies changes over time in how some figures were represented, 24 & 32.

243 Kanawati, *Tomb & Beyond*, 84. Robins, *Proportion,* 23, claims that no scene is ever *exactly* duplicated.

244 Baines, *Schäfer & Egyptian Art*, 8–10.

245 Michalowski & Guterman, *Art of Ancient Egypt*, 195–6; Robins, *Art of Ancient Egypt*, 80–89, also discusses the decline in quality during the First Intermediate Period. However, Michalowski & Guterman, 79, infer that this time could be seen as a 'revolution' in the type of art that was produced.

246 Schäfer, *Principles,* 46, on the balance between creativity and realism. See also Donovan & McCorquodale, *Principles & Themes*, 1.

247 Malek, *Egyptian Art,* 21, warns of not relying wholly upon the art, especially as much art is interpreted away from its original context and some interpretations are based upon style, 32. Schäfer, Principles, 5–6; recommends that, when studying Egyptian art, we attempt to avoid an emotional response and a "personal art experience", as do Kóthay, *Art & Society*, 19, Knudson et al., *Cultural Interpretations*, 303–304, who counsel the need to avoid "negative vibrations" due to an emotional response to a piece of art.

248 Schaefer, *Principles*, viii, as translated by Baines.

Most artists drew from what they knew as well as what they saw. A distinction, therefore, needs to be made between 'formal' and 'informal' decorations, with a greater opportunity to witness creativity, variety and complexity from those decorations not directly relating to the god, the king or the tomb owner.[249]

Within these analyses, it is also important to wary of the problem of applying a modern understanding to decorations that were prepared thousands of years ago for an audience 'knowledgeable' in its meaning. Our modern perceptions need to be restrained in order to avoid interpretation using our sensibilities,[250] so just as it is important to avoid overly 'emotional' responses to the actual scenes themselves, so is it important to avoid applying overly rational explanations. Hopefully, Egyptologists may be able to draw from the knowledge and skill of environmental scientists to develop a broader understanding of the reasons behind the decorations. Nonetheless, the composition of the scenes should enable some inferences to be made; the "*seeking of the message*"[251] of the decorative themes should be possible.

Environmental Influence on Art and Culture

The religious views of the earliest ancient Egyptians indicated they recognised the importance of the river to their society.[252] The land was seen as sacred; the cycle of the river suggested to them the importance of cycles, balance or harmony within the environment rather than domination over it.[253] The goddess of balance, Ma'at, was the personification of harmony with and within nature.[254] One of the gods attested from earliest times was Hapi, the God of the Nile, Lord of the Fishes and Birds.[255] To emphasise the value of the river in providing for the fecundity of the soil, representations of the god were often painted blue,[256]

---

249 Robins, *Proportion,* 21–23.

250 Pierssené, *Explaining Our World,* 6. Later, 83–84, Pierssené also comments about the 'morality' of an interpretation, avoiding politics and pre-conceived ideas. However, Kepes, *Arts of the Environment*, 12, claims that as our understanding of the environment improves, our ability to interpret environmental art should also improve.

251 Pierssené, *Explaining Our World,* 71–82.

252 Brow, *Alluvial Geoarchaeology*, 288.

253 Hughes, *Pan's Travail*, 48; Malek, *Egyptian Art,* 29, where the flood "*brought the land back to life*."

254 Málek, *Egyptian Art*, 27; the organisation and regularised order of cultivation contrasted with the chaos of the flooded marshes.

255 Wilkinson, *Gods & Goddesses*, 106.

256 Wilkinson, *Gods & Goddesses*, 107–108.

with blue having an especial symbolic meaning as it represented ‘precious’ things.[257] This male god was depicted with breasts to suggest nurturing and as corpulent to suggest bounty, indicating the especial importance attributed to him.[258] The god Osiris, whom Hapi suckled, was seen as the embodiment of agriculture and vegetation.[259]

Decorations could be unique to an area, where local situations and circumstances had influenced tomb decoration programmes.[260] The provincial art that arose at the end of the Old Kingdom did so to meet local demand.[261] These factors may result in outcomes that are not ‘traditional’.[262] Ideas and contexts change and these have been identified within the art.[263] In the cemetery of Hamra Dom, in tombs 66 and 73, the standard late Old Kingdom provincial repertoire of art is offered, with decorations dominated by scenes of hunting, fishing, fowling, butchering, and the inspection of cattle. However, they are notable for the lack of scenes depicting cultivation. Save-Soderbergh suggests this may be a reflection of the local environment at the time perhaps not being suitable for agricultural activity.[264] This allows us to contend that the environment must have had some influence (even if only sub-consciously) upon what was seen to be important at that time and place.[265]

---

257 Williams, *Per-Neb*, 50–52. (thanks to N. Richie for this suggestion.)

258 Michalowski & Guterman, *Art of Ancient Egypt*, 99.

259 Hughes, *Sustainable Agriculture*, 14–15. Malek, *Egyptian Art*, 29, identifies the increasing potency of symbols representing Osiris that developed during the Fifth Dynasty

260 Vischak, *Elephantine Identity,* 454. Brunner-Traut, *Epilogue*, 434, notes that geographical locations were identified beside some tomb decorations, indicating that the need to identify the location was “appropriate”.

261 Aldred, *Days of the Pharaohs*, 106–112, identifies the lack of quality but revels in the increased liveliness and originality that was displayed.

262 Donovan & McCorquodale, *Principles & Themes*, 4, on Mo’alla’s unique cattle.

263 See for example, Malek, *Egyptian Art*, 29, identifying the apparent rise in the potency of symbols representing Osiris. For the potential for an ecological change to influence religious beliefs, see the Discussion (Chapter 11).

264 Save-Soderbergh, *Hamra Dom*, 33–35.

265 Smith & Simpson, *Art & Architecture*, 78, where the arrival of ‘oasis people’ with mats and birds came to be seen as important in some regions; Shirai, *Ideal & Reality,* 329, providing instructions/roles for mourners and attendees at the funeral. See also Siebels, *Agricultural Scenes*, 55–56, outlining the entire agricultural sequence as some form of instruction manual. Are these examples of realism over symbolism?

2.3 – Using Art to make Inferences about Nature

One of the inferences under exploration is that the changing ecological situation may have led society to a greater awareness of the surrounding environment. In turn, this influenced decorations that depicted the 'real' world.[266] If the hypothesis is accurate, then it follows that the tomb wall scenes produced over the time frame in question should allow for the elaboration of suppositions about the ecology in which Egyptians found themselves at the end of the Old Kingdom.[267] Since it was mentioned in writings at the time,[268] it is believed that artistic evidence may also be used to make inferences about the climate. It is hoped that it may become possible to see if a changing ecological situation resulted in an increasing environmental influence that could be discernible,[269] with this awareness of the changing circumstances becoming noticeable in the scenic detail produced by the people of the time.[270] Perhaps an artistic narrative may be developed by tracking changes to the decoration programmes in relation to supposed environmental changes,[271] in addition to the other influences that existed.

It may be that this awareness of changes in the surrounding environment was evidenced by an increasing emphasis placed on scenes depicting more authentic surroundings, for example an increase in depictions of fishes able to survive in desiccated pools.[272] As we attempt to identify evidence of an increasing environmental awareness in the depictions that were produced at the time, alterations to the tomb decoration programme may become apparent.[273] Misgivings about the decline in the quantity and quality of available food should be visible

---

266 Church & Bell, *Settlement Patterns*, 713; Kinzig et al., *Assessing Cascading Effects*. See also the development of decorations outlined in Harpur, *Decorations*.

267 Osborn, *Men of the Stone Age*, 392–434, suggests this 'preoccupation' amongst all prehistoric societies that he had studied.

268 Neuberger & Thornes, *Art & Climate*, 95, note that references to climate can be found in ancient Egyptian writing. Later, 102, thay suggest some changes in artistic composition as a result of a changing Mediterranean climatic conditions.

269 Robins, *Art of Ancient Egypt,* 78 and Aldred, *Days of the Pharaohs,* 109, suggest that the quality of tomb decorations from early Dynasty 6 onwards infers economic problems.

270 Neuberger & Thornes, *Art and Climate*, 95–96, note that references to climate can be found in ancient Egyptian writing. They also note that Greek and Roman art does not allow historians to "*draw significant conclusions with respect to climate*" but "*according to the late art historian, Dr H.W. Janson* [with respect to clouds] . . . *the change from no-clouds to clouds occurs in a few decades*", showing that changes in composition enable some form of inference to be made.

271 Kanawati, *Tomb & Beyond*, 97, comments on the accuracy of most depictions.

272 Said, *River Nile*, 179. For an extended commentary, see Chapter 7, Fishing.

273 Pierssené, *Explaining Our World*, 2.

upon these same walls.[274] Could it be mere coincidence that iconography relating to the storage of grain seems to become increasingly common during the latter stages of the Old Kingdom[275], or could this greater frequency be related to an increasing importance assigned to this activity in times of scarcity. In a similar manner, the abundance of depictions of the rendering of accounts and punishments of errant estate managers increased over the same time frame,[276] once again suggesting an area of increased concern in Egyptians' daily lives.

Patterns of Change

In attempting to explain the cultural developments that occurred in ancient Egypt at the end of the Old Kingdom, some have suggested a link between the collapse of central government and a deteriorating environment.[277] Ankhtify's autobiography indicates a difficult time for Egypt.[278] Since Egypt had experienced low inundations in the past,[279] the decline in flood levels alone cannot be the significant factor in explaining the fall of the entire Old Kingdom.[280] As agricultural output became less dependable as a consequence of population pressures and/or climate change or as a consequence of inadequate government response to these situations,[281] it may have become that resources needed to have been sourced from further afield. In his acceptance of Bell's suggestion that a changing environment at the end of the Old Kingdom may have led to a detrimental consequence for the government of the time, Said identified aspects of tomb decoration and literature that may indicate the changing climatic circumstances that were taking place: for example, the increasing use of freshwater fish in artistic representations,[282] and therefore presumably in the diet, suggest that the cereal proportion of the diet had begun to decline.[283]

---

274 Baines, *Schäfer & Egyptian Art*, 9, on the importance of the role of narrative in art.

275 For the filling of granaries see Simpson, *Kawab & Khafkhufu,* 24–25, pls. 36[b], 37[b], fig. 47.

276 For the rendering of accounts, see, for example, Moussa & Altenmüller, *Nianchchnum & Chnumhotep*, 127, Taf. 54 [a, b], Abb. 24. For the punishment of errant estate managers, see for example, MMA, *Egyptian Art*, 404–407, fig. 126, depicting punishment scenes from the tomb of Tepemankh II.

277 Bell, *Dark Age Egypt*, 1–3; Bell, *Oldest Nile Floods*, 569–573, Büntgen et al., *Climate & Human Susceptibility*, 578–582. Hassan, *Re-reading Ipuwer*, 357–377. See also Cleuziou, *Archaeology & Climate*, 29–36.

278 Vandier, *Mo'alla*, Inscription No. 10, 220–222.

279 Hassan, *Nile Floods*, 1–23.

280 Bárta, *Long or Short Term?* Disputing the role of climate alone as the cause.

281 Bard, *Archaeology of Ancient Egypt*, 162–166. For argument of floods as the most significant factor, see Hassan, *Nile Floods*, 1–23. See commentary on the causes in Dee, *Dating the Decline*, 323.

282 Said, *River Nile*, 138–143, 179.

283 For example, Butzer, *Stratigraphy & Climate*, 5–23; Gorny, *Environment, Archaeology & History*, 81–92; Cornevin, *Paléoclimatologie de L'Égypte Ancienne*, 183–203.

Throughout the Old Kingdom and into the period beyond, changes can be observed to both the variety and frequency of decorations in tombs.[284] It seems likely that the scribes who composed the scenes on the walls of the tombs they were decorating would have been aware of their surrounds.[285] It may be that the greater awareness of the surrounding environment is evidenced by the increasing emphasis placed on scenes depicting the world as it was, not as it should be.[286]

Perhaps the desert provided a larger proportion of the resources utilised towards the end of the Old Kingdom in response.[287] Desert hunt scenes do not follow the 'normal' conventions of tomb scenes,[288] perhaps indicating their production at times when more authentic depictions were becoming fashionable.

The evidence of an awareness among the ancient Egyptians of changing environmental circumstances has been noted previously.[289] As society acquired a greater awareness of the surrounding environment, this increased understanding should have influenced the adoption of decorations depicting a world that the society found more recognisable.[290]

---

284 Smith & Simpson, *Art & Architecture*, 2, on decorations as representations of 'life on earth'. See also, Harpur, *Decorations.*

285 Baines, *Schäfer & Egyptian Art*, 18–21, recognises the relationship between symbolism and art and the importance of linking culture to its art.

286 Smith & Simpson, *Art & Architecture*, 3, on the increasing development in the treatment of the surroundings, and 42, on the rise of decoration themes relating to agriculture, fishing and hunting. See also Baines, *Schäfer & Egyptian Art*, 8–10, on the accuracy of representations. Tiradritti, *Art, Architecture & History*, 24, recognises that, despite most figures being drawn in an abstract manner, faces seem produced in almost portrait-like detail.

287 Said, *River Nile*, 142–143, 176. Bard, *Archaeology of Ancient Egypt*, 162–166, suggests that declining flood levels alone were not the significant factor in the decline, citing population pressures and poor government as contributing factors.

288 Robins, *Proportion,* 6. Did the 'relaxation of the rules' symbolise the chaos of the desert?

289 Said, *River Nile*, 138–143, could be identifying examples of such changes. Neuberger & Thornes, *Art and Climate*, 95–96, note that Greek and Roman art does not allow historians to "*draw significant conclusions with respect to climate*" but "*according to the late art historian, Dr H.W. Janson,* [with respect to clouds] . . . *the change from no-clouds to clouds occurs in a few decades*", showing that changes in composition enable some form of inference to be made.

290 Church & Bell, *Settlement Patterns*, 713; Kinzig et al., *Assessing Cascading Effects*. Rzóska, *Palaeo-Ecology*, 35, identifies changing landscape representations during the Fifth Dynasty. See also the development of decorations in Harpur, *Decorations*.

2.4 – The Method

In a similar manner to how succession studies identify patterns of change within an environment, this 'succession' approach may be relevant to a study of Egyptian art. In attempting to identify possible cultural influences, the present author has previously plotted variations in the distribution and abundance of specific tomb decoration themes. The aim of those investigations had been to identify changes in patterns as an indicator of variations in the relative importance of an idea or religious belief.[291] The number of times a theme is repeated may be used as an indicator of the relative importance of that theme. The spatial distribution, and the time at which it was produced, may also be used to indicate the relative importance of a theme between different locales and time periods. In the studies mentioned above stylistic changes have been identified as having taken place.

To investigate changes in tomb decoration programmes over time, it is necessary to identify what types of depictions existed, what they displayed and when they occurred. Harpur's work tracing the development of tomb decorations[292] has been expanded and deposited in digital form in the Oxford Expedition to Egypt (OEE) database. This 'Scene-details Database' is a series of records collating the decoration data for Old Kingdom tombs ("c. 2650–2150 BC") that have so far been recorded.[293] Within this database, the decoration types have been classified into 15 broadly defined 'themes.' The 15 themes are as follows:

1. Marsh-related activities
2. Desert and desert-related activities
3. Agricultural pursuits
4. Pastureland and animal husbandry
5. Orchard scenes
6. Gardening
7. Bird procession and poultry yard scenes
8. Manufacture and storage of wine and oil
9. Food preparation and brewing
10. Workshop activities
11. Commerce, including management of workers and possessions
12. Dance, music and games
13. Medical procedures, relaxation and bodily care
14. Warfare and war-related activities
15. Funerary rites and funeral scenes

---

291 Burn, *Similarity, Coincidence or Progression; Pyramid Texts* and *Mehu*.
292 Harpur, *Decoration*.
293 OEE *Scene-details Database,* doi:10. 5284/1000009

Each of these themes has been categorised into more precise 'scene types.' For example, Theme: 4. Pasture and animal-husbandry scenes, has been sub-divided into 10 scene types. The pastureland scene types are as follows…

4.1. Fighting bulls
4.2. Livestock browsing in pasture
4.3. Cattle mating in pasture
4.4. Cow giving birth
4.5. Milking a cow
4.6. Hobbled and tethered calves
4.7. Goats in or near trees
4.8. Feeding domesticated animals by hand
4.9. Force-feeding hyenas
4.10. Overseer seated near animal-tending activities

While discoveries have been made after the publication of this database, the large number of tombs recorded (495)[294] means that there is a lot of data contained within, with large changes needed before the overall pattern would change in a statistically significant manner. Evidence changing one or two pieces of data would make any overall change to the database inconsequential, in statistical terms. In conjunction with the MastaBase[295] data list; a database containing the iconographic and textual evidence on Old Kingdom elite tombs, using evidence from tombs not included in the database and incorporating more recent discoveries, the statistical analyses that follow utilise the OEE classification terminology.

With regard to the present study, it was thought that it might be possible to identify thematic changes as a consequence of the environmental changes that were actually being experienced. Importantly, when judging their significance, this study will look to the *subject* of the scenes and not their *quality* to be the consequential factor. Plotting the distribution and abundance of artistic themes across the latter stages of the Old Kingdom should help identify the changes that the society was undergoing by helping us to identify the changes in ideas and preoccupations of the elite. Due to the breadth of this study, it was not possible to investigate each tomb and each decoration in order to re-classify it anew, though this would have been the ideal situation. Since the initial investigation was basically a statistical exploration, then it seemed a valid approach to use data already collected. Therefore, it has used the work provided by the OEE and the MastaBase study group as the basis for

---

[294] https://archaeologydataservice.ac.uk/archives/view/oee_ahrc_2006/queryTombs.cfm?CFID=55702db0-0133-49de-9715-a7c6b74bd627&CFTOKEN=0 Total tombs recorded = 495 as at Marsh 18th, 2019.

[295] http://mastabase.org. This database from the Leiden Mastaba Study Group aims to make iconographical data of all Old Kingdom elite tombs (including provincial tombs) available freely online.

classification and the formation of the A.R.I.D. spreadsheet. During the latter stages of the study, in the Discussion and Analysis, relevant tomb scenes to the project will be considered. The method adopted here involves plotting the distribution and abundance of decoration themes across the time frame in question – from Dynasty Four to Dynasty Eight. The term 'abundance' is the measure of the number of times a particular decoration theme has been attested. The term 'distribution' describes its appearance within the Dynastic chronology. Where the dating is ambiguous, the dating criteria applied by the MastaBase Study group will be applied, since this is the more recent analysis.

The method applied in this investigation followed these subsequent steps:

1. A tomb was identified as belonging to the appropriate time frame (from Dynasty Four to Dynasty Eight) and assigned to a particular King. (King Teti, for example, was identified as VI.I: as the First King (I) in the Sixth Dynasty (VI).
2. Once a tomb has been categorised according to the above classification system, the different decorative themes were identified and plotted on a spreadsheet.
3. This was performed each tomb within the set time period.
4. A total for each of the themes was determined and the relative proportion of each type compared to all of the recorded attestations was calculated.
5. Those calculations were then used to analyse the changing patterns in the tomb decoration programme over the Old Kingdom, from Dynasty Four to Dynasty Eight.

Chronology

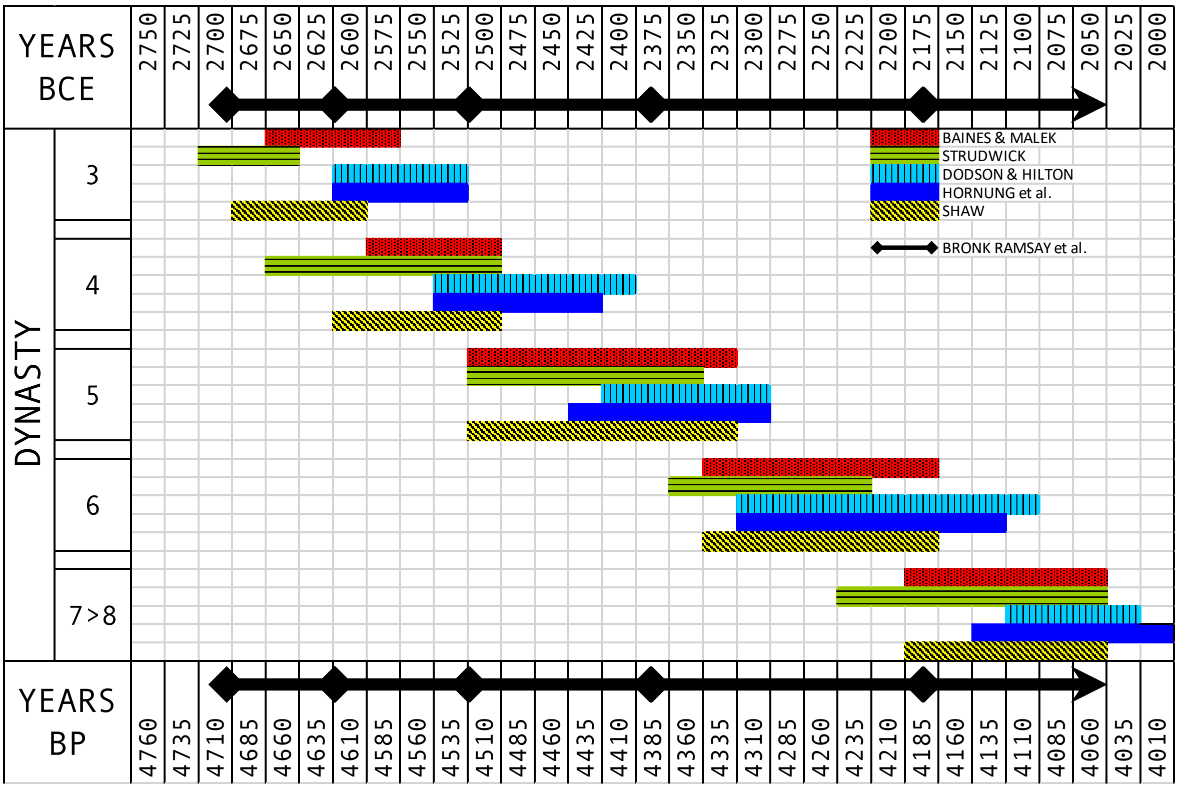
A debate that seems to be progressing at an infinitesimally slow pace is the one related to resolving dates of specific stages of Egyptian history. Not all of the dates suggested within the Scene-details database are accepted within the wider Egyptological community. Very little debate exists with regard to the order of Dynasties. The minor discussion with regard to orders of succession,[296] or for that matter, who was related to whom,[297] does not interfere with the long-term or overall consequences of this investigation.

[296] For example, the order of Shepseskare and Raneferef: Verner, *Who was Shepseskare*?, 581–602. For a summary of the opposite arguments, see Baker, *Encyclopaedia of Pharaohs* I, 427–428.

[297] See the debate discussed in Krejčí, et al., *Queen Khentkaus III,* 33–35 and Verner, *Sons of the Sun*, 24. For a detailed examination of this see Callender, *In Hathor's Image*, 149–154.

Using the database in its entirety from Dynasty Four to Dynasty Eight should allow the internal dating errors to balance one another out; it is to be expected that those dates thought too recent should be balanced out by those dates thought too late. Many scientific reports give a non-specific date in 'BP' or '(years) Before Present', neatly side-stepping the issue. Objects, tombs or decorations are 'dated' to a stage in Egypt's history in a manner that may sometimes appear circular, leading to some sense of 'unreliability'. Relative time frames are simple and provide a sense of continuity within the topic. However, when linking context to a potential foreign influence or artefacts originally deriving from an overseas location to a particular place in time and space, a more precise time frame than a relative chronology is needed.[298] To help overcome the absence of an absolute chronology, a number of proposed chronological systems have been put forward (see Figure 14: Proposed chronological frameworks).[299]

Figure 14: Proposed chronological frameworks



298 Butzer & Enfield, *Critical Perspectives,* 3629. This is particularly relevant to discussions involving climate change as it impacted upon neighbouring cultures.

299 For a brief overview and evolution of the various considerations and arguments, see von Beckerath, *Chronology,* 174–179; Baines & Malek, *Atlas*, 8; Kitchen, *Chronology,* 206; Shaw, *Oxford History,* 482–483; Strudwick, *Texts*, xxix-xxxi; Dodson & Hilton, *Families,* 287–288; Hornung et al., *Chronology,* 490–491. To compare these discussions with a scientific investigation, see Bronk Ramsay et al., *Radiocarbon Chronology.*

The summary table compares some selected proposed chronologies as outlined by Baines and Malek,[300] Strudwick,[301] Dodson and Hilton,[302] Hornung et al.[303] and Shaw.[304] The diamonds represent the median dates as proposed by the Oxford Chronology Project.[305] Notwithstanding the fact that an absolute chronology eludes us, it is difficult to discuss historical events without some understanding of the broad chronological sequence. This debate with respect to an absolute time frame is never-ending, and its solution lies beyond the purview of this investigation.

Investigation Chronology

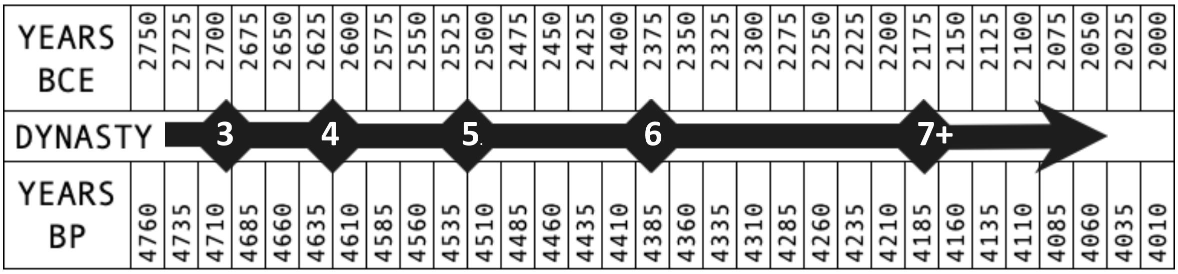
If famine was a significant cause in the decline of good or effective governance, then when this famine occurred in the timeline of dynastic succession is an important consideration. To accurately identify the time frame for the apparent decline in water availability and consequent deterioration of agricultural potential, the chronological framework requires absolute rather than relative figures. With increasingly sophisticated technology available to investigate the history of ancient Egypt and the River Nile itself, a more reliable time frame becomes increasingly possible. Recent detailed radio-carbon work by Bronk Ramsay and colleagues has provided a suggested chronology for the end of the Old Kingdom.[306] Large numbers of datable artefacts were investigated in order to produce a reliable date for the era. This systematic investigation represents a significant step forward in the scientific corroboration of Egyptian dynastic chronology.[307] In their conclusion, Bronk Ramsay and his team suggest that Shaw's 'consensus chronology'[308] is the timeframe that most convincingly fits their data.[309]

---

300 Baines & Malek, *Atlas,* 8.
301 Strudwick, *Texts,* xxix-xxxi.
302 Dodson & Hilton, *Families,* 287–288.
303 Hornung et al., *Chronology,* 490–491.
304 Shaw, *Oxford,* 482-483.
305 Shaw, *Oxford History,* 480–481.
306 Bronk Ramsay et al, *Radiocarbon Chronology*, fig. 1, table 1.
307 Bruins, *Dating Pharaonic Egypt*, 1490.
308 Shaw, *Oxford History*, 482–483.
309 Bronk Ramsay et al., *Radiocarbon Chronology*, 1556. For a detailed discussion of the suitability of this approach, see Höflmayer, *Dating Catastrophes*, 124–125.

For this investigation, this chronology (see Figure 15: Project chronology), as outlined by Shaw[310] and favoured by Bronk Ramsay et al., will be adopted.

Figure 15: Project chronology



At the points between the diamond shapes, it seems reasonably certain that the Dynasty in question appears to have been active and in control. The amount of control and effectiveness of administration is yet to be determined. Based upon this outline, the 'drought' that had become severe by 2200 BCE, and has been suggested by many as a major factor in the fall of the Old Kingdom, can be tentatively dated to the latter stages of the reign of Pepy I.

310 Shaw, *Oxford History,* 480–481. The suggested improvements and modifications from Sowada, *Egypt in Eastern Mediterranean,* tables 2 & 3, do not impact upon the scope of the project. However, see Discussion, Chapter 11.

SUMMATION: CHAPTER TWO

Tomb Decorations as a Potential Artistic Narrative

The basic points of this chapter include:

- ⇒ Despite generalisations that ancient Egypt was a stable, though somewhat stagnant and sometimes inert society, the society experience was always changing.
- ⇒ Throughout Egyptian history, the culture displayed a continuous evolution in style and form.
- ⇒ Some of these changes were due to changing religious beliefs, others to regional variations and others to external influences.
- ⇒ The art produced to decorate the tombs of the elite displayed the major preoccupations and concerns of the society in which the elite orbited.

Disturbances or disruptions to the natural order must have impinged upon the perception of those involved in the organisation and administration of the society. It is suggested that the society was discerning enough to identify changes to its environment. It has been proposed that one of the responses due to this changing awareness would be that the art produced should display a newly developing perception of this environmental change. In recognising that changes to the decoration programme over time indicate some external stimulation upon the culture, it is believed that identifying changes to the decoration programme allows us also to identify changes in stresses and concerns. Applying succession studies to these artworks should allow for the identification of changes in the patterns of presentations and possible changes in perceptions and emphases over the time frame under investigation.

Part B

The Ecological Background

CHAPTER THREE

THE ECOLOGY OF RIVERS

Note: An abridged version of this chapter has been published:
Burn, J. 2014. 'Marshlands, Drought and the Great Famine: On the Significance of Marshlands to the End of the Old Kingdom,' in K. Accetta, R. Fellinger, P. L. Gončalves, S. Musselwhite, and W. P. van Pelt (eds.), Publications of the Proceedings of CRE XIV - Crossing Boundaries, 34–48, Cambridge.

3.0 – INTRODUCTION

Before it is possible to identify changes to the tomb decoration programme that may have arisen in response to changing environmental circumstances, it is necessary to identify the types of ecological alterations that may have developed in the Old Kingdom in response to a lower-than-normal river. Within a weakening river, as the environmental factors alter, the biological profile of the river would also be constantly shifting. The interactions within the environment now take place under baseline conditions that are fundamentally different to those experienced normally.

This chapter examines the scientific basis upon which a possible decline in Nile flood levels in the late Old Kingdom and subsequent years can be identified. A summary of basic ecological terms will be introduced and a basic outline of the fundamental principles of riverine ecology will be presented. The term 'drought' will be re-defined as it relates to a river – that is: the availability of less than normal amounts of water, and those factors that may change in response to a drought, and how they would be affected, will be identified. Modern ecological examinations of waterways currently experiencing low water flow will be applied to the situation that may have existed in ancient Egypt. From these analyses, suggestions as to the responses made by those organisms reliant on the river's regular patterns can be extracted.

3.1 – Aspects of Riverine Ecosystems

Ecosystems are classified according to the physical, chemical and biological properties that they exhibit.[311] Due to variations in geology and geography, as well as the vagaries in flow, each and every riverine ecosystem exhibits characteristics that are unique to themselves.[312] This and the varying combination of factors leads to each river ecosystem displaying unique features. Compared to other bodies of water, the most significant feature of rivers is that they flow in one direction only,[313] leading to varying ecosystems which usually differ along the river's length.[314] The subsequent environmental characteristics can be studied by simplifying them so they can be more readily observed and measured.[315]

Factors within Riverine Ecosystems

The physical factors that have the greatest long-term effect on a river system are those that are related to the geology and geography of the site.[316] Geological factors are usually determined by the underlying rock structure, which impacts upon the nature of the soil[317] and influences the direction that a river may follow.[318] Because this investigation is looking into a relatively small section of geological time, the long-term geological impacts upon the river flow, such as the persistent weathering of the underlying rock structure, can be ignored. Geographical factors include, for example, latitude, altitude, amount of sunlight exposure, average temperature, annual rainfall and direction of the prevailing winds, and these factors impact upon the value of the surrounding soil, which determines the quality and variety of nutrients washed into the river.[319]

---

311 Angelier, *Streams & Rivers*, 215.

312 Venkatachalapathy & Karthikeyan, *Water Quality Index*, 708.

313 Bukaveckas, *Rivers*, 721–727; Allan & Castillo, *Stream Ecology*, 371; Giller & Malmqvist, *Streams & Rivers*, 10–13; Ward et al., *Riverine Landscape Diversity*, 517–539; Fisher & Sponseller, *Rivers as Ecosystems*, 494–496, figs 2, 3.

314 Allan & Castillo, *Stream Ecology*, 371; Giller & Malmqvist, *Streams & Rivers*, 10–13; Bukaveckas, *Rivers*, 726–727; Ward et al., *Riverine Landscape Diversity*, 517–539; Fisher & Sponseller, *Rivers as Ecosystems*, 494–496, figs 2, 3.

315 Rzóska & Wickens, *Vegetation*, 84; Allan & Castillo, *Stream Ecology*, 371. Weins, *Riverine Landscapes*, 501–515, provides an excellent overview of the features involved.

316 Venkatesan et al., *Fluvial System Analysis*, 221–222.

317 Yitayew & Melesse, *Water Resource Issues*, 402–407.

318 Bukaveckas, *Rivers*, 723–724; Venkatesan et al., *Fluvial System Analysis*, 201.

319 Yitayew & Melesse, *Water Resource Issues*, 402–407; Cushing & Allan, *Streams,* 366.

The chemical factors significant to a river include acidity, salinity, and the level of dissolved oxygen, which in turn affect the quantity and quality of nutrients contained within the river.[320] The chemistry of a waterway, therefore, has a significant impact upon the variety and success of its biology.[321] The biological factors that make up an ecosystem develop as a consequence of the interaction between its physical and chemical components. An ecosystem's biological factors include the life cycles of those organisms living within it and are a composite of the interactions of all of the living things within that environment.[322] This interaction usually depends on the flow of energy through the environment and is best investigated by observing the food webs that have developed within it.[323]

Food Chains and Food Webs

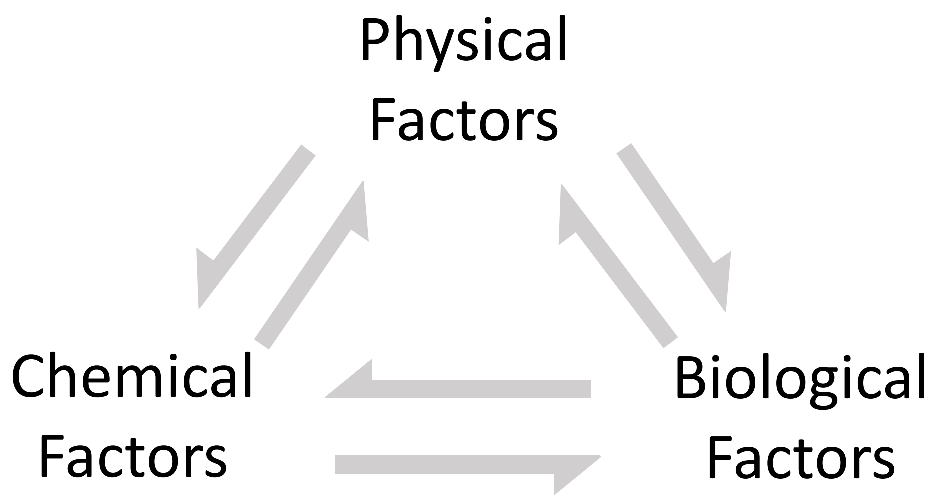
All food chains start with a 'producer', an organism that converts sunlight energy into food. Producers are generally plants. Animals are typically 'consumers', an organism that eats another. These animals are preyed upon by increasingly larger animals as the food energy travels up a food chain. All the individual food chains in an area can be represented by a more complex food web.[324] Changes to one biological, physical or chemical component within a food web can have ramifications to the entire food web mechanism.[325]

Changes in nutrient content and composition impact upon the biological nature of waterways.[326] This results in changes to its chemical properties, by altering the acidity, which can influence the solubility of many substances within the waterway.[327] Changes to the acidity within a waterway can subsequently affect those organisms living within it.[328] High acidity in a waterway, for example, can harm the maturation of invertebrate life within, as well as impede particular developmental stages of some fish species.[329]

---

320 Allan & Castillo, *Stream Ecology*, 68–72; Ramkumar et al., *Land Use Dynamics,* 4; Venkatachalapathy & Karthikeyan, *Water Quality Index*, 708–709.
321 Dhanakumar et al., *Phosphorous Fractionation*, 478.
322 Boyd, *Water Quality,* 244; Ramkumar et al., *Land Use Dynamics,* 2–7.
323 Menon et al., *Species Diversity*, 730–731; Bukaveckas, *Rivers*, 728–731.
324 Boyd, *Water Quality*, 206–218.
325 Boyd, *Water Quality*, xiii; El-Sheekh, *Nile River Ecosystems*, 15, Menon et al., *Species Diversity*, 745.
326 Fisher & Sponseller, *Rivers as Ecosystems*, 498–497, fig. 4; Bukaveckas, *Rivers*, 727.
327 United States Geological Survey, 'pH – Water Properties', *http://water.usgs.gov/edu/ph.html* (Apr. 9, 2016).
328 Giller & Malmqvist, *Streams & Rivers*, 53–54; Mohammad, et al., *Crayfish Development*, 272.
329 Rzóska, *Nile Biology*, 211; Boyd, *Water Quality*, 176–177, table 8.4.

Figure 16: Environmental factor interactions



Each of these factors may influence and impact upon the others[330] (see Figure 16: Environmental factor interactions). For example, the temperature of the water impacts upon the solubility of various chemicals, such as oxygen and carbon dioxide.[331] Excess sunlight in a drought may speed up decomposition of dead organisms, building up a toxic overload or undesirable chemicals in a habitat. The rate of flow changes the dissolved oxygen content in the river, which impacts upon the life cycles of some of its organisms. Other impacts to an ecosystem can arise from the way it is utilised or exploited, for example excessive harvesting of one particular food type or the addition of waste products not naturally associated with that waterway.[332]

---

330 Ramkumar et al., *Land Use Dynamics,* 5; Angelier, *Streams & Rivers*, 215, 709.

331 Boyd, *Water Quality*, 48–57.

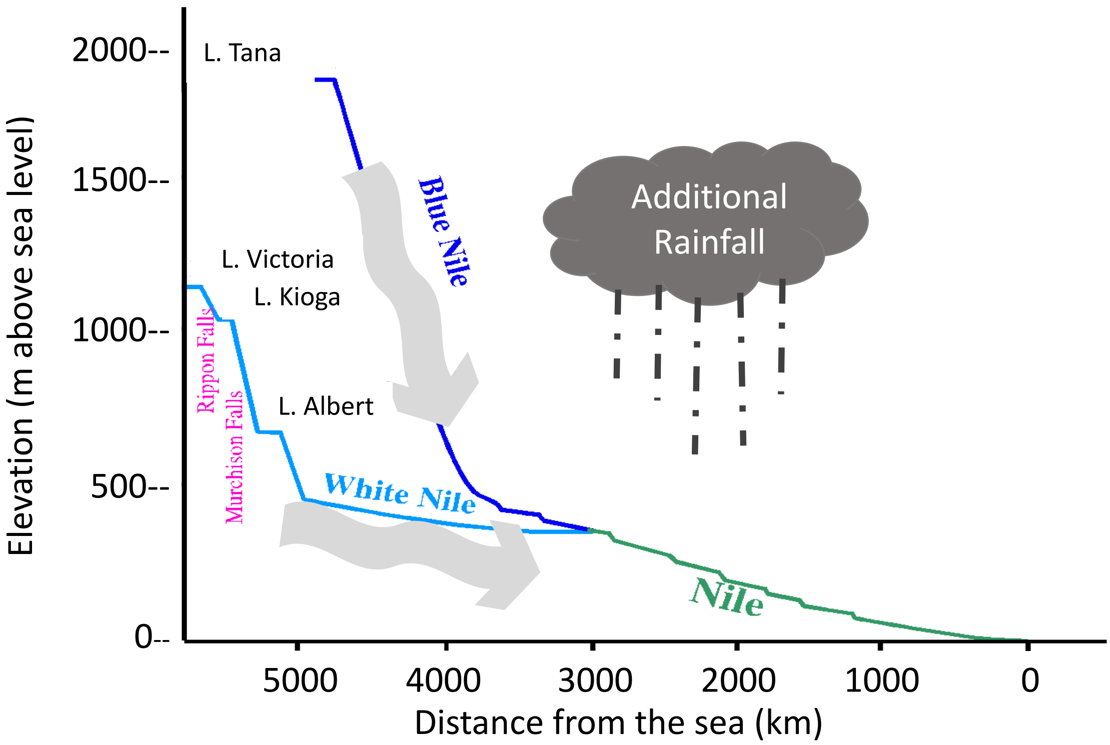
332 See, for example, Soliman, et al., *Plant Species Nile Islands,* identifying factors affecting the spatial distribution of plant species in Nile islands of mid Egypt, 70–92.

3.2 – Physical Factors in Riverine Ecosystems

Volume, Flow Rate and Nutrient Transport

The main physical factor that impacts upon riverine ecosystems is the power of the river.[333] The amount of rainfall in a catchment decides the volume of water that flows along a river's length.[334] The altitude from which the water travels provides a gravitational force that helps develop the speed.[335] In the case of the Nile, for example, the amount of monsoonal rain that falls over equatorial Africa, the altitude from which it descends and the distance that it has to travel all contribute to its flow rate (see Figure 17: Factors affecting Nilotic flow). The latent power of the flow is potentially amplified by the storage of water in the high-altitude lakes.

Figure 17: Factors affecting Nilotic flow



333 Kotoky & Dutta, *Spatio-temporal Variations*, 258–259; Giller & Malmqvist, *Streams & Rivers*, 55–67.
334 Melesse et al., *Hydrologic Threats*, 2–3; Bravard & Petit, *Geomorphology*, 387–389;
335 Bravard & Petit, *Geomorphology*, 392–394; Giller & Malmqvist, *Streams & Rivers*, 31–43.

The more rapid the flow, the greater the force of the water.[336] This allows the water to develop a 'momentum', or impetus, which affects sediment movement and nutrient transport. Rapidly flowing – that is, highly energetic water – can carry larger quantities of sediments for a longer time and can therefore transfer more sediment further.[337] The width of the river is determined by the volume of water flowing through it, and the breadth of the floodplain is determined by the quantity of water overflowing from the river in an inundation.[338] The subsequent depth of the river is also determined by the energy with which it flows.[339] A river's capacity to deposit silt was made up of two factors: speed and volume. The greater its speed, the longer the time and the further the distance the river could carry sediments. The greater its volume, the larger the amount of silt and resources it could deliver to waiting farmers.'[340]

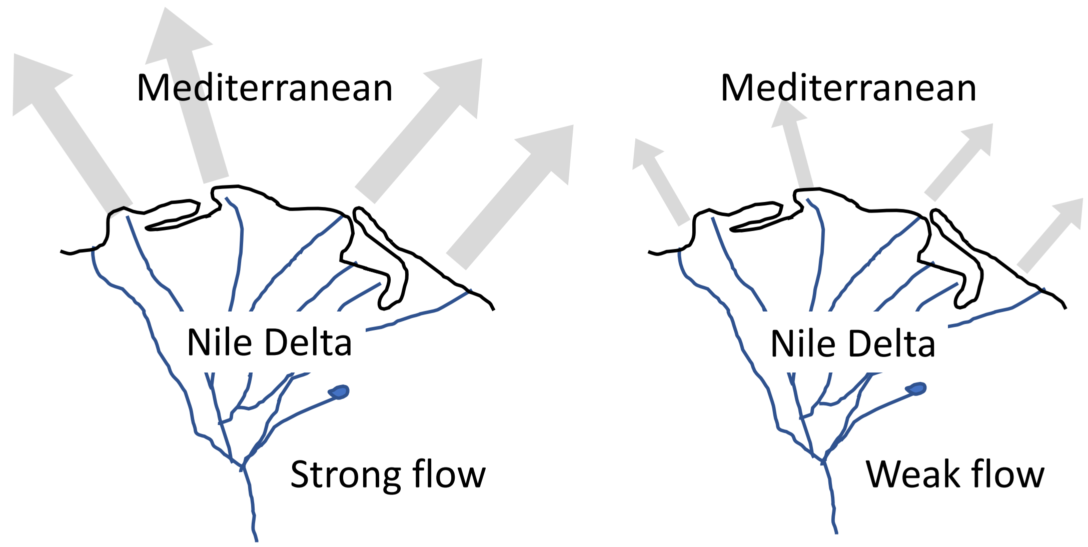
Erosion and Secondary Channels

The features that allow water to develop a 'momentum' also influence the amount of erosion that potentially may occur;[341] and the greater the volume of water, the more erosive the river can become.[342] Erosion, the "*moving of sediments from one area to another over a short-term period*",[343] is an important factor in the deposition of sediments.[344] In studies relevant to this investigation, evidence of sapropel (dark-coloured seabed sediments rich in organic matter) from the floor of the Mediterranean, for example, has allowed for the rates of historic erosion depositions of Nile sediments to be determined (see Figure 18: Sediment deposition due to river power). The thickness of the layer indicates the amount of sediment carried, and, hence, the volume of the Nile, while the distance from the river mouth indicates the power of its flow at that time. These results have been used to corroborate the idea that the river displayed significant low levels of flow during the time frame under investigations.[345]

---

336 Venkatesan et al., *Fluvial System Analysis*, 221, table 3.
337 Zahran & Willis, *Vegetation of Egypt*, 254–255; Mekonnen & Melesse, *Soil Erosion Mapping*, 211–213.
338 Thirukumaran & Ramkumar, *Remote Sensing*, 161–167; Venkatesan et al., *Fluvial System Analysis*, 212–221, fig. 10.
339 Kotoky et al., *Flood Management*, 240; Venkatesan et al., *Fluvial System Analysis*, 206–208, fig. 4.
340 Ramkumar et al., *Land Use Dynamics,* 2–3.
341 Kotoky et al., *Flood Management*, 239–241; Cushing & Allan, *Streams,* 366.
342 Kotoky & Dutta, *Spatio-temporal Variations*, 258–259.
343 Birx (ed.), *Encyclopedia of Time: Science, Philosophy, Theology, & Culture*, http://dx.doi.org.simsrad.net.ocs. mq.edu.au/10.4135/ 9781412963961.n183 (Apr. 8, 2016).
344 Body, *Water Quality,* xi–xiii, 313.
345 Krom, *Nile Sediment Fluctuations*, 71–74.

Figure 18: Sediment deposition due to river power



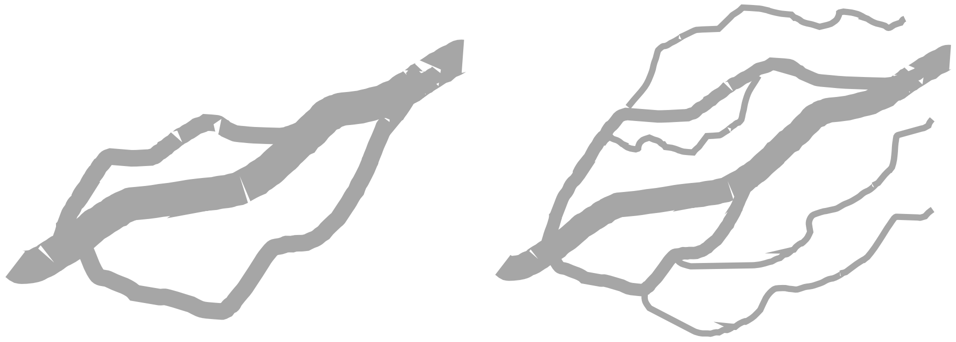
The rate of erosion impacts upon the width of the marshes that are found alongside river systems.[346] The stability of the soil strata is affected by the energy of the water that is flowing across it.[347] Reduced power leads to a weakening of the river's ability to break up clumps of matter that can encumber the flow and allows for the development of strong stable soil. Strong, stable soil that is well-bound by the roots of plants growing within it acts to resist erosion, allowing plants growing on the riverbanks to develop greater purchase, further promoting marsh survival or expansion.[348]

During times of a weaker river, secondary channels can form where the river does not have enough strength to force its way back to the main flow (see Figure 19: Secondary channel formation).[349] It is expected that the number of secondary channels should increase during weaker floods because water with less energy is forced to divert its passage when it encounters a blockage, rather than driving its way through.[350] Because of the less powerful flow, it is also expected that these secondary channels would be shallower, with the added potential to allow more marshland to development.

---

346 Steenhuis et al., *Erosion & Discharge*, 146; Allen & Pye, *Saltmarsh Morphodynamics*, 11–12.
347 Pethick, *Saltmarsh Geomorphology*, 43–47.
348 Giller & Malmqvist, *Streams & Rivers*, 50–53; Thirukumaran & Ramkumar, *Remote Sensing*, 162–163; Boyd, *Water Quality*, 317–318, 336–337.
349 Thompson, *Swamp Development*, 177–178; Sallam & El-Barbary, *Secondary Channels*, 489.
350 Sallam & El-Barbary, *Secondary Channels,* 494–498; Thompson, *Swamp Development*, 181, fig 26.

Figure 19: Secondary channel formation



Strong Flow ➔ fewer secondary channels   Weaker Flow ➔ more secondary channels

Turbidity, Light Penetration and Heat Exchange

The physical factor labelled as 'turbidity', describes the 'cloudiness' of a system.[351] The turbidity of a river is a measure of how much fine matter remains suspended in the waterway: this material can be clay, silt, non-living particulates, plankton, and other microscopic plants and animals;[352] and this property affects how readily light passes through it. The depth of penetration of light and heat has been shown to be a function of the flow of the river.[353] Rivers with a weaker-than-average flow are less agitated and are more likely to be less cloudy.[354] The slower a river, the clearer it is, because even the finest particles it carries remain suspended for a shorter amount of time.[355]

How deeply light penetrates into the water is influenced by the amount of suspended solid material present,[356] which in turn impacts upon the biological factors within the waterway.[357] Sunlight is needed for photosynthesis,[358] so light is an important ecological factor in

---

351 U.S. Geological Survey (USGS) definition: "*Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample*." USGS, https://water.usgs.gov/edu/turbidity.html (Mar. 28, 2016). For an outline of how turbidity may affect a waterway, see Allan & Castillo, *Stream Ecology*, 45, 109, 128.

352 El-Sheekh, *Nile River Ecosystems*, 6.

353 Davies-Colley & Nagels, *Light Penetration,* 5, fig. 3*;* Smith et al., *Optical Characteristics*, 301–312; Boyd, *Water Quality*, 102, 319.

354 Entz, *Lakes Nasser & Nubia*, 285–288.

355 Davies-Colley & Nagels, *Light Penetration*, 1–2.

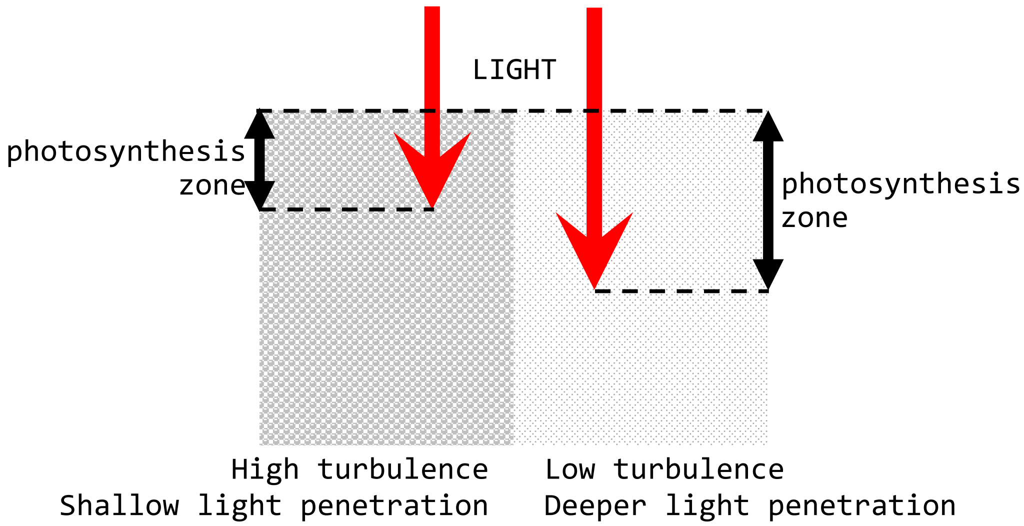
356 Abtew, *Land & Water,* 122–123; Boyd, *Water Quality,* 106–107, 112; Ramkumar et al., *Land Use Dynamics*, 4; El-Sheekh, *Nile River Ecosystems*, 6.

357 Allan & Castillo, *Stream Ecology*, 131–132; Boyd, *Water Quality*, 18, fig. 5.2, 111–112.

358 El-Sheekh, *Nile River Ecosystems,* 14–15; Boyd, *Water Quality*, 108.

determining how deep plants can exist.[359] There is a specific light requirement range for each plant found in aquatic ecosystems.[360] The deeper light penetrates a waterway, the deeper the 'photosynthetic zone' (see Figure 20: Turbidity and zone of photosynthesis), allowing for the development of more complex food webs.[361] High turbidity levels can cause problems for an aquatic ecosystem.[362]

Figure 20: Turbidity and zone of photosynthesis



While a slower river would typically allow light to penetrate more deeply[363] and improve the potential for an increase in photosynthetic activity,[364] a wider photosynthetic zone can lead to an increase in the growth of algae and other microscopic plants,[365] which could rapidly make the waterway much cloudier, negating this change, and further increasing the temperature gradient differences, as the algae absorb heat in the upper layers of the waterway.[366] This growth also impacts upon the wider food web within the habitat.

---

359 Westlake, *Light Climate for Plants*, 99– 119.

360 Boyd, *Water Quality*, 206, fig. 10.7.

361 El-Sheekh, *Nile River Ecosystems*, 20; Balagurunathan & Shanmugasundaram, *Microbial Biodiversity*, 582–583; Boyd, *Water Quality*, 18, 215, fig. 10.11.

362 El-Sheekh, *Nile River Ecosystems,* 6–7.

363 Davies-Colley & Nagels, *Light Penetration*, 3–4.

364 Boyd, *Water Quality,* 107, fig. 5.2, 213; Bukaveckas, *Rivers*, 731.

365 Steward et al., *River Runs Dry,* 205.

366 de Jonge & Elliott, *Eutrophication*, 318; Boyd, *Water Quality*, 108.

The flow rate also impacts upon how quickly the surface layer warms because the depth of light penetration also impacts upon the temperature that develops in the upper layers of the waterway.[367] Conversely, while low turbidity levels invite light and heat into the water, high levels of turbidity can also raise the temperature of the top layers because suspended particles near the surface speed up the absorption of heat from sunlight. Distinct layers can be expected to develop due to reduced mixing of materials that are moving at a more sedate pace.[368]

Finally, the temperature of the water impacts on the solubility of chemicals within it, which can also influence the type of food webs that may develop. This in turn can impact upon the dissolved oxygen content because less oxygen can be dissolved in warm water than in cold.[369] Also, the different pace might be slower than that to which the organisms within them have become habituated.

---

367 Body, *Water Quality*, 25; Narmada et al., *Groundwater Quality Assessment*, 571.
368 Entz, *Lakes Nasser & Nubia*, 282, 286; de Jonge & Elliott, *Eutrophication*, 314–315.
369 El-Sheekh, *Nile River Ecosystems*, 4–5.

3.3 – Chemical Factors in Riverine Ecosystems

The major properties that influence the chemical nature of a river include salinity, acidity and oxygen availability. These properties are significantly transformed by the temperature of the water, since water temperature affects salt and oxygen solubility. These factors may be influenced by one another. Also, as these factors change, the biological capacities of the waterway subsequently exhibit different characteristics.

Salinity

Salinity is a measure of the 'saltiness', or the amount of dissolved salt, present in a waterway.[370] Sunlight causes evaporation which can change the concentration of substances such as salt within the river, typically increasing them.[371] Salinity is an ecological factor of considerable importance, because it can influence the kinds of plants that will grow not just in the water, but in the vicinity, and also influence the types of organisms that live in a body of water.[372] Salinity values can vary across the width, depth and length of the waterway. This factor becomes increasingly significant in areas where the water is shallow or slowly moving, such as in the secondary channels that would have formed along the edges of the Nile.[373] Faster, deeper waterways experience less evaporation, so the situation may arise where chemical concentrations within the river at the same location could be different, depending on speed.[374]

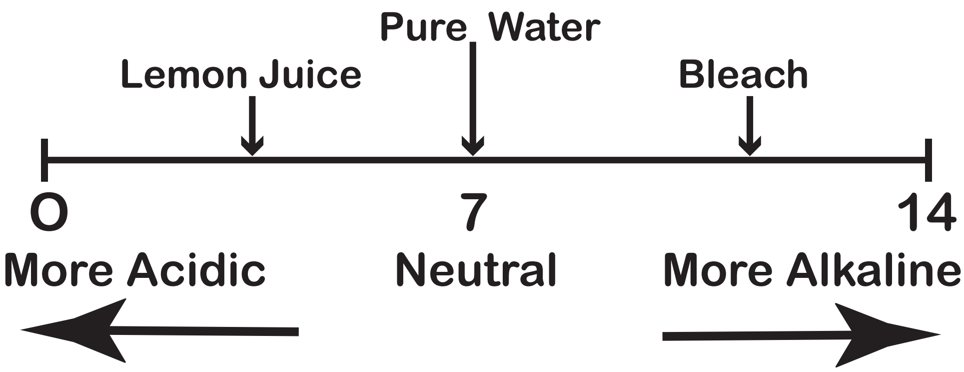
Acidity of the Waterways

The measurement of acidity (pH), is another indicator of the relative health of a waterway,[375] as the acidity of a waterway influences the type and variety of organisms able to inhabit that region.[376] The pH scale ranges from 0 to 14. Substances with pH of less than 7 are acidic;

---

370 Biology Online, http://www.biology-online.org/dictionary/Salinity (Nov. 15, 2016); Boyd, *Water Quality*, 8, 71. Abtew, *Land & Water*, 124–125.
371 Boyd, *Water Quality*, 9–12, 106, table 6.1.
372 Boyd, *Water Quality*, 99–100.
373 Narmada et al., *Groundwater Quality Assessment*, 571–572.
374 Zahran & Willis, *Vegetation of Egypt*, 300–301.
375 Schindler, *Acid Rain & Freshwater*, 149–157; Boyd, *Water Quality*, 175–176.
376 Boyd, *Water Quality*, 177–178, table 8.4.

with values ranging from mild (~6.0) to very strong (~1.0). Substances with pH greater than 7 are alkaline; with values ranging from mild (~8.0) to very strong (~13.0).[377] Pure water displays neither acidic nor particularly alkaline properties; it is termed 'neutral', with an ideal pH value of 7.0–7.4.[378] A pH scale with representative examples is shown in the following figure.[379]



The pH of a waterway is influenced by many factors, including changes in nutrient level and salinity,[380] as well as the amount of carbon dioxide absorbed into the water,[381] and the amount of dead and decaying material within the waterway.[382]

Oxygen Availability

Dissolved oxygen is the most important water quality variable in aquatic ecosystems[383] as all aerobic organisms must have an adequate supply of it.[384] Oxygen levels impact upon the type of life that can exist within that area.[385] Oxygen solubility is related to water temperature, and other chemical and biological factors.[386] The slower a waterway is moving, the lesser the absorbance of oxygen from the atmosphere into the water.[387]

---

377 Ramkumar et al., *Land Use Dynamics,* 4; Boyd et al., *Interpretation of pH*, 403–408.
378 Kemling, *Acid Rain*, 1–2; Boyd, *Water Quality*, 157; Ramachandra et al., *Ecohydrology*, 633.
379 Summarised from 'pH – Water Properties', United States Geological Survey, http://water.usgs.gov/edu/ph.html (Apr. 19, 2017).
380 El-Sheekh, *Nile River Ecosystems*, 4–5.
381 Boyd, *Water Quality*, 133–136, 157–160.
382 Boyd, *Water Quality*, 198–199; El-Sheekh, *Nile River Ecosystems*, 15–17.
383 Balagurunathan & Shanmugasundaram, *Microbial Biodiversity*, 587–588; Rudolf et al., *Dissolved Oxygen Content*, 89–91.
384 Venkatachalapathy & Karthikeyan, *Water Quality Index*, 723; Boyd, *Water Quality*, 133–136, table 6.5.
385 Saarinen et al., *River Water Acidity*, 360; Mohammed et al., *Crayfish Development*, 281–282; El-Sheekh, *Nile River Ecosystems*, 4, 8, 14.
386 Boyd, *Water Quality*, 123–126.
387 Ramachandra et al., *Ecohydrology*, 635.

Higher temperatures mean less oxygen can be dissolved within the water.[388] The concentration of other substances, such as salt, can also interfere with the processes of normal gas exchange.[389] The utilisation of oxygen in the decomposition of nutrients also lowers the oxygen content within the water[390] (see the discussion of 'eutrophication', below).

Similarly, the ability of water to dissolve carbon dioxide is affected by changes to temperature.[391] This is one factor that helps determine the acidity of the waterway.[392] Warmer water absorbs less carbon dioxide, which means that less acid can form. This leads to the waterway departing from its natural level of acidity, one that may have developed over many years of adaptation.

---

388 El-Sheekh, *Nile River Ecosystems*, 6.
389 Boyd, *Water Quality*, 116–118, fig. 6.1.
390 Boyd, *Water Quality*, 133, 189, 204–205; James et al., *Environmental Integrity*, 518.
391 Boyd, *Water Quality*, 168–169, fig. 8.1; Bukaveckas, *Rivers*, 727.
392 Boyd, *Water Quality*, 201, fig. 10.0.

3.4 – Biological Factors in Riverine Ecosystems

Historically, inundations delivered vast amounts of silt to the riverbanks alongside the flooding waterway. The number and variety of nutrients carried by a river influence the variety and abundance of food webs that can develop within it.[393]

Nutrient Availability and Changing Habitats

The simplest and fastest-moving organisms take advantage of nutrient delivery most effectively.[394] Photosynthesising algae cover the first few centimetres of the water's surface, competing for light. The nutrients within a river are also utilised by plants as a part of their growth cycle.[395] The chemical by-products of the photosynthetic process make the water more alkaline. Generally, if plant growth burgeons, fragile organisms that cannot survive under these increasingly alkaline conditions will die, while hardier animals that feed on algae will experience population growth.[396]

As time passes, the inorganic nutrients upon which the algae rely become depleted, causing the algae to die. These drop to the bottom of the river. Bacteria, which help decompose this dead algal matter, leach oxygen from the water, increasing the acidity of the riverbed, tipping the river pH balance to becoming slightly more acidic.[397] Bottom-feeding animals that cannot handle the low oxygen content and greater acidity die off, potentially decreasing the biodiversity of the environment. This process of decomposition occurs as a natural part of any ecosystem. However, circumstances arise where it unfolds at a pace more rapid than the local habitat can deal with. If a rapid increase in nutrient quantity occurs, for example, then the usual cycles can be interrupted.[398] It is usually a consequence of an over-supply of nutrients leading to a decrease in the amount of oxygen available for normal metabolic processes that causes an imbalance to develop in the local ecosystem.

---

393 El-Sheekh, *Nile River Ecosystems*, 3; Boyd, *Water Quality*, 204–207.

394 Quintana et al., *Predation, Competition & Size*, 52–55; Våge, et al, *Competition & Resource Availability*, 1442–1444.

395 Stevenson, *Algae of Rivers*, 114–122.

396 Sterner, *Role of Zooplankton*, 678–688.

397 Zahran & Willis, *Vegetation of Egypt*, 257; El-Sheekh, *Nile River Ecosystems*, 14; Boyd, *Water Quality*, 125–128.

398 Khan & Ansari, *Eutrophication*, 450–452.

Food Web Considerations

All food chains rely on the sun as the ultimate source of energy because each chain begins with a plant that utilises the process of photosynthesis to convert sunlight into energy. Plants are eaten by herbivores and they, in their turn, are eaten by carnivores and so on up the food chain. A habitat's food web is built up by combining all the individual food chains together; and this is affected by the availability of nutrients.[399] The usual consequence of an overabundance of nutrients is excess algal growth which can then interfere with the normal biological function of a waterway.[400]

Aquatic plants need two essential minerals to grow: nitrogen and phosphorus. Nutrient build-up, with its commensurate increase in biological pollution, encourages the development of anaerobic conditions within the waterway, so micro-organisms such as blue-green algae begin to thrive.[401] A surfeit of nutrients stimulates the rapid growth of plants and algae, clogging the waterways. Some areas within the waterway can become oxygen-depleted: this process is known as 'eutrophication'.[402]. Eutrophication commonly develops because of an imbalance within the food web.[403] As the balance of nutrients changes, some life cycles become more difficult and others easier. The number of scavenger and decomposer organisms would increase due to the increased mortality rates among oxygen breathers. In these instances, when the nutrients remain in the river, the organic base should develop more rapidly. An increased nutrient load or significant shift in the food balance may encourage certain plant species to weaken, and others to thrive.[404] In circumstances of environmental change, as the nutrient balance shifts, the proportion of species that made up the initial food web would alter.[405] Consequently, when a waterway becomes nutrient-rich, the ecology of the system changes, with this new situation encouraging overall plant growth,[406] a phenomenon that has also been recorded in the modern river Nile.[407]

---

399 Bukaveckas, *Rivers*, 730–731; Fisher & Sponseller, *Rivers as Ecosystems*, 496–497.
400 Art, *Dictionary of Ecology*, 196; de Jonge & Elliott, *Eutrophication*, 306.
401 Rzóska, *Nile Biology*, 209; Khan & Ansari, *Eutrophication*, 473.
402 Abtew, *Land & Water*, 126; Boyd, *Water Quality*, 259–261; de Jonge & Elliott, *Eutrophication*, 310, fig. 4.
403 Khan & Ansari, *Eutrophication*, 450–452.
404 Khan & Ansari, *Eutrophication*, 461–462.
405 Thompson, *Swamp Development*, 188–190; Bernhardt et al., *Rapid Pollen Responses*, 736.
406 Mitsch & Gosselink, *Wetlands*, 150; Tiner, *Wetland Indicators*, 297.
407 Rzóska, *Upper Nile Swamps*, 5; Sallam & El-Barbary, *Secondary Channels*, 494–498.

3.5 – Rivers and Drought

In natural ecosystems, the interactions described above are usually balanced, with the system cycling through regular patterns. In times of disturbance, such as irregular or unnatural water flow, this system is knocked out of equilibrium.[408] The following section will attempt to identify some potential changes that may occur to an ecosystem that is experiencing changes to its normal situation. Since some parts of most rivers are naturally deeper than others,[409] there already exists areas displaying different environmental characteristics within the habitat.[410] As the flow rates diminish or change, these differences become more pronounced, and the subsequent effects become more exaggerated.[411]

Flow Rates Determine Habitat and Biodiversity

Bunn and Arthington have elucidated the basic ecological principles underpinning the consequences of a minimal flow:[412]

1. *Flow is a major determinant of physical habitat in streams, which in turn is a major determinant of biotic composition. This physical habitat in turn influences the distribution and abundance of aquatic organisms.*
2. *Aquatic species have evolved life history strategies primarily in direct response to the natural flow regimes. Alteration to the natural flow regimes can lead to a loss of biodiversity of native species.*
3. *Maintenance of natural patterns of connectivity is essential to the viability of populations of many riverine species. Species survival diminishes when these populations become isolated.*
4. *The invasion and success of exotic and introduced species in rivers is facilitated by the alterations to the normal flow regimes.*

In presenting a hypothetical response to a restricted flow regime in the Nile River, these principles will be used as the basis for projections.

---

408 Steward et al., *River Runs Dry*, 207–208, citing Australia evidence of environmental change.
409 Bravard & Petit, *Geomorphology*, 388–389.
410 Boyd, *Water Quality*, 17, fig. 1.12.; Fisher & Sponseller, *Rivers as Ecosystems*, 494–496, figs 2, 3.
411 Bukaveckas, *Rivers*, 728; Fisher & Sponseller, *Rivers as Ecosystems*, 497.
412 Bunn & Arthington, *Altered Flow Regimes*, 492–493.

Sediment Transport and Nutrient Supply

The power of a river determines how much sediment it can carry, how far the sediments can be carried and how large the particles of sediment can be.[413] Therefore, as the river weakens, the distribution of particles to the surrounding environment is also affected. As a river begins to progressively slow, the largest sediment particles settle out first, and the lightest particles remain suspended for the longest time.[414] If a river breaks its banks, the alluvial soil deposited is composed of these finer particles. With a weaker flow, heavy particles which could be transported by more energetic water, are not carried as far, so they settle out much more rapidly than normal. Smaller particles, normally suspended in the river, would not remain suspended for as long, and therefore do not travel as far as usual. A river experiencing lower flow or volume than normal, exhibits a different pattern in the distribution of its sediments.[415]

If an ecosystem that is consistently flooded experiences drought, then the overall productivity of the primary producers, the plants, would be lower than normal due to a smaller-than-average water and nutrient supply.[416] Less material could be transported along the river's length and more of it would settle within the environs of the river, closer to its source. Therefore, a series of long-term, non-flood events would impact upon those organisms that have adapted to a more drenched situation. Since less nutrients leave the river, the quality of nutrient supply to the floodplain would deteriorate, explaining why a low flood would result in a downturn in agricultural productivity.[417]

With a weaker flow, the 'cleansing' activity of the river would be lessened; a river that does not 'flush' itself as well as a stronger one experiences organic remains lingering in the waterway for a longer time.[418] A weaker river, therefore, retains the detritus that had accumulated within it, leading to a rapid increase in biological material[419] with the

---

413 Bukaveckas, *Rivers*, 726; Giller & Malmqvist, *Streams & Rivers*, 56–58, fig. 3.7.
414 Bravard & Petit, *Geomorphology*, 387.
415 Revel et al., *Nile River Dynamics*, 200–221.
416 Rzóska, *Upper Nile Swamps*, 5.
417 For modern parallels, see Yitayew & Melesse, *Water Resources Issues*, 406–407; Maybeck, *African Waterways*, 303.
418 de Jonge & Elliott, *Eutrophication*, 310–311; Rzóska, *Joint Nile*, 269.
419 Giller & Malmqvist, *Streams & Rivers*, 49–51; Sallam & El-Barbary, *Secondary Channels*, 493–496; de Jonge & Elliott, *Eutrophication*, 306, 310–311.

commensurate loss of oxygen and change in acidity levels.[420] The reported sediment decreases, and subsequent fertility decline in northern Egypt since the construction of the Aswan dam are a modern example of this phenomenon.[421]

Temperature changes and evaporations rates in weaker rivers

As a river becomes slower and shallower, its capacity to absorb solar radiation increases,[422] with the top layer heating more readily.[423] Since a weaker river would result in less mixing of water, the waterway would display larger temperature gradients between the surface and depths than would be typical.[424] Slower rivers become warmer rivers because they dissipate less energy in their motion. Warmer rivers experience greater rates of evaporation, which leads to an increase in the salinity level.[425] The shallower areas become warmer than deeper areas, and with more secondary channels developing, the differences in salinity levels between different parts of the river becomes amplified and the consequences more significant.[426] These factors affect the acidity level, altering 'normal' or 'natural' water quality levels.[427] As many species require specific temperature ranges for their metabolic functions,[428] this would lead to variances in local populations.[429] Many riverine organisms respond poorly to increases in the salinity level, especially if the changes are relatively rapid.[430]

Within the secondary channels, the water flow would be slower than that experienced by the rest of the river.[431] Secondary channels would experience the same lowering turbidity and higher algal growth as described previously, only at a faster scale.[432] Warm water has a lower dissolved oxygen content than does cold, so as a river warms the amount of oxygen available

420 Bukaveckas, *Rivers*, 727; de Jonge & Elliott, *Eutrophication*, 312.
421 Zahran & Willis, *Vegetation of Egypt*, 255; Bard, *Archaeology of Ancient Egypt*, 56.
422 Boyd, *Water Quality*, 16.
423 Boyd, *Water Quality*, 215.
424 Entz, *Lakes Nasser & Nubia*, 282; Boyd, *Water Quality*, 17–18, fig. 1.12.
425 Boyd, *Water Quality*, 24–25.
426 Abdo, *Water Quality*, 486–487.
427 Rzóska, *Descent*, 211.
428 Boyd, *Water Quality*, 198–199, fig 10.2.
429 See, for example, Suberkropp, *Temperature & Seasonal Occurrence*, 53–62; Lytle & Poff, *Natural Flow Regimes*, 95–97.
430 Poff & Zimmerman, *Altered Flow Regimes*, 195–198, 201, figs 2, 3, 4; Fisher & Sponseller, *Rivers as Ecosystems*, 497.
431 Boyd, *Water Quality*, 18.
432 Boyd, *Water Quality*, 315; Khan & Ansari, *Eutrophication*, 474.

for its inhabitants decreases,[433] further exacerbating the differences between secondary channels and the major branches.[434] As the amount of dissolved oxygen drops below normal levels, it impacts upon the normal functioning of the micro-organisms present, altering the food cycles and changing the population dynamics.[435]

Characteristics of Weakened Rivers

When the volume of water becomes too low to initiate an inundation, then the potential for the water to change the landscape is weakened. These physical impacts alter the expression of the chemical and biological characteristics of the ecosystem.[436] In the modern condition, the alteration of flow regimes is often claimed to be the most serious and continuing threat to the ecological sustainability of many rivers and their associated floodplains and wetlands.[437] Most modern-day reductions in river flow are a result of human interaction, such as excessive irrigation or the construction of dams. In riverine terms, if no flooding occurs, then the nutrients that are normally lost during an inundation remain in the river,[438] which results in changes to the biological and chemical nature of the river.[439]

---

433 Thompson, *Swamp Development,* 187; Boyd, *Water Quality*, 48, 131.
434 Boyd, *Water Quality*, 121, 211, fig. 10.9.
435 Entz, *Lakes Nasser & Nubia*, 293; Lytle & Poff, *Natural Flow Regimes*, 98–99; Boyd, *Water Quality*, 55–56, fig. 3.4, 201.
436 Poff & Zimmerman, *Ecological Responses*, 201–204.
437 Ward et al., *Floodplain Biodiversity*, 125–139; Lundqvist, *Avert Hydrocide*, 428–430; Bravard & Petit, *Geomorphology*, 387; Bukaveckas, *Rivers*, 723.
438 Rzóska, *Joint Nile*, 269.
439 Steward et al., *River Runs Dry,* 207–208.

SUMMATION: CHAPTER THREE

Can a River Experience Drought?

The basics points discussed in the chapter include the following:

- ⇒ A weakening river is a less forceful river and diminishes the potential for the water to change the landscape.
- ⇒ A weaker river develops more secondary channels
- ⇒ A weaker river does not cleanse the river as normal as it cannot carry as many sediments as a stronger one, so the deposition of nutrients occurs over a different pattern of sites.
- ⇒ A weaker river mixes its layers less, leading to more exaggerated differences in the layers' properties and develops wider water temperature and oxygen level variances
- ⇒ A weaker river warms the surface layers up more readily, increasing surface evaporation. Increased evaporation changes the chemical composition of the waterway and develops greater salinity and acidity ranges.
- ⇒ A warmer river stores less oxygen than normal, exacerbating the process of eutrophication.
- ⇒ A weaker river allows light to penetrate more deeply, increasing the photosynthetic zone.
- ⇒ A weaker river does not flood as fully so retains more nutrients, changing its biology.

These factors interact with one another and impact upon the lifecycles naturally present. Due to an increased nutrient load, and changing physical and chemical factors, the ecological properties of the river and its surroundings change. Changing ecological circumstances affect plant growth and the subsequent food chains that rely on them. As a result, the food webs that exist in 'normal' situation are altered. Is it possible to apply these considerations to a specific river – the Nile itself – in times of 'drought'?

Chapter Four

The A.R.I.D. Hypothesis

A River In Drought

Note: An abridged version of this chapter has been published:
Burn, J. W. 2018. 'A River in Drought: Consequences of a Low Nile at the End of the Old Kingdom.' In Environment and Ecology Research, 2018, 6 (5), 446–460, doi: 10.13189/eer.2018.060505

4.0 – Introduction

PLEASE NOTE. Because of the importance of ensuring that the methodology used in evaluating potential environmental changes was scientifically valid, sections of this work have been sent for peer-review and subsequent publication in a journal specialising in ecological analyses of environments (see above).

The ancient Egyptians relied on the inundation to invigorate the soil and provide impetus for a new growing season. In a 'regular' flood, the Nile spilled nutrients onto the nearby land. In riverine terms, nutrients are lost during an inundation; if an inundation did not occur, then those nutrients that were carried in the river remained in the river.[440] As outlined earlier, this investigation is focussing upon the river in times of drought – that is, when the river is *not* flooding. What could happen if the Nile River ecosystem was disrupted for longer, more rapidly or more significantly than normal? Rapid environmental change, particularly change that is unusually long in duration or exceptionally severe, would have resulted in uncharacteristically swift environmental responses.[441]

---

440 Rzóska, *Joint Nile*, 269.
441 For example, see Kushlan, *Environmental Stability*, 821–825; Gorman & Karr, *Habitat Structure*, 570–515; Arthington et al., *Habitat Disturbance*, 61–66.

In the terms of this examination, therefore, the context needs to be turned about (inwards?) towards how a situation of lower-than-normal water levels would impact upon the river. If the nutrients were not released by a flood, then their retention in the river would have resulted in changes to the ecology of the river, changing the environmental characteristics of the river itself.[442] Most likely, this would have changed the characteristics of the river and impacted upon the flora and fauna existing within and alongside the waterway.[443]

In the previous section, changes to the normal riverine situation resulting from a significant decline in flow have been presented. From current investigations and archaeological evidence, we should be able to propose some modifications to the Nile ecosystem caused by an 'unnatural' or irregular flow.

In this chapter, the proposed ecological changes to riverine systems in drought identified previously will be applied to the River Nile itself. Modern ecological research into plant species that historically existed in ancient Egypt will provide evidence that we can seek to apply to the situation that may have arisen at the end of the Old Kingdom. Proposed subsequent impacts of changes in the ecology of the Nile upon the society and culture of the Old Kingdom will then be presented.

---

442 Poff & Zimmerman, *Ecological Responses*, 201–204.
443 Arthington et al., *River Ecosystems*, 492; Balagurunathan & Shanmugasundaram, *Microbial Biodiversity*, 576.

4.1 – Nilotic Ecosystem Response to 'Drought'

The annual flood normally experienced by the Nile maintained a regular cycle to which the living things within the ecosystem had adapted.[444] Riverine species that had evolved to natural seasonal flow would have reacted differently if these patterns became irregular or unreliable. Despite evidence suggesting an increasingly arid countryside from the Predynastic era onwards,[445] the series of consecutive or strong drought effects at the end of the Old kingdom appeared to have impacted the society in a more significant manner.

The Nile Wetland Classification

According to the Ramsar Classification System for Inland Wetland Type,[446] it seems best to categorise the River Nile as an M–Class Inland Wetland (see Table 1: Ramsar Classification categories). These are inland wetlands characterised by permanent plants on the edge of a permanent flowing waterway. While some regions within the river, such as in the delta, or along some of the sluggish secondary channels, may display slightly different characteristics,[447] this classification holds generally true for the major segment of the river. Obviously, this characterisation may be affected by the water use practices of modern Egypt. For this investigation, it seems reasonable to apply the modern Ramsar classification to that situation existing before the construction of the Aswan Dam as the basis for an analysis of the potential late Old Kingdom changes that have been hypothesised.[448] As the amount of water flowing through the river system declined, then it is arguable that changes would develop between different sections of the river and these changes could become more pronounced or exaggerated if the conditions persisted.[449]

---

[444] Sallam & El-Barbary, *Secondary Channels,* 494–498.

[445] Bell, *Oldest Nile Floods,* 569–573, suggesting a decline in average flood level and resource availability from as early as the 1st Dynasty.

[446] The Convention on Wetlands, called the Ramsar Convention, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources, see https://www.ramsar.org/ (March 13, 2017)

[447] Thompson, *Swamp Development*, 177.

[448] Stanton, *White Nile Marshes*, 375–379, for example, allows for some inferences to be made.

[449] Wilkinson & Stevens, *Environmental Archaeology*, 68.

Table 1: Ramsar classification categories

INLAND WETLANDS				
Fresh water	Flowing water	Permanent	Rivers, streams, creeks	M
			Deltas	L
			Springs, oases	Y
		Seasonal/Intermittent	Rivers, streams, creeks	N
	Lakes and pools	Permanent	Size > 8 ha	O
			Size < 8 ha	Tp
		Seasonal/Intermittent	Size > 8 ha	P
			Size < 8 ha	Ts
	Marshes on inorganic soils	Permanent	Herb-dominated	Tp
		Permanent/Seasonal/Intermittent	Shrub-dominated	W
			Tree-dominated	Xf
		Seasonal/Intermittent	Herb-dominated	Ts
	Marshes on peat soils	Permanent	Non-forested	U
			Forested	Xp
	Marshes on inorganic/peat soils	High Altitude (alpine)		Va
		Tundra		Vt
Saline, brackish or alkaline water	Lakes	Permanent		Q
		Seasonal/Intermittent		R
	Marshes & pools	Permanent		Sp
		Seasonal/Intermittent		Ss
Fresh, saline, brackish or alkaline water	Geothermal			Zg
	Subterranean			Zk(b)

Modified from 'Information Sheet Ramsar Wetlands', http://archive.ramsar.org/cda/en/ramsar-documents-guidelines-strategic-framework-and/main/ramsar/1-31-105%5E20823_4000_0__#B Annex 1.

Fortunately for our investigation, data was collected from the last 'natural' flood before the closing of the Aswan Dam.[450] We can develop some assumptions based on some of the data that was collected at the time and updated as recently as 2015.[451]

---

450 Halim et al., *The Last Normal Nile Flood*, 401–425; see also El-Maghraby et al., *Zooplankton Community*, 527–530.

451 See Abd-El Monsef et al., *Aswan Impact*.

Ecological Impacts of a Low River

The amount of rainfall and glacial melt occurring in central Africa determined the volume of water that flowed along its length. The river carried water all the way from the Ethiopian Highlands and the Lakes of Central Africa,[452] with the maximum altitude for one of the sources of the Nile approximately 2,700 metres above sea level.[453] A riverine drought was occasioned by either declining rainfall or a lack of snow melt.

The basic ecological principles associated with the consequences of a minimal flow, as identified previously,[454] can be used to make inferences about the possible consequences to the ecosystem of the Nile. In the modern condition, the reduction of flow regimes is the most significant ongoing threat to rivers and their associated floodplain wetlands;[455] with most causes of reduced flows in modern-day rivers explained as a direct consequence of human intervention – for example, the rapid removal of water from waterways for industry or agriculture.[456] The consequences downstream should allow us to simulate what could have happened to the Nile when it experienced a significant change in its regular flow regime in the Old Kingdom. The idea that a river may benefit if an inundation does not occur or that the flow is less than normal will be discussed in more detail in this chapter.

The consequences to the chemical properties that would have developed have been described in Chapter Three, with increases in salinity in some areas anticipated due to a weaker river developing slightly warmer water leading to increased evaporation. Greater temperature variances would be expected and, as a consequence oxygen solubility would decrease overall, leading to the development of increasingly anaerobic conditions in secondary channels areas. Decreasing aerobic conditions would change the microbial food webs that existed, and this would have increased the probability of significant changes to the biological properties of the organisms existing in these areas.

---

452 Abtew & Melesse, *Nile River Basin*, 14–15.
453 Woodward et al., *Nile Evolution*, 261; Wilkinson & Stevens, *Environmental Archaeology,* 66–67; Abtew & Melesse, *Nile River Basin*, 10.
454 Bunn & Arthington, *Altered Flow Regimes*, 492–493, fig. 1.
455 Ward et al., *Floodplain Biodiversity*, 125–139; Lundqvist, *Avert Hydrocide*, 428–430.
456 See, for example, Ramdani et al., *Environmental Influences*, 114–115.

4.2 – Aquatic Plants' Response to Drought

While the historical evidence suggests that the significant Nile River plankton communities have not changed considerably over the past three thousand years,[457] human activity has had a much more considerable impact upon the macroscopic (large enough to see) plants that were important to the ancient Egyptian.[458] From very early on in Egyptology, researchers have been using microscopes to analyse fossil plant remains to reconstruct the history of vegetation in Egypt from geological deposits and archaeological finds.[459] These sediments contain seeds, spores and/or pollen grains deposited in them over historical time. To better understand the biodiversity of plant species present during Dynastic times, sedimentary analyses has allowed for the basic plants to have been identified.[460] It is important to realise that the final resting place of the seeds, spores or grains may not be an indication of their origin.[461] The dispersal properties of pollen, spores and seeds influence the final resting place of these materials. The size, shape, buoyancy, aerodynamics and density of individual spores, pollen grains or seeds, for example, all impact their dispersal.[462]

According to the theory of *'superposition'*, the deeper the sample, the more ancient the time of deposition.[463] Using the same concept as applied to archaeological excavations, this allows for an estimation of age of the plant deposits. The variations in abundance in each layer allow us to infer the distribution of the assorted plant types over time. Measuring these distributions to the top layer enables comparison with to the modern-day situation and allows for a succession sequence over time to be developed.[464]

---

457 Hamdan et al, *Climate &Collapse,* 44–45, identify that water levels changed as did the amount of sedimentation. Avnaim-Katav, et al., *Shallow Marine Record*, 144–145, show variances the proportions of planktonic fossils, but does not seem to indicate changes in the types present.

458 Taher & Abdel-Motelib, *Microbial Sedimentary Structures*, 341–353, for example, shows very little changes in the overall sedimentary geology of structure until the impact of the modern human.

459 Wilkinson & Stevens, *Environmental Archaeology*, 23–25, 62–63; Butzer, *Environment & Human Ecology*, 53–78.

460 Frils et al., *Fossil Water Lilies*, 357.

461 Moore, *Pollen Travel*, 388–389; Caracuta et al., *Amheida Archaeobotanical Analysis,* 45–48.

462 Wilkinson & Stevens, *Environmental Archaeology*, 96, fig. 39.

463 As sedimentary layers are deposited atop of one another, the youngest is the top-most layer. Reference.com, https://www.reference.com/science/geology-principle-superposition (Nov. 23, 2016).

464 Bernhardt, *Wetland Responses*, 126–129; Zahran & Willis, *Vegetation of Egypt*, 306, fig. 7.1.

As well as sedimentary analyses, mudbrick analysis enables the determination of the mud contents.[465] Studies of mudbrick samples have yielded well-preserved seeds, spores and pollen grains; all of which combine to serve as an indicator of which cereal type was being harvested at the time, with the rest of the pollen assembly being indicators of the common weeds that were growing within or near the crop.[466] Since the bricks were made on demand,[467] they yield a relatively accurate time frame, serving as "*cultural time-capsules*"[468] preserving a picture of the local environment at that time.[469] For example, the varying abundance and diversity of pollen types found in the composition of mudbricks around the Dakhlah Oasis has enabled the floral evolution of that region to be assessed.[470]

Other artefacts also provide information about the plant life present at a particular location, such as wood remains in fires or fossilised insects whose dietary requirements are particularly specific.[471] The combination of this data allows for the reconstruction of past vegetation,[472] and identifies the succession or changes in the biodiversity,[473] as well as identifying and tracing human interaction.[474] Improved technological abilities, such as the scanning electron microscope, have made identification much more reliable.[475]

Fundamental Vegetation Types

Zahran and Willis have presented a classification system categorising the ancient botanical landforms into seven fundamental 'vegetation groups':[476] 1 - Desert; 2 - Salt marsh, 3 – Mountain, 4 - Sand dune, 5 - Reed swamp, 6 - Freshwater and 7 - Saline water vegetation types.

---

465 Ayyad et al., *Mudbrick Pollen Information*, 77–96.
466 Zahran & Willis, *Vegetation of Egypt*, 309–310, fig. 7.4.
467 Ayyad et al., *Mudbrick Pollen Information*, 79–80.
468 Zahran & Willis, *Vegetation of Egypt*, 311.
469 Ayyad et al., *Mudbrick Pollen Information*, 77–96.
470 To see contemporary pollen diversity, see Ritchie, *Modern Pollen Spectra*, 1–6; and to see that of the archaeological past, see Ritchie*, Dakhleh Oasis Palaeobotany*, 74–80. Schrank & Mahmoud, *Dakhla Oasis Cretaceous Palynology*, 188–189, provides another historical overview.;.
471 Wilkinson & Stevens, *Environmental Archaeology*, 100–103.
472 Wilkinson & Stevens, *Environmental Archaeology*, 89–95, figs 37, 38; Hamden et al., *Faiyum Sedimentary Record*, 1–3. For an extensive analysis of pollen grain deposition along the Mediterranean coast of Egypt, see Ayyad, *Pollen Grain Ecology* (PhD thesis).
473 Saad & Sami, *Nile Delta Deposits*, 467–503; Zahran & Willis, *Vegetation of Egypt*, 305.
474 Kamal et al., *Hydrophyte Nutrient Status*, 1–2.
475 Zahran & Willis, *Vegetation of Egypt*, 308, note the precision of the detail obvious in the examples in their fig. 7.3.
476 Zahran & Willis, *Vegetation of Egypt*, 317.

For this investigation, the vegetation groups of relevance are those whose profiles relate to the Reed swamp and Freshwater habitats. Plants identified as historically significant in freshwater and reed swamp habitats include *Phragmites australis* and *Typha domingensis* (cattails/bulrushes) as the most common 'reeds'; and *Cyperus papyrus* and the two lotuses,[477] the White (*Nymphaea lotus*) and the Blue (*Nymphaea caerulea*), as the most important waterway plants.[478] More areas along the river, especially in the slower and weaker secondary channels, would have developed properties displaying increasingly similar characteristics to those of mildly saline habitats as the Nile flood levels declined.

---

477 Though, more properly, waterlilies – see Conard, *Waterlilies*, 194 and Les et al., *Classification of Water Lilies*, 41–44.

478 Zahran & Willis, *Vegetation of Egypt*, 312, 318.

4.3 – Papyrus and A River In Drought

The simple papyrus plant, *Cyperus papyrus*, is a large, emergent, aquatic perennial, with erect culms that can grow up to five metres tall.[479] Today, it is almost unknown in the modern vegetative profile of Egypt.[480] The remains of papyrus is found commonly in the archaeological record, especially in the marshland regions,[481] and, without bio-archaeological corroboration,[482] the only evidence for its existence at the time frame under investigation would be cultural.[483]

The *Cyperus* genus produces large numbers of seeds and, in 'normal' flood levels, most are lost: they are washed away downstream, too waterlogged to germinate. Some settle too deeply into the mud and cannot germinate due to lack of oxygen; and some sink too deeply into the water so they do not receive the necessary amount of sunlight required to stimulate germination.[484] Their tough roots can extend one metre or more into the soil, and they can also spread through the use of rhizomes. Rhizomes are a type of plant stem situated either at the soil surface or underground that contains nodes from which roots and shoots originate; they are unique in that they grow perpendicular, permitting new shoots to grow up out of the ground, and, when separated, each piece of a rhizome is capable of producing a new plant.[485] Papyrus displays the capacity to exploit two distinct habitat types: shallow water and the edges where the river meets the land, the land beside the water.[486] This enhanced facility of papyrus to rapidly grow in two different habitats allows it to respond more readily to changes in water level compared to similar plants,[487] and, as such, it can rapidly increase its own biomass and density.[488]

---

479 CABI Invasive Species Compendium, '*Cyperus papyrus*', https://www.cabi.org/ISC/datasheet/17503, (Dec. 3, 2017).

480 Kew Information Database, '*Cyperus papyrus',* http://data.kew.org/sid/SidServlet?ID=7263&Num=gcm#Salt (Nov. 23, 2016).

481 Bernhardt et al., *Wetland Responses*, 137–138; Butzer, *Environment & Human Ecology*, 53–56.

482 Butzer, *Environment & Human Ecology*, 53–56; Zahran & Willis, *Vegetation of Egypt*, 311.

483 Kamrin, 'Papyrus in Ancient Egypt', http://www.metmuseum.org/toah/hd/papy/hd_papy.htm(Nov. 21, 2016); Plantz Africa, '*Cyperus papyrus*', http://www.plantzafrica.com/plantcd/cyperuspap.htm (Nov. 21, 2016).

484 Hammer, *Freshwater Wetlands*, 263–264; Boar, *Papyrus Water Level Response*, 88–90.

485 https://biologydictionary.net/rhizome/ (Nov. 13, 2017)

486 Mitsch & Gosselink, *Wetlands*, 390, fig. 12.4.

487 Jones & Muthuri, *Biomass in Papyrus*, 347.

488 Lind, *Ugandan Swamps*, 169.

Response to Changing Physical Factors

As noted earlier, the power of the water affects the rate of erosion, thus impacting upon the width of the marshes.[489] A weaker-than-usual river would result in a smaller volume of flowing water, suggesting that a commensurate decrease in the rate of erosion should occur. Lind, in identifying the ability of papyrus to grow on the edge of a riverbank, also notes its capability to 'clump' upon itself, forming islands,[490] and reports that these clumps can also influence the rate of flow of the river. As a consequence of a weaker river, the forces hindering the ability of papyrus to clump would diminish, and so the size of papyrus clumps would be expected to increase.[491] In Egypt, this increased distribution of papyrus plants would effectively produce an obstacle; in Arabic, the term *sudd* relates to such an obstacle or blockage within the river.[492] Over time, these islands further increase in volume as they collect detritus.[493]

Once established, sedge-type plants, such as the papyrus, send out rhizomes to spread along the nearby soil strata,[494] but the spread of these rhizomes is usually limited by the power of the water.[495] The stability of the stratum in which the papyrus is growing is affected by the energy of the water that is flowing across it.[496] Since a weaker river has less energy to carve out new channels, this increases the number of secondary channels as water flows around obstacles not through them. Both a weaker river and a greater supply of habitats delivered by an expanded number of secondary channels should encourage rhizomes to spread more readily. Rhizomes spread better when water availability is lower than the conditions needed for successful seed germination to take place.[497]

In a low flood, erosive conditions become less severe as the momentum of the water reduces – the flow less powerful and the mud becomes less fluid. Additionally, the water is not as deep. In those circumstances, more seeds would have an increased chance of surviving to

---

489 Allen & Pye, *Saltmarsh Morphodynamics*, 11–12.
490 Lind, *Ugandan Swamps*, 167.
491 Ellery et al., *Channel Blockage*, 29–31; Thompson, *Swamp Development*, 192.
492 Rzóska, *Nile Biology*, 202; Ellery et al., *Channel Blockage*, 29; Mitsch & Gosselink, *Wetlands*, 39; Ellery et al., *Channel Blockage*, 34–35, fig. 5
493 Jones & Muthuri, *Biomass in Papyrus*, 355.
494 Jones & Muthuri, *Biomass in Papyrus*, 354.
495 Rzóska, *Nile Biology*, 205.
496 Pethick, *Saltmarsh Geomorphology*, 43–47; Rzóska, *Descent*, 205.
497 Boar, *Papyrus Water Level Response*, 90.

germination.[498] In times of low water, the incidence of papyrus pollen deposition rates in the Mediterranean decreased,[499] implying that more pollen remained within the river, increasing the potential for germination. A weaker river produces less turbulence; this lowers turbidity and allows light to penetrate deeper into the water, encouraging plant growth.[500]

Response to Changing Chemical Factors

The consistent (though weaker) Nile flow suggests that more marshlands would have developed due to a surplus of nutrients, but we should never perceive the Nile marshlands as motionless 'swamps.'[501] Since water flow in secondary channels is weaker than in the primary channel of the river, and with the water column becoming increasingly shallow,[502] it has been suggested that the secondary channels of a weaker river would have experienced an increasing level of salinity.[503]

Since the development of the Aswan Dam, with the consequent lower flow, agricultural fields in the Nile Valley became saltier and less fertile than earlier records indicated.[504] Due to increased evaporation in shallow water, it is expected that the salinity levels within secondary channels would be greater than those in the main part of the river; however, papyrus has been identified as a plant that appears able to tolerate slight increases in salinity.[505]

In a low flood, those nutrients that were normally 'lost' to the land in a 'natural' flood remain, changing acidity levels from those normally existing.[506] Papyrus display an ability to tolerate a wider range of acidity levels than similar plants,[507] suggesting that it is well-suited to survive the acidity changes that could develop during times of lower-than-usual volume.

---

498 Boar, *Papyrus Water Level Response*, 88–89; Mitsch & Gosselink, *Wetlands*, 392.
499 Bernhardt, *Delta Vegetation*, 616–618.
500 Tiner, *Wetland Indicators*, 18, fig. 2.1.A.
501 Tiner, *Wetland Indicators*, 282.
502 Entz, *Lakes Nasser & Nubia*, 282–285.
503 Thompson, *Swamp Development*, 178.
504 Abd-El Monsef et al., *Aswan Dam Impact,* 1882–1883; Halim et al., *Last Nile Flood*, 401–425.
505 Mashaly & el-Halawany, *Vegetation Analysis*, 1189.
506 Rzóska, *Joint Nile*, 269.
507 Speight & Blackith, *The Animals*, 354.

Response to Changing Biological Factors

The rate of cycling of nutrients within the ecosystem is affected by the amount of water flowing through it,[508] with the loss of nutrients to the land during an inundation normally inhibiting papyrus growth.[509] A lower-than-normal flood, however, would not distribute these nutrients as widely over the surrounding countryside, retaining the nutrients instead within the band of papyrus and other plants bordering the river. Papyrus clumps present considerable absorbing surfaces as they spread out over the water at river and lake edges, and as the floating mats form, large amounts of nutrients would have been trapped within and become incorporated into the plant mass.[510] Combined with the reduction in water current leading to a larger area of sheltered living conditions at the river's edges,[511] the greater nutrient levels delivered by a weaker river, therefore, would have provided the impetus for a bloom of papyrus. A weaker river also seems to allow an increase in the growth rate of those micro-organisms that 'fix' nitrogen, improving the nutrient quality of the host, in this case the papyrus.[512] Since it has been reported that swift water flow within a river results in a more rapid loss of organic material from that system,[513] then it seems logical that the reverse – that a slow river retains organic matter – is true.[514]

Ecological Implications for Papyrus in Drought

While excess flooding and rapid drying events hinder germination,[515] slight changes do not affect the setting of seeds. Salinity does not seem to impact upon the germination and growth of papyrus, nor is papyrus affected by slight increases in temperature. It seems, that in response to a new setting presented by a weaker river flow, one with a greater concentration of nutrients, warmer-than-usual water temperatures, and a slightly more saline environment, papyrus would experience a significant boost to its survival chances.

---

508 Mitsch & Gosselink, *Wetlands*, 147.
509 Jones, *Papyrus Photosynthesis*, 359.
510 Boar, *Papyrus Water Level Response*, 91; Thompson, *Swamp Development*, 182; Gaudet, *Papyrus Nutrients*, 415–416.
511 Rzóska, *Upper Nile Swamps*, 11.
512 Thompson, *Swamp Development*, 188.
513 Mitsch & Gosselink, *Wetlands*, 150.
514 Rzóska, *Joint Nile*, 269–270; Hammer, *Freshwater Wetlands*, 74; Krom et al., *Nile Sediment Fluctuations*, 73; Mitsch & Gosselink, *Wetlands*, 107, 145
515 Boar, *Papyrus Water Level Response*, 90.

4.4 – PHRAGMITES AND A RIVER IN DROUGHT

Phragmites australis is an indigenous species displaying a long historical association with Egypt. Known commonly as 'reeds', *Phragmites* has been found growing in many diverse habitats, including freshwater marshes, oxbow lakes, swales, and backwater areas of rivers and streams, as well as on flat ground.[516] As with papyrus, reeds can reproduce sexually and asexually via rhizomes. The ability of the huge numbers of seeds produced to be dispersed by wind as well as water assures their rapid scattering.[517] The main form of asexual propagation is the rhizome, but roots are also able to develop from fragments of the rhizome that have settled above ground on moist land.[518] Another form of asexual reproduction employed by phragmites is the ability of any part of the stem that touches the ground to develop a root system, this is known as a 'stolon.'[519] The ability to utilise many reproductive methods results in a widespread distribution within the river.

Responses to Changing Physical Factors

Phragmites is termed an 'invasive' plant, since the reed beds grow into the surrounding environment.[520] These plants can spread at a rapid rate, weakening the soil by retaining moisture: the result is what is termed by some a 'losing stream', where the water percolates into the nearby shore as the reeds spread into it, making the waterway more marsh-like.[521] The 'gaining of ground' by these sedge-type plants is a behaviour characteristic of the genus.[522]

Since flooding has been suggested as a control strategy,[523] the inference is that a slower river or a lower water level is conducive to phragmites growth. Experimental ecology trials

---

516 Uchytil, *Phragmites australis*, 1; Zahran & Willis, *Vegetation of Egypt*, 314.

517 Hosier, 'The ecology of an unwelcome exotic, *Phragmites australis*', http://nceppc.weebly.com/uploads/6/8/4/6/6846349/14_hosier_the_ecol_of_phragmites.pdf (Aug. 12, 2015).

518 Huhta, *Common Reed*, 1–3. As opposed to rhizomes which exist under the ground, these rhizome-like structures that exist above ground are termed 'stolons'.

519 Ailstock, *Phragmites Adaptions*, 1–2.

520 Holm et al., *World's Worst Weeds;* Kettenring et al., *Phragmites Invasion*, 1306–1311; Global Invasive Species Database, http://www.iucngisd.org/gisd/speciesname/Phragmites+australis (Aug. 12, 2015).

521 Kettenring et al., *Phragmites Invasion*, 1306–1307.

522 Hammer, *Freshwater Wetlands*, 156–158, fig. 8.2.

523 Hellings & Gallagher, *Flooding on Phragmites*, 41–49; Marks et al., *Phragmites*, 7; Zahran & Willis, *Vegetation of Egypt*, 75–76.

studying growth rates of phragmites in response to long-term low water availability have identified minimal negative growth reaction.[524] Along the Nile, with its many secondary channels, it would be expected, then, that the reed populations would be more common in the slower-flowing water, especially in a season of low inundation. Phragmites' internal structure allows it to resist dehydration, enabling it to survive extensive dry periods.[525]

Responses to Changing Chemical and Biological Factors

The reed seems to grow best in areas with slow water,[526] displaying the ability to tolerate slightly more brackish conditions compared to other riverine plants.[527] In the modern era, *Phragmites australis* growth has been promoted by an increase in soil salinity brought about as a consequence of de-icing roads and pathways, in America, for example; suggesting that it responds more favourably to an increase in salinity than similar plants.[528] Due to this tolerance, some reed swamps that exhibit higher than normal levels of salinity have become almost mono-cultures of phragmites.[529] This suggests that an increase in water salt content due to higher rates of evaporation during times of historically lower-than-normal Nile inundations would have no detrimental effect.[530] On the contrary, an advantageous salt tolerance would have improved phragmites survival.

Reeds appear to respond to an increase in nutrient supply in a manner similar to papyrus,[531] growing best in areas with slow water and silted substrates.[532] Phragmites' growth, like that of papyrus, does not seem to be as impaired as most plants when their habitat becomes oxygen poor.[533]

---

524 Zhao et al., *Nutrient Accumulation*, 19–20, table 1, fig. 2.
525 Rzóska, *Nile Biology*, 205.
526 Köbbing et al., *Reed Utilisation*, 1–2.
527 Chambers et al., *Phragmites Expansion*, 398–406.
528 McNabb & Batterson, *Phragmites Occurrence;* Marks et al., *Phragmites Australis,* 285–294; Marks et al., *Phragmites Stewardship*, 2–4.
529 Zahran & Willis, *Vegetation of Egypt*, 56.
530 Yang et.al, *Phragmites Stress,* 420–426.
531 Haslam, *Reed*, 1–4. See also Kettenring et al., *Phragmites Invasion*, 1306.
532 Zhao et al., *Nutrient Accumulation,* 20–22, table 2; Barkworth et al., *Flora*, 790–799; Meadows & Saltonstall, *Phragmites Distribution*, 99–107; Zahran & Willis, *Vegetation of Egypt*, 66.
533 Zhao et al., *Nutrient Accumulation,* 24. In many parts of the world, *P. australis* is being considered as a plant of remediation for eutrophic wetlands.

Ecological Implications for Phragmites in Drought

Because of the varied reproductive strategies available to phragmites, the reed responds swiftly to habitat disturbance.[534] In the more recent timeframe, various examples of human manipulation, impacts or disturbance to environments appear to promote phragmites growth.[535] These examples allow inferences to be made about how the plant would have responded to historical changes to its environment. For example, restriction of the tidal inundation of a marsh and sedimentation may favour reeds,[536] suggesting that a lower-than-normal flood event would not have had a detrimental effect, but more likely would have encouraged phragmites response.

---

534 Roman et al., *Salt Marsh Vegetation Change*, 141–150; Minchinton & Bertness, *Phragmites Spread*, 1404–1408, tables 1–3.

535 Marks et al., *Phragmites Stewardship,* 1–3; Kettenring et al., *Phragmites Invasion*, 1307; Minchinton & Bertness, *Phragmites Spread*, 1412–1414.

536 Hosier, 'The ecology of an unwelcome exotic, Phragmites australis', http://nceppc.weebly.com/uploads/6/8/4/6/6846349/14_hosier_the_ecol_of__phragmites.pdf (Aug. 12, 2015).

4.5 – Cattails and A River In Drought

The primary cattail species, *Typha domingensis*, commonly called a 'bulrush', is usually found in close proximity to phragmites.[537] It is a tall marsh herb able to achieve heights of 2–2.5 metres.[538] Cattails propagate by seeds, which can be broadcast by wind,[539] as well as by stout creeping rhizomes,[540] but cannot spread beyond shallow water.[541] Typha generally do not occupy as wide a range of riverine habitats as that inhabited by phragmites, both due to their biology and physiology.[542] The immature bulrush is thought to be good cattle food.[543]

Responses to Changing Physical Factors

'Creeping' rhizomes are so called because of the rate of movement. Absence of new water results in a limited growth season.[544] Since erosion has less of an impact in a low river event,[545] plant stability would be increased; however, less powerful water flow results in a weakened ability of the cattail rhizomes to penetrate the subsoil,[546] presumably because the sediment is less disturbed. Experimental investigation of the relationship between water flow and plant growth suggests that low water availability impairs the overall fitness of the species, but excess water also limits growth rate.[547]

While higher-than-normal water temperatures inhibit plant growth rates for Typha species,[548] it has been shown that increased soil temperature slows the formation of new rhizomes but encourages rhizomes already present to grow more rapidly.[549]

---

537 Though not in identical habitats – Zahran & Willis, *Vegetation of Egypt*, 260–266. See Shaltout & Ahmed, *Plant Life*, annex 3.2 and 3.8 for a habitat guide and its geographical distribution.
538 Eid et al., *Typha Growth Dynamics*, 63–72.
539 Zahran & Willis, *Vegetation of Egypt*, 278.
540 Shaltout & Ahmed, *Plant Life*, 112.
541 Zahran & Willis, *Vegetation of Egypt*, 272–275.
542 Zahran & Willis, *Vegetation of Egypt*, 63.
543 Shaltout & Ahmed, *Plant Life*, 117; Zahran & Willis, *Vegetation of Egypt*, 298.
544 Mexicano et al., *Ecological Engineering*, 174.
545 Grace, *Effects of Water Depth*, 765.
546 Glenn et al., *Salinity & Growth*, 84; Grace & Wetzel, *Typha Population Dynamics*, 140.
547 Vivian et al., *Wetland Plant Growth*, 1003–1007, figs 4, 5, 7.
548 Cary & Weerts, *Growth & Water Temperature,* 115.
549 Eid et al., *Typha Growth Dynamics*, 68–69; McNaughton, *Typha Ecotype Function*, 323.

Responses to Changing Chemical and Biological Factors

Extremely low pH values (highly acidic) are toxic for the growth of typha species.[550] *Typha* are usually less dominant in the more saline parts of the swamps than are the *Phragmites* species.[551] Cattails do not respond well in conditions more saline than normal; as the salinity increases, their overall numbers decline,[552] and the spread of the rhizome is limited. While the mature plant is able to tolerate some minor salinity increase, seed germination is less successful and seedling growth less sturdy.[553] Root structure is modified when subjected to salt stress.[554] However, cattails exhibit different sensitivities to salinity at different stages in their life cycle, displaying a certain resilience to changing environmental situations.[555]

In waterways where the sediment is highly nutritious, cattails can predominate, becoming almost mono-cultures.[556] Their deep roots aid them in resisting changes in soil quality, leaving the plant less affected by drying out of its territory.[557]

An increase in phosphorus nutrition enables cattails to resist some of the negative effects of salt on their development.[558] An increase in nitrogen-based nutrients, such as rapidly decaying organic matter, does not aid typha growth but it seems to help the plant develop resistance to the toxic effects of cyanobacteria.[559] As the soil becomes increasingly anaerobic, the lack of oxygen limits growth potential for the plant, comparing unfavourably with phragmites' ability in this regard.[560]

---

550 Mufarrege et al., *Typha domingensis Adaptability*, 462.
551 Zahran & Willis, *Vegetation of Egypt*, 75–76.
552 Glenn et al., *Salinity & Growth*, 76, 89; Zahran & Willis, *Vegetation of Egypt*, 70; Neubauer, *Ecosystem Responses*, 500.
553 Beare & Zedler, *Cattail Invasion & Resistance*, 167–169; Watkins, *Hydrology, Nutrients & Salinity*, 40–41.
554 Mufarrege et al., *Typha domingensis Adaptability*, 462; García-Hernándeza et al., *Typha Wetlands Salinity Responses*, 201; Mexicano et al., *Ecological Engineering*, 174; Glenn et al., *Salinity & Growth*, 81.
555 Watkins, *Hydrology, Nutrients & Salinity*, 40–41.
556 Zahran & Willis, *Vegetation of Egypt*, 50; Grace, *Nutrient Additions*, 87–88.
557 Goulden et al., *Typha Marsh Evapo-transpiration*, 102.
558 Macek et al., *Typha domingensis Spread*, 1514, fig. 6.
559 Macek et al., *Typha domingensis Spread*, 1517.
560 Pezeshki, *Cattail Photosynthetic Response*, 34; Zahran & Willis, *Vegetation of Egypt*, 70.

Ecological Implications for Cattails in Drought

Typha seems to respond to changing salt levels and variable acidity better than free-floating macrophytes.[561] Typha plants can persist in conditions detrimental to their survival by reverting to a dormant state until conditions improve.[562] This suggests that, while it may not gain biomass in drought-like conditions or in areas inimical to its survival, typha can persist in an environment until the equilibrium is returned. The species appears capable of modifying its morphology in order to adapt to severe conditions.[563] Typha plants respond to a changing environmental situation by adapting their reproductive strategies, emphasising the production of either seeds or rhizomes.[564] Being resistant to cyanobacteria toxins suggests that the species is more likely to persist in conditions where the waterway has become oxygen poor.

In studies identifying the distribution of plants in modern times, Zahran and Willis identify *Phragmites australis* as the most significant reed in Egyptian swamp habitats.[565] Phragmites and typha populations were recorded in close proximity to one another,[566] and it seems that these two groups appear to be in competition for similar habitats and resources. When they are in competition with one another in water channels, a community of phragmites is more likely to overcome *Typha domingensis* than vice versa.[567] So, overall, a weaker flood would hinder typha spread. In the modern slow-moving Nile, phragmites are the prevalent reed.[568]

---

561 Mufarrege et al., *Typha domingensis Adaptability*, 463.
562 Glenn et al., *Salinity & Growth*, 89.
563 Mufarrege et al., *Typha domingensis Adaptability*, 464.
564 McNaughton, *Typha Ecotype Function*, 323.
565 Zahran & Willis, *Vegetation of Egypt*, 274.
566 El-Ghani et al., *Environmental Relationships*, 8–11.
567 Zahran & Willis, *Vegetation of Egypt*, 20–24, 68, 70, 260–265, 298, 300, 302, 314, 318.
568 Sainty, *Weed Control & Utilization*, http://www.fao.org/docrep/field/003/R7236E/R7236E00.htm ; Zahran & Willis, *Vegetation of Egypt*, 318; Boulos & Fahmy, *Grasses*, 507.

4.6 – Lotus and a River in Drought

The plants commonly identified as the blue and white Egyptian lotus are actually members of the water lily family, Nymphaeaceae.[569] However, despite the proper scientific characterisation as a 'lily', the term 'lotus' has stuck in the Egyptological lexicon, and appears that it will so remain.[570] The plants prefer clear, warm, still and slightly acidic waters.[571] They reproduce using both seeds and rhizomes,[572] and in optimum conditions they spread rapidly due to these dual propagation strategies. The growth of the lotus follows an annual cycle and removing the normal water supply can interfere with the normal growth of the plant.[573] Individual plants take up to four years to grow from seed, suggesting that a rapid response to changing environmental factors would be difficult.

Responses to Changing Physical Factors

As the flow of a river decreases, erosion becomes less problematic for the settling of a new lotus into fine sediment.[574] The lotus can survive briefly as a terrestrial plant, but cannot survive a long-term significant fall in water level.[575] Because its leaves lie on the surface of the water,[576] its growth rate is not affected by changes in turbidity; however, it can shade other plants, lowering their ability for photosynthesis.[577] Changes in water temperature do not seem to hinder plant growth, but temperatures above 15°C accelerate the development of disease.[578] If the depth of the secondary channels decreases, the rate of lotus expansion is slowed and *Typha*/*Phragmites* take over, depending on the environmental conditions.[579]

---

569 Hanneder, *Water Lilies and Lotus*, 162, identifies the structural differences between the two plant types, and Izham, *Molecular Characterisation*, 8, identifies the genetic variances between the two.

570 Harer, *Properties of the Egyptian Lotus*, 49–51.

571 Orozco Obando, *Sacred Lotus Evaluation*, 13; Mohamed & Serag, *Anatomy of Lotus*, 4.

572 Khedr & Hegazy, *Ecology of Lotus*, 120; Zahran & Willis, *Vegetation of Egypt*, 268.

573 Ziada, *Economic Potentialities*, 1396–1399, fig. 6.

574 Khedr & El-Demerdash, *Distribution of Aquatic Plants*, 82; Mahomed & Serag, *Anatomy of Lotus*, 4; Shaltout & El-Sheikh, *Vegetation Environment Relations*, 567; Khedr & Hegazy, *Ecology of Lotus*, 127.

575 Zahran & Willis, *Vegetation of Egypt* 276; Orozco Obando, *Sacred Lotus Evaluation*, 14; Khedr & Hegazy, *Ecology of Lotus*, 119.

576 Zahran & Willis, *Vegetation of Egypt*, 271.

577 Mohamed & Serag, *Anatomy of Lotus*, 4; Khedr & Hegazy, *Ecology of Lotus*, 119.

578 Orozco Obando, *Sacred Lotus Evaluation*, 17.

579 Khedr & El-Demerdash, *Distribution of Aquatic Plants*, 82.

Responses to Changing Chemical and Biological Factors

Lotus growth responds poorly to strongly acidic conditions.[580] Although lotus grows best in acidic soil of pH 4.6, growth is not affected by water with pH values ranging from 5.5 to 8.0.[581] Increased salinity is also a hindrance to growth.[582] Increased nutrients in the sediment increase its acidity, potentially reducing the optimum growing conditions of the plant. An increasing concentration of nutrients can speed up plant and rhizome growth[583] but can hinder seedling germination.[584] While the plants may respond favourably to slight increases in nutrient levels in the water, they struggle to grow when water conditions become more anaerobic.[585] Lower than normal oxygen content in the water slows plant development,[586] and if the oxygen content of the sediment declines, it limits the potential germination of the lotus seed.[587]

Ecological Implications for Lotus in Drought

A slowing river would provide more stretches of water that were shallower than normal, developing higher water temperatures. Increasing water temperature would increase evaporation and hence water salinity, limiting plant growth. Extra nutrients would initially encourage plant growth, but then the anaerobic consequences of excess nutrients in the sediment would slow rhizome growth and limit germination. Shallower, narrower channels intimate a decrease in lotus abundance. A weaker river would be less beneficial to lotus growth.

---

580 Khedr & Hegazy, *Ecology of Lotus*, 127; Orozco Obando, *Sacred Lotus Evaluation*, 13.
581 Shen-Miller, *Long Living Lotus,* 239.
582 Orozco Obando, *Sacred Lotus Evaluation*, 13; Khedr & Hegazy, *Ecology of Lotus*, 123, 127, fig.1.
583 Khedr & El-Demerdash, *Distribution of Aquatic Plants*, 76; Khedr & Hegazy, *Ecology of Lotus*, 127.
584 Orozco Obando, *Sacred Lotus Evaluation*, 12; Shen-Miller, *Long Living Lotus*, 239.
585 Plantz Africa, '*Nymphaea nouchali* var. *caerulea*', http://pza.sanbi.org/nymphaea-nouchali-var-caerulea (Nov. 25, 2016).
586 Orozco Obando, *Sacred Lotus Evaluation*, 12, 25, 117.
587 Mohamed & Serag, *Anatomy of Lotus*, 11, tables 3 & 5.

4.7 – Low River Habitat and Food Web Changes

Without an inundation, the nutrients carried by the river would have remained within the river and changed the river's environmental characteristics. As a result, some plant species would thrive while others would experience a downturn in environmental success, resulting in less biodiversity but much greater biomass. Following is a summary table comparing the overall responses of the four major Nilotic plants and their potential response to circumstances where the river did not flood.

Papyrus & Phragmites	Bulrushes & Lotus
Tolerate salinity increase	Salinity increase inhibits growth
Tolerate decreasing oxygen solubility	Narrower oxygen solubility range
Tolerate increasing acidity of waterways	Limited acid tolerance
Asexual (Stolon & Rhizome) reproduction	Mainly sexual reproduction
Masses collect nutrients and add matter	Don't clump

Papyrus and phragmites plants appear to benefit more from circumstances as expected from the analysis of a river in drought. A weakening river would not seem to benefit the lotuses and the typha plants (bulrushes/cattails) as it would the other two.

As well as the increase in biomass accumulation, papyrus decomposition would have enabled nutrients to be returned to the waterway to be, in their turn, re-absorbed by other components of the riverine food web; especially microbes, with perhaps as much as a third of the nutrients within a papyrus clump being returned to the environment each season..[588]

When papyrus clumps grow denser and taller, as it is hypothesised they would in a low Nile inundation, the food webs associated with them would have changed as microhabitats increased in number and variety. The considerable mass and height potential of papyrus would have produced a large number of 'microhabitats' within its storeys.[589] In the modern

588 Gaudet, *Papyrus Nutrients*, 420.
589 Britton, *Papyrus Swamps*, 451.

situation, increased vertical habitat zonation of bird species has been observed within the papyrus columns as papyrus clumps grow taller.[590]

Whereas papyrus clumps grow denser and taller, phragmites species grow outwards.[591] Biomass accumulation, the forming mats of reeds,[592] would have occurred, but the increase in the number of micro-habitats occurs in a manner different to that provided by papyrus. As well as being an aquatic food source, papyrus and phragmites expansion become a significant attractant to birdlife,[593] with a direct relationship between an increase in marsh size and a corresponding increase in bird abundance.[594] As phragmites masses expand, the centres of these masses would have become safe refuges for a variety of animals to avoid predators.[595]

Modern investigations have recorded the rapid increase in numbers of ducks and geese in developing secondary channels, these channels having become important and secure nesting sites. Among the modern-day avian visitors to the Nile, individuals of historically recorded species have been identified.[596] As well as avian organisms, other terrestrial organisms, invertebrate and vertebrate, such as locusts, rodents and small carnivores are attracted to the increase in biomass in search of food and have been identified as living in, on and around the papyrus.[597]

Secondary channels provided an important role in the spawning activities of most Nilotic fish species,[598] whereas the deeper parts of the river provided for a greater variety of the bigger fish species.[599] Migration of fish species can occur along the length of the river and within different parts of the river, providing a variety of resources.[600] A weaker river would have resulted in an increase in the amount of plant material under which fish species could

590 Britton, *Papyrus Swamps*, 459.
591 Gaudet, *Papyrus Nutrients*, 415; Zahran & Willis, *Vegetation of Egypt*, 298.
592 Zahran & Willis, *Vegetation of Egypt*, 296.
593 Mitsch & Gosselink, *Wetlands*, 382.
594 Maclean et al., *Passerine Habitat Loss*, 349; Gagnon Lupien et al, *Bird Diversity*, 34–38.
595 Gagnon Lupien et al., *Bird Diversity*, 38–40.
596 Sallam & El-Barbary, *Secondary Channels*, 496–497.
597 Rzóska, *Descent*, 213; Speight & Blackith, *The Animals*, 354–359; Rzóska, *Upper Nile Swamps,* 27; Gagnon Lupien et al., *Bird Diversity*, 32–33.
598 Sallam & El-Barbary, *Secondary Channels*, 498.
599 Mitsch & Gosselink, *Wetlands*, 400.
600 Rzóska, *Descent*, 211; Speight & Blackith, *The Animals*, 352–353.

have sheltered and gathered food.[601] Despite seeming 'monotonous'[602] in appearance, growing papyrus clumps and reed mats attract larger and more varied shoals of fish[603] and higher numbers and varieties of animals and their predators, and this vegetative fringe has been identified as being the most biologically rich habitat of the river.[604] Considering the huge biomass potential along the fringes of the river,[605] and the identification of small fish species as the most important faunal constituent of these vegetative fringes,[606] then it is to be expected that a more determined effort by the ancient Egyptians to exploit this particular resource should have occurred.

When water flow in marshlands becomes more sluggish, the clogged parts of the river would have exhibited different oxygen characteristics than the faster-flowing parts of the river. Fish distribution and abundance within a river varies according to the particular stage in that organism's life cycle, or the amount of oxygen available for that particular species. Chapman et al. identify how oxygen availability can influence gill development within some fish species, affecting the distribution of a species within waterways.[607] These factors may cause selection pressures on fish populations, leading to variances of distribution and abundance within local populations.[608] Therefore, it would be expected that a re-adjustment of piscine habitats may have occurred. A more detailed investigation of the fish species depicted within Egyptian tomb decoration scenes may identify whether these organisms change in abundance over the time frame under investigation. It would be expected that the depiction of smaller fish, with more included varieties should increase. Catfish and lungfish appear less vulnerable to reduced oxygen levels.[609] Similarly, with a possible decline in distribution due to diminishing oxygen levels, the instances of catfish and lungfish depictions would be expected to occur. This is in fact the case and is discussed more fully in Chapter Seven: Fishing and A River In Drought.

601 Thompson, *Swamp Development*, 190.
602 Rzóska, *Descent*, 213.
603 Thompson, *Swamp* Development, 190–191; Rzóska, *Descent*, 211.
604 Britton, *Papyrus Swamps*, 450; Rzóska, *Upper Nile Swamps,* 13.
605 Jones & Muthuri, *Papyrus Canopy Structure*, 482.
606 Rzóska, *Upper Nile Swamps*, 13–16; Rzóska, *Descent*, 211–212.
607 Chapman et al., *Papyrus Swamp Variations*, 310, 318, 324.
608 Chapman et al., *Papyrus Swamp Variations*, 321.
609 Chapman et al., *Papyrus Swamp Variations*, 318.

Papyrus appears a relatively insignificant plant within the food chains of larger herbivores.[610] Despite its high nutritive value, most large herbivores are poorly adapted to grazing upon such sedge-type marshland flora.[611] However, cattle tend to eat the youngest and freshest shoots, and this damage by grazing animals seems to encourage regrowth and therefore does not interfere significantly with the biomass output.[612] Moreover, the level of grazing has to be quite significant before it appears to have a harmful impact upon the success of sedges, with van Deursen and Drost suggesting that these plant species can accept up to 40 percent grazing and still experience viable reproductive success.[613] So, as the biomass of papyrus and phragmites increased due to changing environmental circumstances, it seems feasible that cattle grazing would have been unable to keep up. Jones and Muthuri suggest that most of the developing flower heads (the umbels) do not produce flowers, but have an important photosynthetic value to the potential of the plant.[614] Since it is the older parts of the plant and rhizome that store the starch needed for the plant's metabolism, grazing upon the growing parts of a plant does not significantly impact upon its reproductive ability.[615]

---

610 Saunders et al., *Papyrus Carbon Cycles*, 489.
611 Muthuri & Kinyamario, *Papyrus Nutritive Value*, 23–24.
612 van Deursen & Drost, *Cattle Defoliation*, 294–295. Britton, *Papyrus Swamps*, 450, also notes the remarkable regenerative capability of the papyrus plant.
613 van Deursen & Drost, *Cattle Defoliation*, 292–293.
614 Jones & Muthuri, *Papyrus Canopy Structure*, 481.
615 Muthuri & Kinyamario, *Papyrus Nutritive Value*, 25–27. For similar investigations into *Phragmites*, see Baran et al, *Phragmites & Nutrition*, 448.

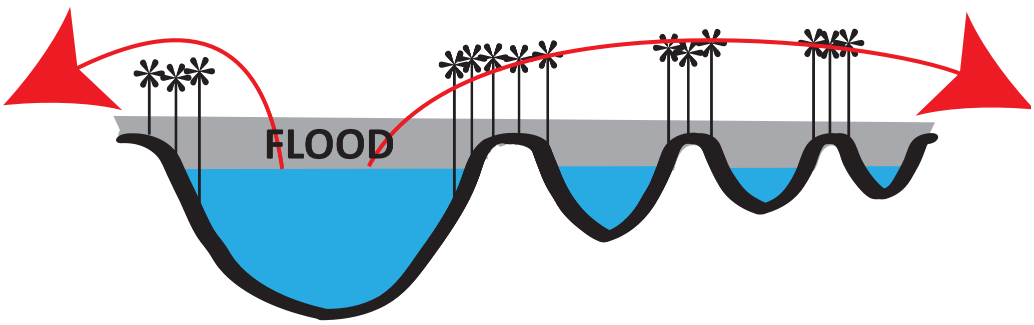
4.8 – The Nile in 'Drought': a Re-Interpretation?

Rzóska points out that, in terms of papyrus marshes, a 'non-flood' event due to a low or non-existent inundation, is merely a loss of water (and its accompanying nutrients) to those relying on the excess for success in agriculture.[616] In riverine terms, a non-inundation means that water and its accompanying nutrients is reserved for utilisation within the river.[617]

Does 'drought' encourage marshlands?

One of the consequences of this excess of nutrients may have been promoted growth of the papyrus marshes and reed beds. The processes leading to such rapid growth can be envisaged as follows. In a normal flood, as the river overflowed its banks, the nutrients carried within are deposited on the riverbanks along its length (see Figure 21: An inundation deposits resources onto the land).

Figure 21: An inundation deposits resources onto the land

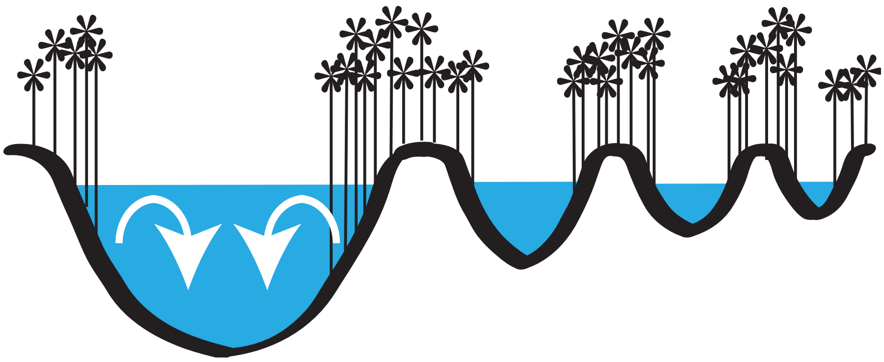


During 'drought', the river would still have carried these nutrients downstream but did not have the necessary volume to overflow its banks, resulting in nutrient retention within the river channel. As the current slowed, it would have lost the necessary momentum to carry these nutrients, which would have been deposited on the riverbed and river's edges rather than beyond (see Figure 22: No inundation means that the nutrients remain in the river).

616 Rzóska, *Descent*, 213; Rzóska, *Upper Nile Swamps*, 2.

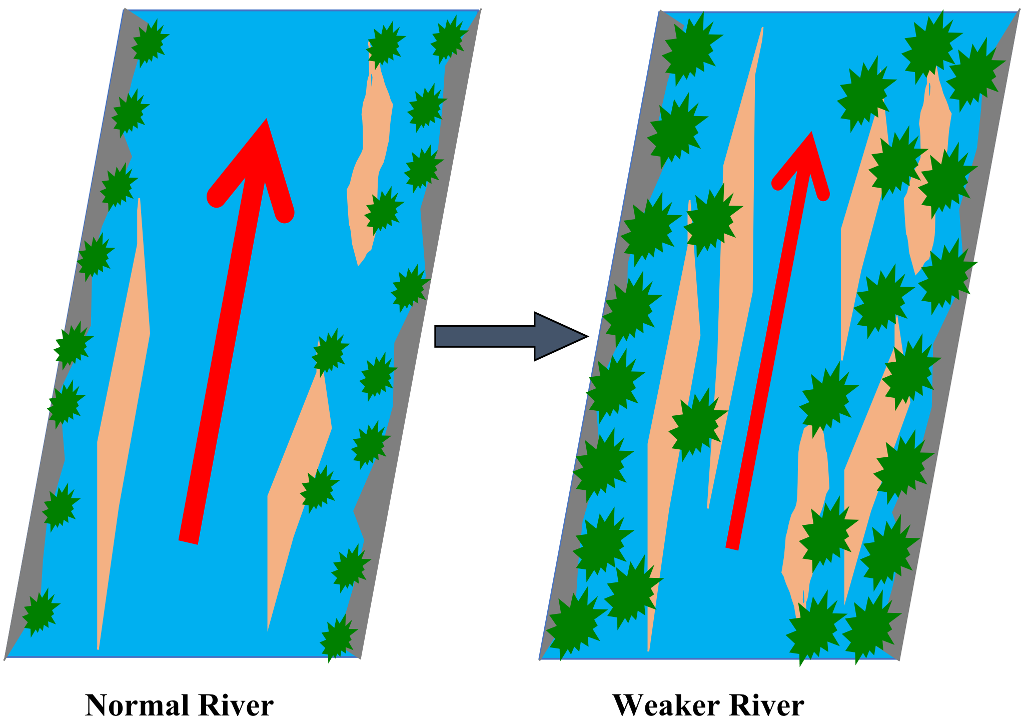
617 Speight & Blackith, *The Animals*, 349; Khan & Ansari, *Eutrophication*, 465–466; Tackholm, Landscape, 59–60;

Figure 22: No inundation means that the nutrients remain in the river



A long-term drought would have magnified this build-up, providing the biological energy for a 'papyrus bloom' and a phragmites expansion. We should expect the river to have narrowed as the river volume (and therefore flow rate) decreased, 'pulling' the papyrus marshes and reed beds to grow inwards towards the centre of the river (see Figure 23: Normal versus weaker river flow).

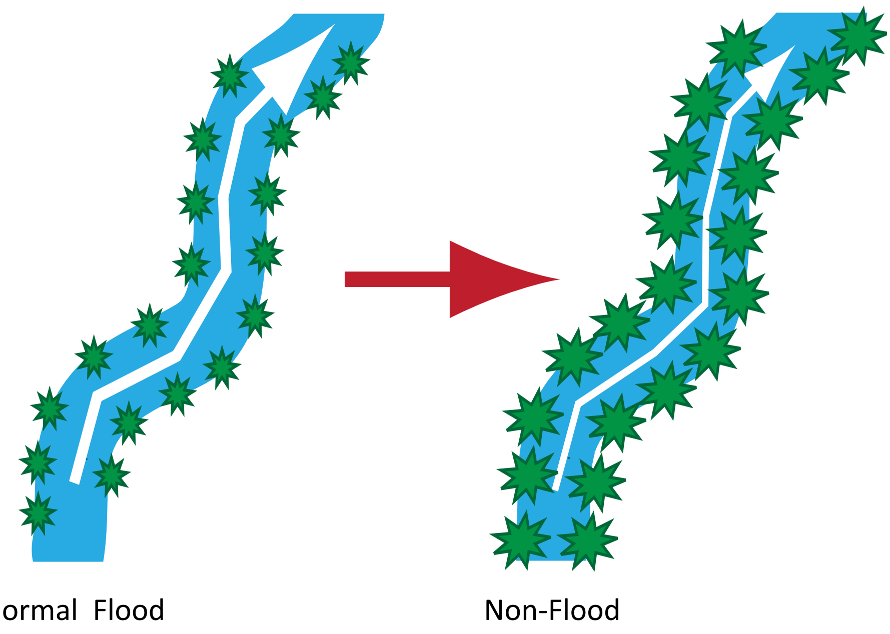
Figure 23: Normal versus weaker river flow



So, as flood levels declined over the Old Kingdom, we would expect to see a significant increase in the amount of marshland developing along the river.[618] Ankhtify, the great overlord of the nomes of Edfu and Hierakonpolis, who had described the desperate situation that developed in the south of the country during the famine,[619] bemoaned in his biography the "*the House of Khui; inundated like a marsh (and) neglected by its keeper*."[620] The 'Marshes of Edfu', those that interfered with the grain distribution plans of Ankhtify,[621] may have developed as the consequence of a bloom in papyrus and phragmites due to the deposition of nutrients within the river.

The rapid growth of papyrus clumps within the river and the increased development of *khors* and *sudds* along its length were a consequence of a lower, slower, but more resource-rich waterway effectively making the river narrower and possibly hampering the movement downstream (see Figure 24: Excess plant growth disrupts flow and hinders transportation).

Figure 24: Excess plant growth disrupts flow and hinders transportation



618 Köln, *Project A5,* http://www.uni-koeln.de/sfb389/a/a5/pics/pic_06.gif (May 21, 2016).
619 Malek, *Old Kingdom*, 118; Manassa, *El-Moalla to El-Deir*, 5; Coulon, *Famine*, 1.
620 Author's translation, from Vandier, *Mo'alla*, 163. See also Manassa, *El-Moalla to El-Deir*, 8.
621 Vandier, *Mo'alla*, 220–221. For commentary on the imagery of storms in the Egyptian mind, see Darnell, *The Message of King Wahankh*, 101–108.

4.9 – NILE VALLEY RAIN: EVEN MORE NUTRIENTS?

Recent evidence points to the likelihood that, at a time when the flood had become less reliable, the Nile valley experienced significant rainfall events.[622] The physical force of the pluvial cascade impacted upon the integrity of some tombs built during this time, for example the tomb of Merefnebef,[623] while other tombs were structurally re-designed to resist the negative impact of a rain-fuelled deluge.[624] While unexpected, rainfall within the Nile valley has been shown to have always occurred, and mounting evidence suggests that severe rainfall events were becoming more commonplace during the timeframe under investigation.[625] Interestingly, much of the land abandonment that occurred in Mesopotamia at this time has been linked to unreliable or irregular rainfall patterns,[626] suggesting a connection between unusual rain events in Egypt with those which occurred in other places around the region at this time.[627]

Alluvial versus Pluvial Events

The variety, source and movement of sediments within a river are very important, because they influence the way that the living organisms within the river develop and interact.[628] In the 'natural' chain of events, the inundation deposited alluvial sediments; those "*deposited by a flowing waterway*"[629] to the river valley as the water overflowed its banks, a process that appeared to be weakening during the time frame under investigation.[630]

Rainfall upon the land drains into the river,[631] producing sediment that becomes a part of the assemblage of the riverbank and its edges. The vast series of wadis that can be observed on

---

622 Myśliwiec et al., *Saqqara Geoarchaeology & Paleoclimate*, 294–295; Hayes, *Most Ancient Land*, 96; Geriesh et al., *Groundwater Flow Regime,* 605, fig 21; Alexandra et al., *Mummies & Aridity*, 92–100.
623 Myśliwiec et al., *Merefnebef,* 41, pl. 7b.
624 Kuraszkiewicz, *Architectural Innovations*, 32.
625 Welc & Marks, *Old Kingdom Climate*, 124–133; Sowada, *Sixth Dynasty Weather Evidence*, 69–74; Welc & Trzciński, *Dry Moat Geology*, 323–343; Trzciński et al., *West Saqqara Geoarchaeology*, 194.
626 Myśliwiec et al., *Saqqara Geoarchaeology & Paleoclimate,* 295–298; Fiorentino, *Syrian Climate Change*, 56.
627 Kowalska & Kuraszkiewicz, *End of a World*, 173–176; Walker et al., *Holocene Subdivision*, 653–656.
628 Allan & Castillo, *Stream Ecology*, 19, 41, 75.
629 The Science Dictionary, https://www.thesciencedictionary.com/results/alluvial (Oct. 16, 2016).
630 Butzer, *Geological Deposits*, 77; Stanley & Warne, *Delta in Destruction*, 801–802.
631 Woodward et al., *Nile Evolution*, 265.

any satellite map indicate that water was flowing towards the river on a semi-regular basis:[632] these wadis have been identified as indications of rainfall.[633] The depth of these wadis suggests that it did so in some considerable volume.[634] With rainfall comes run-off, which flows into the nearest waterway, transporting pluvial sediments: those sediments are "*made of sand and earth that is washed down by rainfall*."[635] The composition and structure of alluvial sediments is different to pluvial sediments and can be readily identified by scientific means,[636] as can the direction of the pluvial flow.[637]

Rainfall Events and Impacts

While the inundation was relatively predictable, whatever its level, rainfall events in Egypt occurred with irregular and unpredictable timing, thereby interfering with the progression of the 'normal' cultivation cycle. Just as too little flooding meant that irrigation efforts were ineffective, excessive flooding was also problematic.[638] Agricultural success further south, for example, is attributed to lack of large inundations, with excess water flowing downstream.[639] Just as the flood governed the annual outcomes of agriculture, the timing of rainfall events would also have impacted upon the success, or otherwise, of the cultivation cycle.[640]

The term 'erosivity' is defined as *a measure of the potential ability of material to be eroded by rain, wind, or surface run-off.*[641] The power of the run-off is a function of the volume and speed of water, which influences how much sediment is moved.[642] In recent history, it has been shown that the more variable and irregular the weather patterns, the more readily

---

632 Technological advances have enabled scientists to identify many these sites: for example, York & Kennedy, *Google Earth and Archaeology,* 1284–1293; Déodat & Lecoq, *Using Google Earth*, 321–338; and especially, Parcak, *Satellite Remote Sensing*.

633 For rainfall patterns during the Early Dynastic and Old Kingdom periods, see Butzer & Hansen, *Desert & River,* 121; Butzer, *Hydraulic Civilisation*, 13 & 106; Hassan et al., *Nile Floodplain at Saqqara*, 57.

634 Welc & Marks, *Old Kingdom Climate Change*, 8; Hassan et al., *Nile Floodplain at Saqqara*, 59–63, figs 5 & 6.

635 The Science Dictionary, https://www.thesciencedictionary.com/results/pluvial (Oct. 16, 2016).

636 Bárta, *In Mud Forgotten*, 75–82; Welc & Marks, *Old Kingdom Climate Change*, 1–10.

637 See, for example, in Myśliwiec et al., *Saqqara Geoarchaeology & Paleoclimate*, 286–289, figs 14–15.

638 Coulon, *Famine*, 1.

639 Macklin et al., *Nile Floodwater Farming*, 698.

640 Morris, *Art of Not Collapsing,* 79–81, Soroush & Mordechai, *Short-term Cataclysm*, 7–8; Nicholson & Shaw, *Materials & Technology*, 514.

641 Zorn & Komac, 'Erosivity', *Encyclopedia of Natural Hazards*, https://link.springer.com/referenceworkentry/10.1007%2F978-1-4020-4399-4_121 (Nov. 21, 2017).

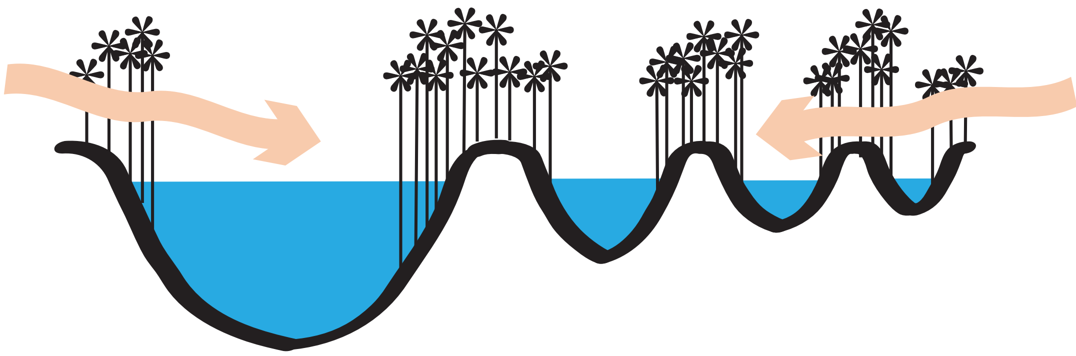
642 Sukhanovski et al., *Rainfall Erosivity Index*, 51–57; Diodato & Bellocchi, *Rainfall Erosivity*, 969–970.

the soil is eroded and the land degraded.[643] Drainage pathways in ancient Egypt would have been constructed based upon experience of previous inundations. Large amounts of water flowing towards the river must have compromised the design of the irrigation channels and must have also interfered with basic agricultural infrastructure as the channels were designed to take advantage of water moving away from the river not towards it.[644] These events would have developed stresses in the agriculture cycle, something with which an inadequately organised administrative system may have been unable to cope. Poor administration may have meant that the repairs may not have been completed in time to take advantage of the excess water.

Do Rainfall Events Encourage More Marshlands?

During times of rain, the river would have accumulated additional nutrients as the torrent transferred (returned?) pluvial sediments, which would have been built up from a previous alluvial event, from the land back into the river. Organic wastes from previous users of the soil would have been washed into the river in accompaniment (see Figure 25: Rainfall returns nutrients to the river). This nutrient surge may have helped precipitate a papyrus and phragmites 'bloom', causing a further expansion of marshlands.

Figure 25: Rainfall returns nutrients to the river



643 Bintliff, *Time, Process & Catastrophism*, 422–423; Alpert et al., *Paradoxical Rainfall*, 135–154; Diodato et al., *Erosive Rainfall Anomalies;* 2078–2093; Diodato & Bellocchi, *Rainfall Erosivity*, 977.

644 Bintliff, *Time, Process & Catastrophism*, 429–430.

SUMMATION: CHAPTER FOUR

The River Blooms in 'Drought'

The main points determined in this chapter include:

⇒ A 'drought' would have resulted in a weaker Nile

⇒ The Nile would have flowed less powerfully with a reduced main channel and the river would have developed a greater number of shallower and warmer secondary channels.

⇒ These areas were expected to be warmer, more salty, able to contain less dissolved oxygen and slightly more acidic.

⇒ Some plant species would have responded more favourably to the changing circumstances than others.

⇒ Papyrus and Phragmites display characteristics that suggest that these species would have responded favourably to these conditions.

⇒ Typha (cattails) and Lotus species have characteristics that suggest that they would experience lessening chances of success in these new conditions

⇒ It was envisaged, therefore, that the Nilotic channels would have become increasingly clogged with thick papyrus clumps and phragmites mats spreading towards the middle, with other two significant plant groups such as the cattails and lotus diminishing in their relative abundance and distribution.

⇒ Fish species would have been attracted to the increased aquatic resources.

⇒ Land animals that would have exploited large papyrus clumps and phragmites mats would have increased in number and variety.

It is anticipated that these external influences would have had an impact upon the culture expressed by the society at that time. It is therefore expected that, within the range of art fashioned upon tomb walls, some of the decorations produced would display this stimulation. The primary goal of this investigation is to attempt to document changes in the decoration programme that suggest these environmental triggers had some impact upon the population at that time.

Part C

The Cultural Response

CHAPTER FIVE

CHANGES IN TOMB WALL SCENES

Note: The following chapter extends the ecological style 'distribution and abundance' analysis method used in two published articles:

1. *Burn, J. W. 2011. 'The Pyramid Texts and Tomb Decoration in Dynasty Six: The Tomb of Mehu at Saqqara.' In Binder, S. (ed.) The Bulletin of the Australian Centre for Egyptology, 22, 17–34, Sydney.*
2. *Burn, J. W. 2012 'An Ecological Approach to Determine the Potential Influence that the Pyramid Texts had upon Dynasty Six Tomb Decorations.' In Bárta, M., Coppens, F. and J. Krejčí (eds.), Abusir and Saqqara in the Year 2010, 233–245, Prague.*

5.0 – INTRODUCTION

If a 'drought' had disrupted the normal biological cycle, the nutrient glut that would have developed would have had a transformative impact upon the Nilotic ecology. This would have had an impression upon the culture. Did this climatic event leave any identifiable influence upon the tomb decorations that were produced at the time?

In this chapter, tomb decoration data will be analysed to test the A.R.I.D. hypothesis. Artistic themes that may shed light on the veracity of the hypothesis will be investigated. The progression of tomb decoration themes will then be examined to investigate the possibility that changing environmental circumstances may have had an impact upon contemporary visual culture.

5.1 –Papyrus: Art Suggesting Riverine Change?

From previously being restricted to the royal tombs, fishing and fowling scenes began to appear on the walls of nobles' tombs in the Fifth Dynasty, and then became a regular theme in tomb wall scenes from the mid-Fifth to the late Old Kingdom. Harpur comments on the changing representations of papyrus thickets in tombs in the mid-late Old Kingdom,[645] Kanawati summarises the overall progression[646] and Woods identifies tombs in which scenes depicting papyrus are changing.[647] In the Dynasty Six tomb of Mereruka at Saqqara, for example, the papyrus clumps make up a significant portion of the fishing and fowling scene,[648] and the wall scenes in the tomb of his wife, Waatetkhethor depict papyrus to a much greater extent than other marsh plants.[649]

By the second half of the Old Kingdom, marsh scenes depicting fishing and fowling had become one of the focal points, if not the main feature, of tomb scenes, becoming more elaborate and increasingly more detailed.[650] Woods identifies the tendency within the wall scenes to also incorporate more than one activity against the same background with the scenes appearing to flow from one into another.[651] A growing emphasis on riverine scenes may explain why the location of these compositions, initially presented inside the tomb, moved to be within view of the river, with Woods identifying the time of Niuserra onwards as the date for the main change of this positioning.[652]

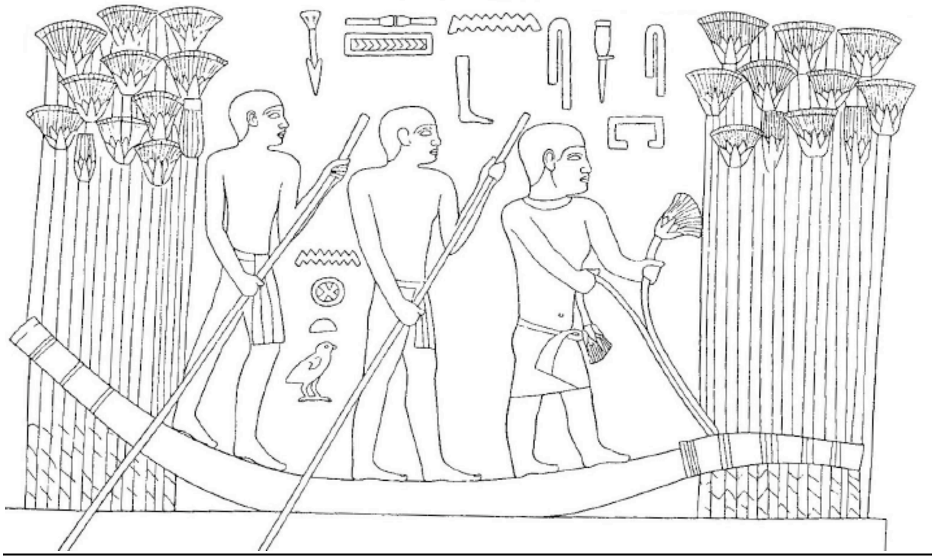
Marshlands Become a More Crowded Place

In the Fourth Dynasty tombs of Seneb at Saqqara and Sabni at Aswan, the figures appear relatively large compared to the papyrus stands (see Figures 26: Tomb of Seneb – Papyrus-pulling and 27: Tomb of Sabni – Spearfishing), assigning greater emphasis to the

---

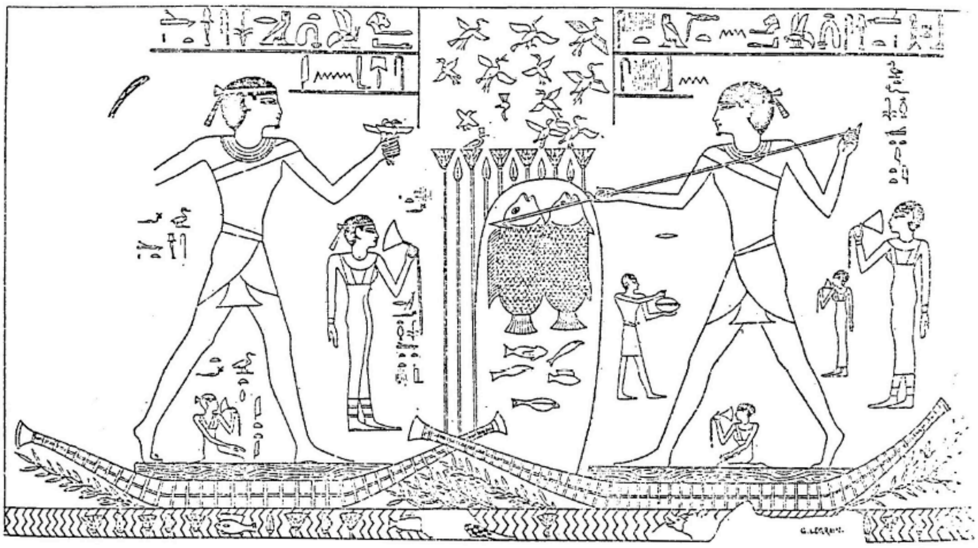
645 Harpur, *Decoration*, 195–196; Woods, *Marshes*, 40–41; Kanawati, *Papyrus Thickets*, 119.
646 Kanawati, *Papyrus Thickets*, 119–212.
647 Harpur, *Decoration*, 189; Woods, *Marshes*, 358.
648 Kanawati, *Mereruka & Teti*, pls. 107, 110.
649 Kanawati & Abder-Raziq, *Waatetkhethor*, 21, pls. 65–66.
650 Harpur, *Decoration*, 197.
651 Harpur, *Decoration*, 194; Woods, *Marshes*, 377.
652 Harpur, *Decoration*, 57, 185; Woods, *Marshes*, 38–39. Burn, *Pyramid Texts*, 233–245, investigates the distribution and abundance of this scene type over the same time frame.

Figure 26: Tomb of Seneb – Papyrus-pulling.



Adapted from Junker, *Gîza* V, 65–67, fig. 15.

Figure 27: Tomb of Sabni – Spearfishing.

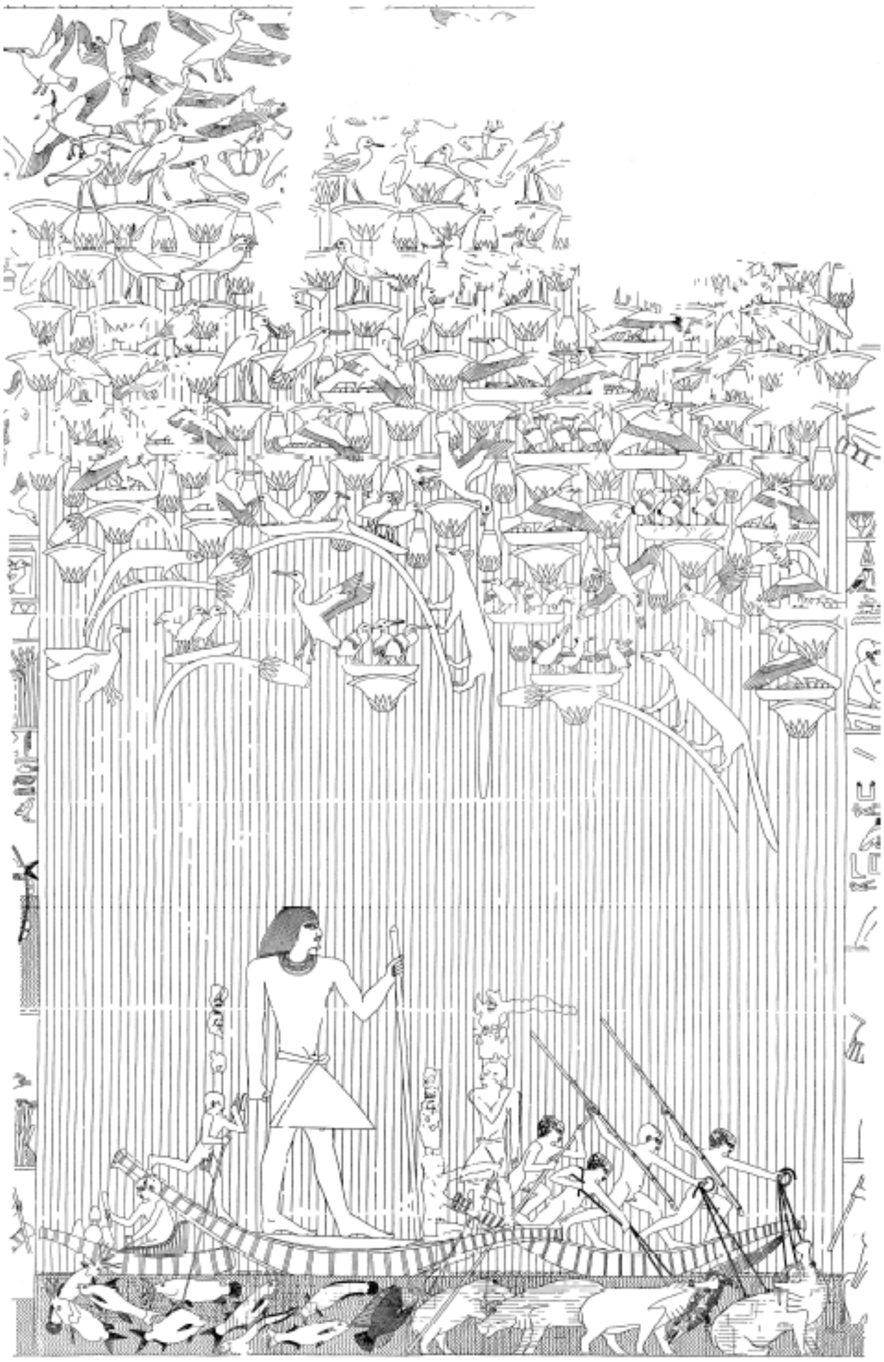


Adapted from de Morgan, *Catalogue des monuments*, 146

individuals themselves. Conversely, in the tomb of Ty at Saqqara,[653] dating to the reign of Niuserra, the stands of papyrus seem to dwarf the subjects (see Figure 28: Tomb of Ty – Papyrus stands).

653 Wild, *Ti*, II, pls. 85–86.

Figure 28: Tomb of Ty – Papyrus stands.



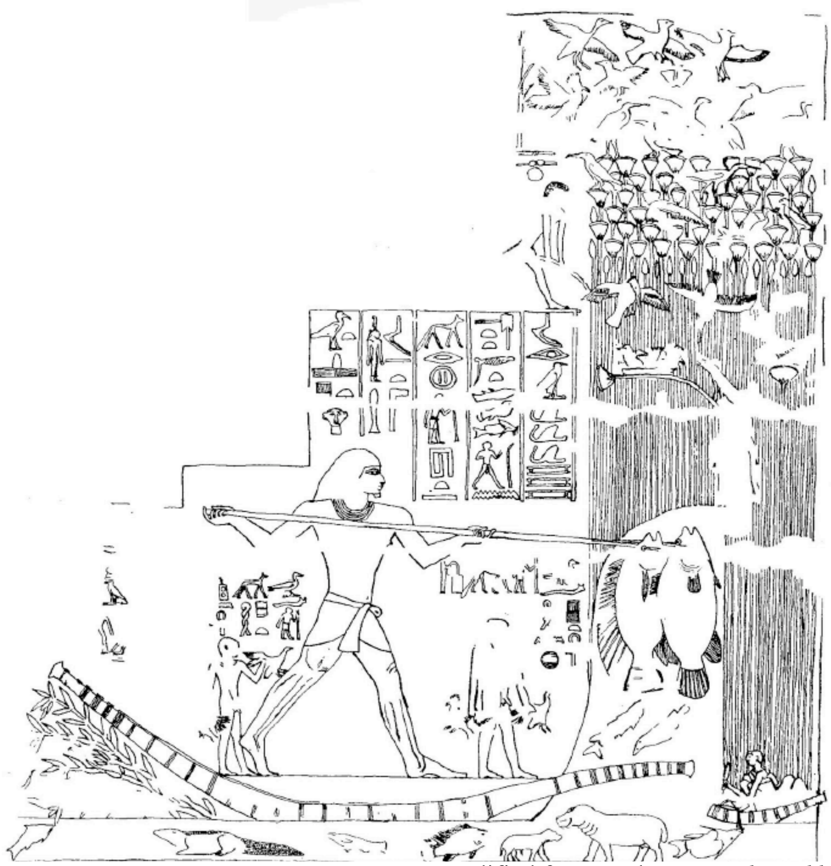
Adapted from Wild, *Ti*, II, pl. 119.

Similarly, in the tombs of Djau and Ibi at Deir el-Gebrawi,[654] Itisen at Giza, Khunes at Zawiyet el- Maiyetin

654 For Djau, see Davies, *Deir el-Gebrâwi* II, pl. 5; Kanawati, *Deir el-Gebrawi* III, pl. 57: for Ibi, see Davies, *Deir el-Gebrâwi* I, pl. 4–6; Kanawati, *Deir el-Gebrawi* III, pls. 46, 47.

and Hetepherakhti at Saqqara, the figures are dwarfed by the papyrus thicket behind,[655] (see Figure 29: Tomb of Hetepherakhti – Spearfishing) indicating that this botanical feature had become more important during the latter half of the Fifth Dynasty and into the Sixth.

Figure 29: Tomb of Hetepherakhti – Spearfishing.



modified from Mohr, *Hetep-her-akhti*, fig. 34, pl. 2.

The marshland depicted in the latter Old Kingdom scenes display a more 'crowded' botanical background than those produced in the Middle Kingdom.[656] At Meir, the Sixth Dynasty tombs of Pepyankh the Middle, Niankhpepy the Black and Pepyankh the Black, for example,[657] represent papyrus in a more congested manner than in the later tombs of Senbi and Wekhhotep.[658] Earlier representations of papyrus are thought to be stylised renditions.[659] In the tomb of Nebemacht at Giza, for example, the arrangement of the papyrus thicket is

655 For Itsen, see Hassan, *Gîza* V, fig. 123, pl. 37; for Khunes, see LD II, pl. 106a and for Hetepherakhti, see Mohr, *Hetep-her-akhti*, fig. 34, pl. 2.

656 Harpur, *Decoration*, 257.

657 Kanawati, *Meir* I, pls. 79–82, updating Blackman, *Meir* IV, pl. 7; Kanawati et al., *Meir* III, pls. 24–28, 69 and Kanawati & Evans, *Meir* II, pls. 34–36, 84 respectively.

658 Harpur, *Decoration*, 199–201. For examples, see Kanawati & Evans, *Meir* IV, pls. 78, 80 and 92 respectively, updating Blackman, *Meir* I, pl. 3 and *Meir* VI, pls. 6, 13.

659 Woods, *Marshes*, 67–68, n. 161, 162.

very controlled and the ranks of birds atop it are ordered in a regimented manner.[660] This representation of papyrus umbels may be designed to perhaps impose more order on an increasingly disordered setting.[661]

However, later, some of these illustrations become less stylised and more irregular. Kantor notes that from the time of Niuserra onwards, the scenes depicting huge papyrus clumps evoke this impression of overgrowth:

> *"… the feeling for the massive, overshadowing character of the papyrus swamps, which produced the tremendous background of sedges used in Ti's tomb, appears to be characteristic chiefly of the Old Kingdom. In later times there was a continuous tendency to diminish the size and rigidity of the swamp landscape…."*[662]

Woods identifies the tumultuous or irregular arrangement of subjects within marshland scenes as one of her characteristic themes: "#174: *The composition of the water is broken up with vegetation – papyrus buds and lotus flowers shown in the water attached to the baseline*." Her selection includes tombs dating from the time frame in question and beyond, and mostly from the provinces.[663] This asymmetrical arrangement of the papyrus thickets can be found in the Memphite tombs of Rakhaefankh,[664] Khufukhaef II,[665] Irenkaptah,[666] Kaemnefert II,[667] Niankh-khnum and Khnumhotep,[668] Ty,[669] Iteti,[670] Neferirtenef[671] and Seneb.[672] With the exception of Rakhaefankh, whose date is under contention, all date from after the time of Niuserra.[673]

At Sheikh Said, in the tomb of Werirni,[674] the arrangement of the papyrus umbels appears similarly haphazard, giving the impression of a vast and overwhelming mass.[675] Other

660 Hassan, *Gîza* IV, fig. 77.
661 Woods, *Five Features,* 1901–1902.
662 Kantor, *Plant Ornament*, 10. Similar tendencies are noted in Harpur, *Decoration*, 257.
663 Woods, *Marshes*, 379.
664 LD II. 9 [lower]. Perhaps Rakhaefankh's date can be clarified by this stylistic criterion.
665 Simpson, *Kawab & Khafkhufu*, pl. 37[a], fig. 47.
666 Moussa & Junge, *Two Craftsmen*, pls. 12–13.
667 Hassan, *Gîza* II, fig. 140.
668 Moussa & Altenmüller, *Nianchchnum und Chnumhotep,* Abb. 12, Taf. 31.
669 Wild, *Ti,* II, pls. 87, 110–112.
670 Badawy, *Iteti*, fig. 17.
671 van de Walle, *Neferirtenef*, pls. 13, 21 (detail).
672 Junker, *Gîza* V, Abb. 15, Taf. 6 [a].
673 Woods, *Marshes*, 362.
674 Davies, *Sheikh Saïd*, pl. 11.
675 Moussa & Altenmüller, *Nianchchnum und Chnumhotep,* Abb. 5, 6, Taf. 74, 75.

provincial tombs that display an indiscriminate umbel arrangement include those of Kakhent and Iufi at el-Hammamiya,[676] Sabni at Qubbet el-Hawa,[677] Mery-aa at El-Hagarsa[678] and Hemre/Isi at Deir el-Gebrawi,[679] suggesting a more chaotic, less ordered, 'wilder' marshland. If the Nile's papyrus clumps and reed mats became larger and more extensive as a consequence of a weaker river flow, it would be expected that the plant growth would be as disordered as the scenes appear to show.

Some decorations appear to have been uniquely provincial, suggesting that the artists were depicting truly what was witnessed.[680] The 'open' appearance of some thickets in the latter half of the Old Kingdom, may represent a desire to depict more clearly what lies within.[681] It is difficult to reconcile the view that these scenes were purely symbolic,[682] as some top tomb officials did not depict themselves engaged in marshland-based activities.[683]

Fishing and Fowling in Crowded Marshlands

Of the fourteen tombs lacking a papyrus-backed fishing scene identified by Woods, all are dated to the late Fifth Dynasty and beyond, with the majority in tombs below the Memphite region.[684] In the tomb of Djau/Shemai at Deir el-Gebrawi, the fishing and fowling scene appears to be set beyond the papyrus bank, giving the impression that these activities are occurring outside the congestion of the papyrus zone.[685] Also at Deir el-Gebrawi, in the tomb of Henqu/Ih[…]f, no papyrus thicket is shown, just a few isolated plants,[686] whereas Ibi is depicted among the papyrus while fowling[687] and beyond them while spearfishing.[688] It would be expected that, as marshlands became more crowded, it would be more difficult to approach spearfishing sites from the banks, making it more practical to approach from open

676 Mackay et al, *Bahrein & Hemamieh*, pl. 26, updated in El-Khouli & Kanawati, *El-Hammamiya*, pls. 35–36.
677 Lhote, *Chefs-d'oeuvre*, fig. 6.
678 Kanawati, *El-Hagarsa* III, pls. 42, 44–45.
679 Davies, *Deir el-Gebrâwi* II*,* pl. 17, updated in Kanawati, *Deir el-Gebrawi* I, pl. 59.
680 Lashien, *El-Qusiya*,150–166, identifies a number of examples.
681 For an elucidation of this point see Chapter 8: Waterfowl and A River In Drought.
682 Vandier, *Manuel* IV, 717.
683 Kanawati, *Papyrus Thickets,* 119.
684 Woods, *Marshes*, 358.
685 Davies, *Deir el-Gebrâwi* II, pls. 3, 5, updated in Kanawati, *Deir el-Gebrawi* III, pls. 57, 69.
686 Davies, *Deir el-Gebrâwi* II, pl. 23, updated in Kanawati, *Deir el-Gebrawi* I, pl. 54.
687 Davies, *Deir el-Gebrâwi* I, pl. 5, updated in Kanawati, *Deir el-Gebrawi* II, pl. 47.
688 Davies, *Deir el-Gebrâwi* I, pl. 3, updated in Kanawati, *Deir el-Gebrawi* II, pl. 46.

water.[689] The representations of the figures of Merefnebef and Mehu, themselves, (both dated to Dynasty Six) appear to be imposed in front of the papyrus thickets,[690] not within them, suggesting that the activity depicted is occurring beyond the papyrus zone

The act of fowling required some ability to sneak up to the prey. Fowling would necessarily have to take place within the papyrus marshes, using the thickets as a form of 'cover'. This arrangement of fowling near the thicket and spearfishing in open water is similar to that depicted in the tombs of Inumin at Saqqara[691] and Iteti/Shedu at Deshasha.[692] In the tomb of Kakhent and Iufi at el-Hammamiya, Iufi, depicted on her pleasure cruise, is not passing through a thicket where her husband is engaged is his activities, but is depicted beyond them.[693] A similar arrangement is seen in the tomb of Idu/Seneni at Qasr el-Sayad, where the fowler is preparing to hurl the throwstick into a thicket, while the spearfishing image appears to have no papyrus backing.[694] The tomb of Kagemni contains a similarly differentiated image, where the marshland activities of husband and wife appear to be in different locations.[695] While spearfishing and fowling may require some 'cover' for their activities, the act of fishing with nets requires more open spaces to avoid entanglement.[696]

Swampweed and boats

Most depictions of rivercraft depict the occupant(s) travelling through the marshes, encountering swampweed in the process. The majority of scenes depicting skiffs but not depicting swampweed present are attested to before the Sixth Dynasty.[697] Initially, swampweed was depicted under the prow, perhaps representing the skiff entering the thicket.[698] Over the time frame spanned by this investigation, the depictions of the skiffs and the positions of these weeds under them changed.[699] Swampweed, normally depicted at

---

689 Kanawati, *Papyrus Thickets*, 122.
690 Myśliwiec et al., *Merefnebef*, 133, pl. 65; Altenmüller, *Mehu*, pls. 9, 11, 13.
691 Kanawati, *Inumin*, pl. 46.
692 Kanawati & McFarlane, *Deshasha*, pl. 44 (spear-fishing) and pl. 48 (fowling).
693 El-Khouli & Kanawati, *El-Hammamiya*, pls. 50–51. Interestingly, this provincial example is claimed by Woods, *Marshes*, 358, to be the earliest representation of this separation of husband and wife.
694 Säve-Söderberg, *Hamra Dom*, pl. 7 (spear-fishing), pl. 8 (fowling).
695 Harpur & Scremin, *Kagemni*, 353–364, 491[3].
696 Kanawati & Abder-Raziq, *Neferseshemre & Seankhuiptah*, pl. 69; Davies, *Deir el-Gebrâwi* I, pls 3–6; Kanawati, *Meir* I, pls 79–82; Altenmüller & Moussa, *Nianchchnum & Chnumhotep*, fig. 12.; Kanawati et al; *Mereruka*, pl. 67.
697 Woods, *Marshes*, Appendix 3, no. 186.
698 Kanawati, *Papyrus Thickets*, 122.
699 Harpur, *Decoration*, 201.

either prow or stern, increasingly appears under both ends.[700] The images in the Sixth Dynasty tombs of Ibi at Deir el-Gebrawi[701] and Pepyankh the Black at Meir,[702] among others, show swampweed under both ends of the vessel. One instance, the tomb of Iynefert, depicts both ends of the vessel atop water plants, but displays the bow passing across lotus flowers, not swampweed.[703] The dating of this type of marsh scene has been fixed to the time of Teti and continues through to the end of the Old Kingdom.[704] This proliferation of the presence of weed may indicate the development of a more crowded waterway through which to traverse in the final stages of the Old Kingdom. More than two-thirds of all tombs depicting this abundance of waterweed are provincial.[705]

The increasing congestion of the river may also be indicated by changes to the design of the small watercraft used to conduct fishing and fowling activities.[706] Baines and Malek supply a schematic illustration of a basic wooden skiff and its component structures. Tracing the evolution in design of boats as represented as tomb decorations, Woods observes that boats develop a gradually rising and curving stern and prow until:[707]

> *"the final shape is mainly attested in marsh scenes dating to the late Sixth Dynasty in the (Upper Egyptian) provincial cemeteries of Naga ed-Dêr, Aswan and Mo'alla. In these scenes, the papyrus boat has a thick base and the prow and stern project sharply up from the water line in contrast to a gradual curve…"*[708]

The thicker base and sharply upturned prow result in a skiff with an apparently shallower draught, as though it was designed to enable it to travel over the water and not through it – another indicator of less-than-smooth travel on the river, perhaps as a results of a more crowded waterway slowing forward progress. In the tomb of Khunes at Qubbet el-Hawa,[709] the skiff depicted has a high prow and stern. In the nearby tombs of Senbi I and Senbi II,[710]

---

700 Woods, *Marshes*, 145, appendix 3, no. 188; Harpur, *Decoration*, 356–363.

701 Fowling: see Davies, *Deir el-Gebrâwi* I, pl. 5, updated in Kanawati, *Deir el-Gebrawi* II, pl. 47. Spearfishing: see Davies, *Deir el-Gebrâwi* I, pl. 3, updated in Kanawati, *Deir el-Gebrawi* II, pl. 46.

702 Fowling: see Blackman & Apted, *Meir* V, pl. 28, updated in Kanawati & Evans, *Meir* II, pl. 88. Spearfishing: see Blackman & Apted, *Meir* V, pl. 24, updated in Kanawati & Evans, *Meir* II, pl. 84.

703 Schürmann, *Ii-nefret*, pl. 21.

704 Woods, *Five Features*, 1904–1906.

705 Harpur, *Decoration*, 201; Woods, *Marshes*, 384.

706 Harpur, *Decoration*, pl. 24; Woods, *Marshes*, appendix 3, nos. 109–128.

707 Baines & Malek, *Atlas*, 68–69; Woods, *Marshes*, 61–63.

708 Woods, *Marshes*, 63.

709 de Morgan, *Catalogue*, 146.

710 Harpur, *Decoration*, pl. 24.

the scene also depicts these more rugged craft atop swampweed encroaching both fore and aft. Similar suggestions that these marshland scenes were set in the delta can also be discounted, because some depict sailing boats nearby, something difficult to perform within the delta.[711] Pepy the Black at Meir, mentions the marshlands of Upper Egypt before he mentions the marshlands of the delta.[712]

However, it is important to not overstate the case for total reliance on visual evidence: the tombs of Mery-aa and Wahi at El-Hagarsa,[713] among a few others,[714] depict the tomb owners undertaking marshland activities without any skiff, despite obviously needing one. This has been explained as most likely a result of poor artistic skills rather than by design choice,[715] however, it could also be an indication of the increasing interrelationship or overlap of those activities involved with the acquisition of riverine resources: the men could be standing on the riverbank.[716]

With these previous examples, the composition of some tomb scenes appeared to be changing. The possibility exists that these changes may be in response to changing environmental circumstances. Perhaps other compositional changes were occurring.

711 Kanawati, *Papyrus Thickets,* 120.
712 Blackman, *Meir* V, pl. 24, updated in Kanawati & Evans, *Meir* II, pl. 84.
713 Kanawati, *El-Hagarsa* III, pls. 42, 44–45 and pl. 28, respectively,
714 Woods, *Five Features*, 1902, n.28, identifies five other instances.
715 Indeed, Vandier, *Manuel* IV, 719, suggests incompetence.
716 Kanawati, *Papyrus Thickets*, 123–124.

5.2–Tomb Decoration: Patterns of Change

Since art represents the major preoccupations of a society, it may be that changes to the art produced by that society reveals a pattern of environmental influence. It is important to recognise that any study relying on 'artistic' evidence is only partially reliable because the 'categories' we apply when we study wall scenes have been assigned in hindsight and after the passage of many centuries, without full knowledge of the artists' philosophies. Alongside those considerations, discrepancies within dating criteria mean that that some attestations are not as precisely assigned as one would like. Additionally, not all pieces of evidence are extant. Also, it is difficult to 'allocate' the date of a tomb to one king because most lifespans and tomb constructions schedules did not align with only one king or with service to only one king. For example, very few tombs have been suggested as belonging to the reigns of Shepseskara and Raneferef, respectively, the fourth and fifth kings of Dynasty Five,[717] though this seems to reflect the brevity of these individuals' reigns rather than any significant social disruption.[718] The life of Ptahshepses, of Abusir, for another example, overlapped at least two kings: his career started as Niuserra's hairdresser, before being appointed Overseer of Upper Egypt under the subsequent king, Menkauhor.[719]

The Sample: Distribution and Abundance of Decoration Themes

A distribution and abundance analysis was performed on the sample data as outlined in Chapter Two. This data was obtained from artistic scenes contained within the Oxford Expedition to Egypt Scene-details Database, drawing from tombs dating from the Fourth Dynasty to the Eighth, with some, perhaps, falling into the First Intermediate Period. 'Abundance' was determined by the number of attestations of each decoration theme and 'distribution' was measured by the date as assigned to the decorations. As mentioned in Chapter Two, despite an incomplete record, the 495+ entries should provide an excellent overview of the decoration programme of the time frame under investigation.

---

[717] Regnal order according to Baines & Malek, *Atlas*, 36; Shaw, *Oxford Encyclopaedia*, 482; Verner, *Dating in the Old Kingdom*, 31–32.

[718] Verner, *Who was Shepseskara*? 581–602.

[719] See, for example, Bárta, *Ptahshepses Junior II*, 66, who inherited his father's role, and whose life overlapped at least two kings. His father's career, starting as the king's hairdresser, eventually becoming Overseer of Upper Egypt, involved service to two kings.

The complete distribution and abundance table is presented in the Appendices[720] and has been summarised in the following table (Table 2: Themes 4th → 8th Dynasties: Abundance and distribution summary).[721] The Roman numerals represent the Dynasty, and the Arabic numerals represent the king: King Teti, for example, is identified as VI.1 where 'VI' indicates Dynasty Six and '1' identifies its first king.

<u>Table 2: Themes 4th→ 8th Dynasties: Abundance and distribution summary</u>

Date	IV	IV	IV	IV	IV	IV	V	V	V	V	V	V	V	V	V	VI	VI	VI	VI	VII	OVERALL	
Description	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	1	2	3	4	?	T	%
1. Marsh-related activities	11	3	1	1	3	15	4	12	15	0	0	123	42	78	130	104	61	14	69	34	720	31.5%
2. Desert and desert-activities	5	0	1	0	0	0	0	0	0	0	0	6	2	2	10	4	2	2	11	2	47	2.1%
3. Agricultural pursuits	4	1	0	0	0	3	1	3	4	0	0	27	6	23	24	14	6	1	19	15	151	6.6%
4. Pastureland and animal-husbandry scenes	4	0	0	0	0	4	0	3	0	0	0	53	11	34	30	28	21	2	31	23	244	10.7%
5. Orchard scenes	0	0	0	0	0	0	0	1	1	0	0	7	1	8	3	10	0	0	1	1	33	1.4%
6. Gardening	0	0	0	0	0	0	0	0	0	0	0	9	0	6	4	5	5	0	0	0	29	1.3%
7. Bird-procession and poultry-yard scenes	0	1	0	0	1	3	0	0	1	0	0	16	5	6	13	11	11	1	3	1	73	3.2%
8. Manufacture and storage of wine and oil	1	0	0	0	0	6	0	0	1	0	0	21	4	15	12	10	7	0	5	1	83	3.6%
9. Food preparation and brewing	3	0	0	0	0	3	1	1	2	0	0	36	2	19	20	21	16	8	24	19	175	7.7%
10. Workshop activities	2	1	0	0	6	10	2	2	0	0	1	33	10	20	12	15	10	1	22	6	153	6.7%
11. Commerce, including the management of workers and possessions	1			2		5	2	1	2		2	25	8	17	20	25	11	1	15	4	141	6.2%
12. Dance, music and games		2		1	4	7	6	8	11			34	8	33	41	21	14	10	19	5	224	9.8%
13. Medical procedures, relaxation and bodily care						2		1	1			3		1	10	10	5	2	5	1	41	1.8%
14. Warfare and war-related activities														1	4				0		5	0.2%
15. Funerary rites and funeral scenes		1		1	6	4	6	3	5		1	28	6	18	23	23	11	4	18	6	164	7.2%
TOTAL ATTESTATIONS PER REIGN	31	9	2	5	20	62	22	35	43	0	4	421	105	281	356	301	180	46	242	118	2283	

Old Kingdom Scene Types: an Overview

As is to be expected for a culture that relied so much upon the river and the bounty provided by the annual inundation, almost one third of all the tomb decorations attested depict a scene whose theme can be related to a marshland activity. Despite the consensus 4200 BP date for an increase in dryness,[722] and with increasing aridity seeming to have been a perennial problem throughout the Old Kingdom, it does seem curious that decorations representing this theme persist in such a large proportion. The next most common theme is pastureland and animal husbandry, followed by depictions involving dance, music and games.

Despite the significance of cultivation to the culture of ancient Egypt, fewer than one in twelve scenes attested are related to the agricultural process.

---

720 For the complete record, the themes have been further subdivided into sub-categories and the totals have been broken down by reign: (see ARID_Appendix_1_Scene_Type_Numbers_Overall.

721 See ARID_Appendix_2_Theme_Summary_Numbers.

722 Equivalent to the end of the Fifth Dynasty, see Part A.

New Iconographical Scenes: Mid-Fifth Dynasty.

From the time of Niuserra onwards [V.6+], an evolution (revolution?) in decorations appears to have occurred, with a substantial increase in both the amount and variety of tomb decorations noted, for example, gardening activities are first depicted during this reign; and scenes depicting the Desert Hunt re-enter the repertoire, last appearing early Dynasty Four.[723]

Table 3: New scene types: Niuserra onwards.

NEW SCENE TYPES	9. Food Preparation and Brewing
1. Marsh-related activities	9.4. Preparing fish for consumption (excluding fish-gutting)
1.10. Men gathering reeds or lotuses in a marsh (excluding artificial pools)	10. Workshop activities
1.16. Fishing with a large net, set from boats	10.2. Linen production
1.17. Fishing with a funnel trap	10.7. Pottery making
1.18. Fishing with a rounded basket trap, or carrying fish in a basket trap	10.8. Seal engraving
1.19. Fishing with a hand-held net	10.9. Staff fashioning
1.20. Boatmen spear-fishing in a marsh (excluding the major figure)	11.Commerce, including management of workers and possessions
1.21. Angling from a boat	11.1. Market scene
1.27. Net-making or repairing a net	11.2. Freight-boat scene
1.28. Drying a fishing net after use	11.6. Tomb owner conveyed on donkeys, probably to inspect possessions
4. Pastureland and animal husbandry	11.10. Officials witnessing a will
4.1. Fighting bulls	12. Dance, music and games
4.3. Cattle mating in pasture	12.4. Lone musician entertaining workers
4.6. Hobbled and tethered calves	12.6. Workers beating rhythms with resonant sticks
4.9. Force-feeding hyenas	12.7. Men or women clapping rhythms for movement (excluding dancing)
5. Orchard scenes	12.8. A board-game called 'senet', or 'draughts'
5.1. Gathering fruit from trees	13. Medical procedures, relaxation and bodily care
5.3. Trapping song-birds in a clapnet	13.4. Manicure scene
6. Gardening	13.5. Pedicure scene
6.1. Hoeing, to prepare or maintain a garden	13.7. Shaving scene
6.2. Watering a garden	14. Warfare and war-related activities
6.3. Cultivating and harvesting vegetables in a garden	14.1. Craftsmen making weapons
6.4. Growing papyrus or lotuses in a man-made garden pool	14.2. Siege scene
7. Bird procession and poultry yard scenes	14.3. Soldiers marching or jogging to a battlefield
7.2. Poultry-yard scene	14.4. Wrestling, perhaps as part of army training
7.3. Force-feeding poultry	15. Funerary rites and funeral scenes
8. Manufacture and storage of wine and oil	15.2. Statue or statues conveyed by boat to a tomb
8.2. Treading grapes or dates in a vat	15.5. Jars of oil or wine conveyed by sledge to a tomb

As identified in Part A, the 15 broad themes of the Scene-details Database, are broken down into more detailed ‘Scene Types’. When the sample was expanded to include those scene types within each category, new scene types that originated from the time of Niuserra emerged (see Table 3: New scene types: Niuserra onwards).

723 Each individual in these early Fourth Dynasty cases was royal or related to the ruling family.

The majority of the new scene types have something to do with the acquisition, exploitation, storage and regulation of food-based resources: of the forty-four new additions, more than two-thirds of the scene types can be classified in this manner. All but one of the nine new additions to Theme 1, *Marsh-related activities*, depict fishing and its associated techniques and technologies. The new scene types added to Theme 13, *Medical procedures, relaxation and bodily care*, represent data from only four different tombs,[724] perhaps skewing the data. Similarly, the scenes added to Theme 14, *Warfare and war-related activities* come from only a few tombs; these examples may skew the data slightly, but are an important feature to note, nevertheless.[725] Interestingly, some of these scene types newly added to the tomb decoration repertoire in the Fifth Dynasty, such as those in Theme 6, *Gardening*, and those from Theme 14, *Warfare and war-related activities*, do not persist long into the decoration catalogue produced for the next dynasty.[726]

Niuserra: A Changing Emphasis?

The significance of the reign of Niuserra has been alluded to earlier and is discussed more fully in Part D. Many of the newly arrived scene types that appeared at the time of Niuserra seem to support the A.R.I.D hypothesis, with many themes relating to the exploitation and acquisition of food resources. Food-producing land may have been so important by this time that it was thought vital to record 'proof' of the family's ownership, or more correctly, rights to utilise the resources produced.[727] For example, a decoration representing officials witnessing a will is related to a deed transferring ownership of agricultural land.[728] Other aspects of Theme 11, *Commerce*, that appear as new representations could possibly be linked to dealing with food resources or agricultural land in the owner's possession. There are almost fifty instances where the tomb owners are depicted travelling to visit their possessions. There are three instances of the tomb owners doing so astride donkeys, while the remaining forty-three are transported by palanquins. Interestingly, there is only one

---

724 A more detailed examination can be found in Chapter 12.
725 The significance of these war-related representations is discussed in Chapter 11.
726 No attestations date to beyond the reign of Pepy I: see Appendix_1_Scene_Numbers_Overall.
727 See Thompson, *Tehna* I, 15–20. Here, in a cemetery in the 16th (Oryx) nome of Upper Egypt, 15 rock-cut tombs dating to the Fourth and Fifth Dynasties, originally discussed in a short article by George Fraser in 1902, are currently being re-examined. The tomb of Nika-ankh II includes a will and has been dated to the early–mid Fifth Dynasty
728 Recorded in the tomb of Wepem-Nefert-Wep, in Hassan, *Giza* II, 190–192, fig. 219, pls. 74–76, and dated 6th–8th Dynasty.

attestation of this activity dates to before the time of Niuserra, found in the tomb of Nefermaet at Maidum.[729] All the rest date from Niuserra onwards, suggesting that this activity had become significant enough to be commemorated within many tombs. Similarly, all of the attestations depicting scene type 11.1, 'Market scenes', date from the mid-Fifth Dynasty onwards.

New Iconographical Scenes: Sixth Dynasty Onwards

In contrast from the time of Niuserra to the end of the Fifth Dynasty, very few new scene types were added to the iconography in the Sixth Dynasty (see Table 4: New scene types: Sixth Dynasty onwards).

Table 4: New scene types: Sixth Dynasty onwards

NEW SCENE TYPES	
1. Marsh-related activities	10. Workshop activities
1.20. Boatmen spear-fishing in a marsh (excluding the major figure)	10.6. Painting onto a screen
1.24. Fishermen registering their catch for distribution by scribes	13. Medical procedures, relaxation and bodily care
5. Orchard scenes	13.8. Circumcision scene
5.4. Trapping song-birds in hand-set traps	13.9. Mouth-examination scene
8. Manufacture and storage of wine and oil	15. Funerary rites and funeral scenes
8.5. Decanting oil	15.5. Jars of oil or wine conveyed by sledge to a tomb

Despite the new scene types in Themes 10, 13 and 15 introducing some new activities, the total number of actual decorations depicting these scenes is quite low, and their absolute number when compared to the overall number of representations attested is very small, and the comparative proportion of attestations with these themes (#10, 13 & 15) either did not change or fell markedly.[730] The observation made above about depictions relating to *Medical procedures, relaxation and bodily care* (Theme 13) is equally valid here, with the new scene type coming from a single tomb. The application of a medical connection to a scene depicting circumcision, and not a religious association, will be discussed later. However, as the marshlands enlarged, it would be expected that the incidence of mosquito-borne diseases should increase as well as an increase in medical conditions associated with increasingly poor water quality. The remaining new iconographic representations appeared within those themes identified as increasing in overall proportion of the total sample and can be readily linked in some way to food resources.

---

729 Harpur, *Maidum*, 67–68, 186–187, fig. 77, pl. 8 [a].

730 Significantly, none of these themes can be linked to the environment or to resources.

5.3 – A Shifting Artistic Imperative?

Within the gamut of tomb decorations, some themes and scene types seem to have endured over the entire time frame under investigation. Because not every tomb used every type of decoration, it is difficult to claim that have been included for symbolic or religious reasons.[731] It is possible to suggest the apparent change in the decorations depicted upon tomb walls represented a society that had become more concerned with ensuring an adequate and regular supply of food. It may be that the change within the decoration sequence indicates the perception that a regular and reliable food supply was becoming a source of increasing concern. This may have led to a (perhaps unconscious) increasing pre-eminence applied to decorations that related to the acquisition, exploitation and utilisation of food resources. Particular emphasis remains upon scene types relating to agriculture (even though this declined, somewhat) and activities relating to marshes, the desert, poultry and the utilisation of cattle.

Tomb Decorations: Proportion as a Variant over Time

Despite a general increase in tomb size *and* a corresponding increase in the total surface area available for scenes to be depicted,[732] some attested themes decreased in their relative comparison: their proportion declined when compared to other themes and at earlier times. While an increased number of attestations may result in an increase in total abundance, the *relative proportion* when compared to the entire sample occupied by the thematic categories changes over the time frame in question, with some increasing at the expense of others, sometimes significantly.

If no external influence were present, then it is reasonable to expect that the overall proportion of decoration themes should display a consistent distribution throughout the relatively short time period that was the Old Kingdom. Therefore, it was deemed important to ascertain if any change in the thematic proportion occurred over the time frame under investigation. [See ARID_Appendix_3_Summary_Pre-Post-D6].

---

[731] Kanawati, *Papyrus Thickets*, 119.

[732] Kanawati, *Administration*, 159; see also El Khouli & Kanawati, *El-Hammimiya*, 13–14.

Pre- and Post-Sixth Dynasty: The Impact of 'Drought'?

According to the suggestions outlined in Part A, those kings of the Sixth Dynasty would have been directly impacted by the onset of the long-term 'drought' thought to have been so disruptive to the society of ancient Egypt.[733] Using similar reasoning, the hypotheses outlined in Part B suggest that during this time, the environment experienced by the society would have changed. To see if any 'turning point' in the progression of tomb decorations can be identified signalling changing environmental conditions, it was determined that the onset of the Sixth Dynasty be imposed as a 'boundary' within the data. Table 5: 'Themes: Pre-Dynasty 6 and Dynasty 6 onwards', presents this data.

Table 5: Themes: Pre-Dynasty 6 and Dynasty 6 onwards

Date	IV	IV	IV	IV	IV	IV	V	V	V	V	V	V	V	V	V	VI	VI	VI	VI	VII	Pre-D6		D6 on	
Description	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	1	2	3	4	?	T	%	T	%
1. Marsh-related activities	11	3	1	1	3	15	4	12	15	0	0	123	42	78	130	104	61	14	69	34	438	31.4%	282	31.8%
2. Desert and desert-activities	5	0	1	0	0	0	0	0	0	0	0	6	2	2	10	4	2	2	11	2	26	1.9%	21	2.4%
3. Agricultural pursuits	4	1	0	0	0	3	1	3	4	0	0	27	6	23	24	14	6	1	19	15	96	6.9%	55	6.2%
4. Pastureland and animal-husbandry scenes	4	0	0	0	0	4	0	3	0	0	0	53	11	34	30	28	21	2	31	23	139	10.0%	105	11.8%
5. Orchard scenes	0	0	0	0	0	0	0	1	1	0	0	7	1	8	3	10	0	0	1	1	21	1.5%	12	1.4%
6. Gardening	0	0	0	0	0	0	0	0	0	0	0	9	0	6	4	5	5	0	0	0	19	1.4%	10	1.1%
7. Bird-procession and poultry-yard scenes	0	1	0	0	1	3	0	0	1	0	0	16	5	6	13	11	11	1	3	1	46	3.3%	27	3.0%
8. Manufacture and storage of wine and oil	1	0	0	0	0	6	0	0	1	0	0	21	4	15	12	10	7	0	5	1	60	4.3%	23	2.6%
9. Food preparation and brewing	3	0	0	0	0	3	1	1	2	0	0	36	2	19	20	21	16	8	24	19	87	6.2%	88	9.9%
10. Workshop activities	2	1	0	0	6	10	2	2	0	0	1	33	10	20	12	15	10	1	22	6	99	7.1%	54	6.1%
11. Commerce, including management etc.	1			2		5	2	1	2		2	25	8	17	20	25	11	1	15	4	85	6.1%	56	6.3%
12. Dance, music and games		2		1	4	7	6	8	11			34	8	33	41	21	14	10	19	5	155	11.1%	69	7.8%
13. Medical, relaxation and bodily care						2		1	1			3		1	10	10	5	2	5	1	18	1.3%	23	2.6%
14. Warfare and war-related activities														1	4				0		5	0.4%	0	0.0%
15. Funerary rites and funeral scenes		1		1	6	4	6	3	5		1	28	6	18	23	23	11	4	18	6	102	7.3%	62	7.0%
TOTAL ATTESTATIONS PER REIGN	31	9	2	5	20	62	22	35	43	0	4	421	105	281	356	301	180	46	242	118	1396		887	

Table 6: 'Themes: Pre- versus post Dynasty 6 – Overall proportion and trends', displays the overall proportion of each wall scene theme out of the total scene sample over the time frame under investigation and identifies whether it varied significantly over the course of the Sixth Dynasty. A change that is less than significant (< ±10%) is represented (≈). Significant trends are represented in the following manner: +10% as (⇧), and –10% as (🡻).

[733] Shaw, *Oxford History,* 480–481, as modified by Sowada, *Egypt in Eastern Mediterranean,* tabs. 2, 3.

Table 6: Themes: Pre- versus post Dynasty 6 – Overall proportion and trends

Date	Pre-D6		D6 on		TREND	
Theme	**T**	**%**	**T**	**%**	**±**	**?**
1. Marsh-related activities	438	31%	282	32%	101%	≈
2. Desert and desert-activities	26	2%	21	2%	127%	⇧
3. Agricultural pursuits	96	7%	55	6%	90%	↓
4. Pastureland and animal-husbandry scenes	139	10%	105	12%	119%	⇧
5. Orchard scenes	21	2%	12	1%	90%	↓
6. Gardening	19	1%	10	1%	83%	↓
7. Bird-procession and poultry-yard scenes	46	3%	27	3%	92%	≈
8. Manufacture and storage of wine and oil	60	4%	23	3%	60%	↓
9. Food preparation and brewing	87	6%	88	10%	159%	⇧
10. Workshop activities	99	7%	54	6%	86%	↓
11. Commerce, including the management of workers and possessions	85	6%	56	6%	104%	≈
12. Dance, music and games	155	11%	69	8%	70%	↓
13. Medical procedures, relaxation and bodily care	18	1%	23	3%	201%	⇧
14. Warfare and war-related activities	5	0%	0	0%	0%	↓
15. Funerary rites and funeral scenes	102	7%	62	7%	96%	≈

The change in overall proportion of wall scene types crossing from the Fifth Dynasty into the Sixth can be summarised as follows:

1. *Marsh-related decorations continued their importance.*
2. *Desert-related decorations increased significantly.*
3. *Agricultural pursuit decorations decreased from the Sixth Dynasty onwards.*
4. *Pastureland and animal husbandry decorations increased significantly.*
5. *Orchard-related decorations decreased.*
6. *Gardening-related decorations decreased.*
7. *Bird procession and poultry-yard themes did not change significantly.*
8. *Decorations depicting the manufacture and storage of wine and oil decreased significantly.*
9. *Food preparation and brewing decorations increased significantly.*
10. *Workshop activities were represented significantly more often before the Sixth Dynasty.*
11. *Commerce and management decorations maintained their significance.*
12. *Dance, music and games were significantly more common before the Sixth Dynasty.*
13. *Representations of medical procedures increased significantly in the Sixth Dynasty.*
14. *Decorations depicting warfare and related activities are not attested in tombs dating to the Sixth Dynasty.*
15. *Decorations depicting various funerary rites and funeral scenes maintained their overall importance.*

Six themes showed 'negative' trends where the decrease, in proportional terms, was more than ten percent (10%) over the time frame in question: Theme 5: *Orchard*, Theme 6: *Gardening*, Theme 8: *Manufacture and storage of wine and oil*, Theme 10: *Workshop activities* and Theme 12: *Dance, music and games*.

Depictions relating to Theme 14, *Warfare and war-related activities*, are not attested during this period. For a detailed discussion of the implications of the 'negative' trends, see Part C. Four scene types showed a 'positive' trend where an increase, in proportional terms, was more than ten percent (10%): Theme 2: *Desert-related activities*, Theme 4: *Pastureland and animal husbandry scenes*, Theme 9: *Food Preparation and Brewing* and Theme 13: *Medical procedures, bodily care and relaxation*. Apart from the last category, (for further discussion, see below), these categories can be readily interpreted as an indication of a growing preoccupation with food resources. The question "why did gardening and orchard scenes decline?" will be discussed in Chapter Six.

Some Result Limitations?

Statistically, warfare-related activities recorded a significant decrease, but there are only two tombs in this period decorated with scenes depicting actual warfare.[734] Another tomb, Khunes at Zawyet el-Maiyetin, displays the making of weapons;[735] but these could derive from a hunting context, though the number of spears represented suggests not. Another, that of Ptahhotep II Thefi at Saqqara, depicts wrestling, which may or may not be military in context, since the participants are juvenile in appearance.[736] Since so few tombs contain decorations relating to actual warfare, this small number does not allow for valid use in statistical analysis. Commentary on this decoration theme will be limited to the discussion.

The overall increase of wall scenes relating to Theme 13, *Medical procedures, relaxation and bodily care*, is difficult to relate to a river in 'drought'. As mentioned previously, a few significant tombs with a particular focus in their decorations may skew the statistics. Incorrectly identified as 'the tomb of the Physician', the tomb of Ankhmahor[737] in the Teti

---

734 These are the tombs of Inti – see Kanawati & McFarlane, *Deshasha*, 24–25, pls. 2, 26, 27; and Kaemheset – see McFarlane, *Mastabas at Saqqara*, 33–34, 48, pls. 2 [a], 10, 11 [a-c].

735 Khunes – see LD II, 108.

736 Davies, *Ptahhetep & Akhethetep I*, 11, pls. 21, 24; Paget & Pirie, *Ptah-hetep*, 29, pl. 33.

737 Badawy, *Nyhetep-Ptah & Ankhmahor*, fig. 27, pl. 30; Kanawati & Hassan, *Ankhmahor*, pls. 19, 55[b].

Cemetery, Saqqara, contains five instances of decorations relating to this individual theme,[738] including the only recorded circumcision scene.[739] This one tomb accounts for more than one third of all the attestations for this theme in the Sixth Dynasty. In an equivalent fashion, the tomb of Khentika, in the same cemetery, also contains many decorations relating to this theme,[740] including a recently identified circumcision scene.[741] Similarly, the tomb of the twins, Niankh-khnum and Khnumhotep, in the Unis Cemetery, Saqqara, personal groomsmen to the king, contain almost one-half of the decorations related to this theme in the Fifth Dynasty.[742] Therefore, three tombs, combined, represent almost two-thirds of the attestations. Because these individual tombs contain such a large share of the data, it seems judicious to partially ignore them when relating the investigation to the hypothesis under examination. Another issue that may skew the data is the increasing tendency for the elite to be buried in the provinces, so that the 'Memphite style' may has travelled with them.[743] This is even more interesting when, as identified later, many of the new themes emphasising resource based scenes, seem to have become significant initially in these same provincial tombs.

Scene Type: Positive Trends

From the extended database were extracted those scene types whose data demonstrated an increase in the overall proportion, when compared to other depictions produced at the same time; i.e. during the Sixth Dynasty (see Table 7: Scene types: Positive trends – D6 onwards). Notice that the vast majority of scene types that show an increase in proportion over the Sixth Dynasty exhibit characteristics that suggest a growing reliance on non-agricultural food sources. Other potentially significant positive trends are some selected scenes within those depicting *Orchard* and *Gardening* scenes (Themes 5 and 6), whose combined total are still quite low compared to many of the other types of decorations.

---

738 These include five scene types: 13.4 Manicure scene, 13.5 Pedicure scene, 13.6 Massage scene, 13.8 Circumcision scene and 13.9 Mouth-examination scene.

739 Badawy, *Nyhetep-Ptah & Ankhmahor*, 19, fig. 27, pl. 30; Kanawati & Hassan, *Ankhmahor*, 49–50, pls. 19, 55b.

740 Wreszinski, *Atlas III;* James & Apted, *Khentika,* pl. 11. This tomb includes three scene types: 13.4 Manicure scene, 13.5 Pedicure scene and 13.6 Massage scene.

741 Ebbel, p.*Ebers*, 115. Megahed & Vymazalová, *Circumcision*, 161–162, suggest, however, that the scenes supposedly representing circumcision actually represent the ritualised shaving of the pubic areas as a sign of cleanliness, while Spiegelman, *Emergency Surgery?* 91–100, suggests it is a procedure resulting from some injury.

742 Moussa & Altenmüller, *Nianchchnum & Chnumhotep*, Taf. 21, 27a; Abb. 10.

743 Swinton, *Dating Tombs*, 171.

Table 7: Scene types: Positive trends – D6 onwards

Scene Type Positive Trends D6+	6. Gardening
	6.3. Cultivating and harvesting vegetables in a garden
1. Marsh-related activities	7. Bird procession and poultry yard scenes
1.1. Spear-fishing and/or fowling scene	7.2. Poultry-yard scene
1.7. Cattle fording a canal or stream	7.3. Force-feeding poultry
1.10. Men gathering reeds or lotuses in a marsh (excluding artificial pools)	9. Food Preparation and Brewing
1.16. Fishing with a large net, set from boats	9.1. Disembowelling and/or skinning an animal
1.17. Fishing with a funnel trap	9.2. Preparing red meat for consumption
1.18. Fishing with a rounded basket trap, or carrying fish in a basket trap	9.3. Preparing fowl for consumption
1.19. Fishing with a hand-held net	9.6. Stages of bread making, with or without brewing
1.20. Boatmen spear-fishing in a marsh (excluding the major figure)	10. Workshop activities
1.21. Angling from a boat	10.3. Jewellery making
1.23. Fish-bearer(s)	10.5. Metal work
1.24. Fishermen registering their catch for distribution by scribes	10.6. Painting onto a screen
1.27. Net-making or repairing a net	10.9. Staff fashioning
2. Desert and desert-related activities	11.Commerce, including management of workers and possessions
2.1. Desert-hunt or desert-landscape scene	11.7. Tomb owner conveyed in a palanquin, probably to inspect possessions
2.2. Hunters returning from the desert with game	11.9. Palanquin seat and its occupant set down after transportation
4. Pastureland and animal husbandry	12. Dance, music and games
4.1. Fighting bulls	12.4. Lone musician entertaining workers
4.2. Livestock browsing in pasture	12.8. A board-game called 'senet', or 'draughts'
4.4. Cow giving birth	12.10. Children's games
4.7. Goats in or near trees	15. Funerary rites and funeral scenes
4.9. Force-feeding hyenas	15.4. Ceremonies in front of a statue, before or after its transportation
5. Orchard scenes	15.5. Jars of oil or wine conveyed by sledge to a tomb
5.4. Trapping song-birds in hand-set traps	15.7. Mummification and funeral procedures

In a similar fashion, the combined total number of scenes depicting *Desert* scenes is still low, when compared to the other categories. However, the significant increase in overall proportion is nonetheless noteworthy. If the drought were so significant, then it was expected that more tombs should be depicting a desert scene; and this was seen to be the case with *Desert-related activities* (Theme 2) continuing to be depicted right into the end of the Old Kingdom, with many new subtleties and refinements added to the repertoire.[744] Some tomb owners chose to depict only this theme in their tomb,[745] though only one Sixth Dynasty tomb owner, Nehwet-Desher-Meri,[746] chose to do so.

An increase in scenes depicting cattle as desert animals, at the same time as a decrease in cultivation of all forms infers that the society may have come increasingly more reliant upon mobile wealth. Scenes depicting the preparation of food and drink increased by almost two-

744 In a conversation with Miroslav Bárta, in June 2014, he pointed out that, in his opinion, the variety and complexity of decorations related to this theme increased. This idea is investigated, and the results are presented in Chapter 10.

745 For example, the 4th Dynasty tombs of Methen and Minkaef. For an extended discussion on the significance of desert hunt scenes and climate change, see Chapter 10.

746 Kanawati, *Akhmim* VIII, 12, pls. 2a, 8a, fig. 3b.

thirds, evidence suggesting a growing concern with an adequate supply of food. Interesting, too, is the fact that, as a proportion of the overall sample, scenes depicting marshland-related activities increased slightly at the same time as did those scenes depicting the desert. If the drought was encouraging a bloom in riverine plants, then this seems reasonable. Also noteworthy is that, in a drought, we appear to have a decrease in the depiction of men utilising large nets set predominantly from boats. At the same time, however, an increase in scenes depicting fishing activity on the river's edge; with people using traps and smaller nets, is noted.

5.4 – Resources: A Need to Re-arrange the Data?

While the OEE Scene details Database provided an effective baseline for the initial overview, its value for continued utilisation needed to be further assessed and evaluated. The Database was designed with different thematic imperatives in mind to that performed in this study. Therefore, we are limited by the initial classifications of the designer of the database. This does not suggest that some of the decorative elements may be counted more than once, but entries appear in places where they may be less than helpful in understanding the artistic progression for the current investigation.

For example, there are nine Oxford scene-detail categories relating to birds and poultry, but they have been grouped into four different themes: *Marshland activities*, *Orchard* scenes, *Bird procession and poultry-yard* scenes and *Food preparation* scenes all contains scenes depicting birds. Similarly, some scenes depicting fishing and its associated techniques and technologies have been classified into the *Marshland* theme, whereas those scenes depicting the consequences of fishing have been categorised into the theme relating to *Food preparation*. Similarly, scene details depicting cattle in various stages of their life cycle are categorised into three different themes: *Marshland activities*, *Pastureland* scenes, and *Food preparation*.

A Resource-based analysis may be needed

The categories of themes as it exists is difficult to relate to the A.R.I.D. hypothesis because the flow of the investigation from the ecological evaluation then becomes focussed on potential resource changes within the environment. For the purpose of this investigation, it may be of added value to investigate all the scenes that focus upon one basic type of resource together. If the role of cattle were to be investigated by tomb decorations depicting them, it would seem practical to cluster all the cattle-related decorations together. It was therefore resolved to link 'resource-related' scene details together under 'resource group' subject headings. This should enable a more coherent exploration of the importance or otherwise of changing patterns in tomb decorations. Areas to be investigated will be those relating to the acquisition, exploitation and regulation of food-based resources.

The resource groups are as follows:

A. CULTIVATION – *The Growing, Recording, Storage and Distribution of Food*
B. FISHING – *Fishing Techniques, Technologies and Associated Activities*
C. AVIAN – *Avian and Associated Attestations, including Waterfowl*
D. PASTURELAND – *Cattle, Pastureland and Animal Husbandry Activities*
E. DESERT – *Desert Activities*

When the data is re-arranged into resource groups, a clearer picture begins to emerge. The narrative of the decoration changes suggest that the consequences of the hypotheses outlined in Chapter Four seems valid. For the complete record showing the themes re-arranged into Resource groups, see ARID_Appendices. Sheet 4: Resource_Group_Numbers)

Table 8: CULTIVATION – The Growing, Recording, Storage and Distribution of Food

CULTIVATION

Date	Pre-D6		D6 On	
Description	ΣT	%	ΣT	%
3.1. Agricultural sequence, from hoeing to stacking grain	78	5.6%	47	5.3%
3.2. Filling granaries and issuing, measuring or recording grain-seed	18	1.3%	8	0.9%
5.1. Gathering fruit from trees	9	0.6%	5	0.6%
6.1. Hoeing, to prepare or maintain a garden	1	0.1%	0	0.0%
6.2. Watering a garden	7	0.5%	4	0.5%
6.3. Cultivating and harvesting vegetables in a garden	6	0.4%	4	0.5%
6.4. Growing papyrus or lotuses in a man-made garden pool	5	0.4%	2	0.2%
8.1. Gathering grapes or dates	14	1.0%	7	0.8%
8.2. Treading grapes or dates in a vat	14	1.0%	6	0.7%
8.3. Extracting juice in a wine press or date press	14	1.0%	5	0.6%
8.4. Filling, sealing, recording and/or storing jars of wine	11	0.8%	3	0.3%
8.5. Decanting oil	0	0.0%	2	0.2%
8.6. Extracting oil in an oil press, and mixing oil	3	0.2%	0	0.0%
8.7. Filling, sealing, recording and/or storing jars of oil	4	0.3%	0	0.0%
11.1. Market scene	8	0.6%	3	0.3%
SUBTOTAL + PROPORTION	192	14%	96	11%
VARIANCE			**-21%**	

Overall, the relative importance of themes relating to the growing of food decreases over the time frame in question. Scenes representing the agricultural sequence decreases slightly, whereas those decorations relating to orchards and the growing of papyrus decrease significantly. Decorations relating to gardening appear to maintain their relative importance.

While there was a very slight, insignificant, increase in representations depicting food, depictions of its storage and distribution declined considerably. From the Fifth to the Sixth Dynasty, the relative proportion of food recording, storage and distribution themes decreased by more than one-third when compared to 'pre-drought' times. This activity was thought to be one of the major drivers for the development of administration during the Predynastic era, yet it is declining considerably. Perhaps this can be linked to a decrease in overall production, resulting in less surplus, resulting in a decline in food available for re-distribution? If an increase in attestations suggests an increase in eminence, then the importance of bread to the society is becoming predominant. Representations depicting the stages of bread-making are the only ones in this category that increased both in raw number and proportion of the total. This decline in cultivation and the importance of bread will be discussed in more detail in Chapter 6, 'Cultivation and A River In Drought'.

Table 9: FISHING – Fishing techniques, technologies and associated activities

FISHING				
Date	**Pre-D6**		**D6 On**	
Description	**ΣT**	**%**	**ΣT**	**%**
1.1. Spear-fishing and/or fowling scene	31	2.2%	59	6.7%
1.15. Dragnet or seine-netting scene	55	3.9%	31	3.5%
1.16. Fishing with a large net, set from boats	3	0.2%	3	0.3%
1.17. Fishing with a funnel trap	3	0.2%	8	0.9%
1.18. Fishing with a rounded basket trap, or carrying fish in a basket	5	0.4%	4	0.5%
1.19. Fishing with a hand-held net	14	1.0%	10	1.1%
1.20. Boatmen spear-fishing in a marsh (excluding the major figure)	0	0.0%	2	0.2%
1.21. Angling from a boat	14	1.0%	19	2.1%
1.22. Fish-gutter cleaning a recent catch of fish	29	2.1%	9	1.0%
1.23. Fish-bearer(s)	25	1.8%	21	2.4%
1.24. Fishermen registering their catch for distribution by scribes	0	0.0%	2	0.2%
1.27. Net-making or repairing a net	4	0.3%	7	0.8%
1.28. Drying a fishing net after use	1	0.1%	1	0.1%
9.4. Preparing fish for consumption (excluding fish-gutting)	5	0.4%	1	0.1%
SUBTOTAL + PROPORTION	189	13.5%	177	20.0%
VARIANCE	**+47%**			

As identified earlier, a reduced inundation and a weaker river flow would have led to an increased retention of nutrients within the river. This would have led to an increase in some aquatic plant numbers, which would have impacted upon the diversity and variety of habitats that may have developed. This change would affect the fish populations as a consequence.

The apparent increasing importance of fishing and its associated activities will be expanded upon in Chapter 7, 'Fishing and A River In Drought'.

Table 10: AVIAN – Avian and Associated Attestations, including Waterfowl

AVIAN

Description / Date	Pre-D6 ΣT	Pre-D6 %	D6 On ΣT	D6 On %
1.13. Clapnet or bird-trapping scene	16	1.1%	7	0.8%
1.14. Workers placing captured marsh birds in cages	16	1.1%	7	0.8%
5.2. Netting song-birds in an orchard	11	0.8%	4	0.5%
5.3. Trapping song-birds in a clapnet	1	0.1%	0	0.0%
5.4. Trapping song-birds in hand-set traps	0	0.0%	3	0.3%
7.1. Bird-procession scene	40	2.9%	7	0.8%
7.2. Poultry-yard scene	3	0.2%	12	1.4%
7.3. Force-feeding poultry	3	0.2%	8	0.9%
9.3. Preparing fowl for consumption	23	1.6%	22	2.5%
SUBTOTAL + PROPORTION	113	8.1%	70	7.9%
VARIANCE	**-3%**			

A slight decline in overall abundance occurs. However, if we focus upon the subset relating to only poultry, a significant increase in representations of that one food category, at the expense of the other avian attestations, can be noticed (see Table 11: Waterfowl).

Table 11: Waterfowl

WATERFOWL

Description / Date	Pre-D6 ΣT	Pre-D6 %	D6 On ΣT	D6 On %
1.14. Workers placing captured marsh birds in cages	16	1.1%	7	0.8%
7.2. Poultry-yard scene	3	0.2%	12	1.4%
7.3. Force-feeding poultry	3	0.2%	8	0.9%
9.3. Preparing fowl for consumption	23	1.6%	22	2.5%
SUBTOTAL + PROPORTION	45	3%	49	6%
VARIANCE	**+71%**			

Although this large increase in poultry scenes may be eye-catching, it is important to realise that the proportion is an increase over a small sample set; nevertheless, the increase is highly suggestive. An increase in representations of an apparently unimportant and unpretentious animal group such as poultry, as a part of tomb scenes, does warrant some discussion. This will be expanded upon in Chapter 8, 'Poultry and A River In Drought'.

Table 12: PASTURELAND – Cattle, pastureland and animal husbandry activities

PASTURELAND				
Date	Pre-D6		D6 On	
Description	ΣT	%	ΣT	%
1.7. Cattle fording a canal or stream	32	2.3%	22	2.5%
4.1. Fighting bulls	1	0.1%	16	1.8%
4.2. Livestock browsing in pasture	6	0.4%	9	1.0%
4.3. Cattle mating in pasture	11	0.8%	7	0.8%
4.4. Cow giving birth	20	1.4%	15	1.7%
4.5. Milking a cow	29	2.1%	19	2.1%
4.6. Hobbled and tethered calves	16	1.1%	3	0.3%
4.7. Goats in or near trees	12	0.9%	15	1.7%
4.8. Feeding domesticated animals by hand	29	2.1%	15	1.7%
4.9. Force-feeding hyenas	1	0.1%	4	0.5%
4.10. Overseer seated near animal-tending activities	14	1.0%	2	0.2%
9.1. Disembowelling and/or skinning an animal	7	0.5%	5	0.6%
9.2. Preparing red meat for consumption	11	0.8%	17	1.9%
SUBTOTAL + PROPORTION	189	13.5%	149	16.8%
VARIANCE	+24%			

In total number, there are almost as many attestations of cattle and pastureland-related depictions in the Sixth Dynasty as there are during the Fourth and Fifth Dynasties combined As an overall proportion, despite the apparent 'decline' at the end of the Sixth Dynasty, this scene type incorporates a greater proportion of tomb wall scenes. With an increase in total volume of papyrus and phragmites plants proposed, it is to be expected that the overall number of grazing animals would have increased in consequence, and therefore, depictions of these should have increased in a corresponding manner. The perceived increased significance of 'mobile sources of food' and the rise of the southern cattle barons will be expanded upon in Chapter 9, 'The Rise of Cattle and A River In Drought.'

Table 13: DESERT – Desert Activities Desert activities

THE DESERT				
Date	Pre-D6		D6 On	
Description	ΣT	%	ΣT	%
2.1. Desert-hunt or desert-landscape scene	20	1.4%	16	1.8%
2.2. Hunters returning from the desert with game	6	0.4%	5	0.6%
SUBTOTAL + PROPORTION	26	1.9%	21	2.4%
VARIANCE	+27%			

It seems quite consistent for an increase in depictions of the desert hunt to have occurred during the 'drought'. As the land began to dry out due to lower-than-average inundations, the ecotone, "*the region where one type of habitat or natural environment meets another*",[747] would have thinned, leading to a merging of the desert and the riverside ecosystems. This will be expanded upon in Chapter 10, 'The Desert and A River In Drought'.

Theme Proportion Changes and A River In Drought

During the Sixth Dynasty, the proportion of decorative features related to the actual growing of food decreased slightly. So, too, did those wall scenes relating to the storage, distribution and preparation of food. This may suggest an apparent decline in the relative importance of agriculture. Representations depicting the stages of bread-making are the only ones in this category that increased both in raw number and overall proportion. If an increase in attestations suggests an increase in apparent eminence, then the importance of bread to the society is becoming predominant. The relative proportion of scenes depicting birds and their trapping around orchards, declined. However, representations depicting poultry and waterfowl increased significantly, as did fishing and pastureland activities. Interestingly, the only theme in which *every* decoration sub-scene type proportionately increased was that of *Desert*.

[747] http://dictionary.cambridge.org/dictionary/english/ecotone (Aug. 31, 2017).

5.5 – A Changing Emphasis in Tomb Decoration?

Despite paleo-ecological, paleoclimatic and archaeological evidence of an increasing dryness in the Nile valley, marshland scenes remained the most significant proportion of tomb decorations. If agriculture were declining, it would be expected that the relative proportion of scenes representing activities related to the Desert Hunt might increase, as is the case. The changes in the distribution and abundance of tomb decorations may lead to the development of a potential 'visual narrative' regarding the acquisition, exploitation and distribution of resources over the time frame under investigation. This narrative as depicted by the change in tomb decorations during the period of the Old Kingdom and may allow us to infer a changing environmental situation.

It appears that, from the data presented, a new preoccupation seems to have arisen amongst those producing decorative features for tombs. A larger than usual proportion of wall scenes depicted scenes about or alongside the river. In times of drought, the normal expectation would be that food becomes scarcer and increasingly precious. As outlined previously, if the river did not flood, leading to a drought upon the land, the resources remaining within the river should encourage a rapid growth of riverine and riverbank plants.

While the potential impact of the drought is thought to have been over-rated, it appears that the effects were being noticed by tomb owners and artists. It is also noteworthy that, though the 4200BP event was a significant factor in driving environmental change, the gradual aridification of the Nile Valley had begun earlier.[748] From the time of Niuserra onwards, administrative reforms were continuously enacted to attempt to improve the state's efficiency,[749] and changes in the art can be spotted from his reign onwards, which may link to an underlying motive for these administrative changes. The relative proportion of decorations relating to the exploitation of resources increased over the time frame in question.[750] It may be relevant to note what was happening in the few generations before the onset of the 'drought'.

---

748 Seidlmayer, *Old Kingdom Elephantine*, 108–127.

749 Bárta, *Long Term Short Term*, 183–186, summarises some of the reforms, including marriage alliances with potentates as well as administrative changes, attempted by the kings of the latter Fifth Dynasty.

750 Bárta, *Punctuated Equilibrium,* 12–13.

Fishing and Fowling in the Marshes in A.R.I.D times

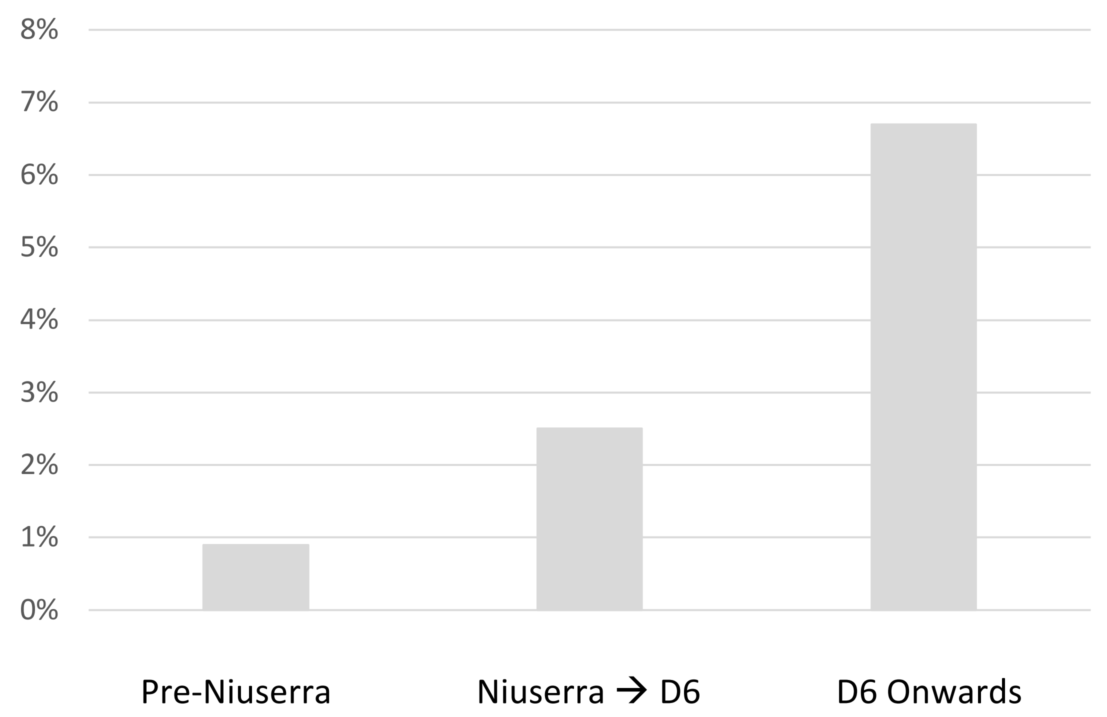
Depictions of the tomb owner fishing and/or fowling increased by more than seven times from the earlier Old Kingdom to the end of the Sixth Dynasty (see Table 14: Fishing and fowling in the marshes: total numbers.)

Table 14: Fishing and fowling in the marshes: total numbers

Fishing and Fowling	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Total numbers of attestations	2	29	59

While raw numbers show an absolute increase, the relative proportion of fishing and fowling scenes, compared to other attestations indicates the apparent increasing significance of this feature being added to a tomb's decoration programme (see Figure 30: Fishing and fowling in the marshes: overall proportion change), especially considering this is a time when it has been suggested that the river became a more attractive haven for fishes and bird species.

Figure 30: Fishing and fowling in the marshes: overall proportion change



SUMMATION: CHAPTER FIVE

An Unfolding Ecological Narrative?

The basic arguments arising from this chapter include:

⇒ A distribution and abundance of tomb scenes types in tombs from Dynasty Four to Dynasty Eight showed changes in the progression of the tomb decoration programme.

⇒ Despite average tomb sizes increasing, some themes did not persist throughout the period, while new theme types entered the tomb decoration programme.

⇒ The relative proportion of some scene types, when compared to all attested scenes, changed over the time frame under investigation.

⇒ Changing the analysis to one that investigated the art based on the scenes' subject indicated that scenes depicting the growing, storage and preparation of food declined in overall proportion compared to the total.

⇒ Those scenes depicting activities in the marshlands, such as fishing and catching waterfowl, scenes with the desert as a subject and those scenes relating to the exploitation of cattle increased in apparent importance.

As outlined in Chapter Four, the changing riverine ecological situation that was predicted indicated a less reliable agricultural output would be expected. Changing food web conditions suggested that fish numbers would have increased, bird habitats would have changed, and more cattle food become available. This appears to be the case from the initial statistical analysis. Changing environmental circumstances could also be the 'inspiration' behind the increasing detail in scenes depicting the desert hunt. For the unfolding 'narrative' of these changes, see ARID_Appendix_4_Narrative_Summaries. A more detailed investigation into the posited environmental changes and their potential societal impact follows.

CHAPTER SIX

CULTIVATION'S DECLINE AND A RIVER IN DROUGHT

6.0 – INTRODUCTION

In Chapter Five, it was noted that the relative proportion of decorative features relating to the cultivation of food appeared to have decreased significantly over the time frame of this investigation. Representations of the storage and distribution of resources decreased by an even greater amount. This led to the inference that the relative prominence of cultivation and the distribution of its produce decreased over the time frame of this investigation. Regular lower-than-usual inundations may have influenced the tomb owners and artists in their choice of subject matter for tomb decorations produced at this time.

In this chapter, the chronicle of changing artistic representations of cultivated resources will be outlined in greater depth, and the possible impact of declining resources upon Old Kingdom society will be assessed.

6.1 – CULTIVATION'S DECLINING IMPORTANCE

Despite agricultural scenes having more than twice as many attestations in the OEE Scene-details Database as those depicting orchards and gardens, more variation in scene types are offered for the latter category. Classification of decorations depicting the agriculture sequence within the database have been broken down into only two scene types, whereas eight scene types have been assigned to those decorations related to orchards and gardening. This does not imply that, to the database designer, the subject was not as important but is a function of the database design itself.

The variety of scene types within each category was important. Within the first scene type, 3.1. *Agricultural sequence, from hoeing to stacking grain*,[751] the database offers fifteen scene details, suggesting the possibility of a narrative sequence.[752] They are as follows:

3.1.1. Hoeing, to prepare the ground for sowing
3.1.2. Sowing seed on prepared ground
3.1.3. Ploughing, to prepare the ground or to cover sown seed
3.1.4. Workers driving sheep over sown seed
3.1.5. Flax harvest
3.1.6. Tying flax into bundles
3.1.7. Grain harvest
3.1.8. Gleaner, either gleaning or accompanying workers returning home with grain
3.1.9. Tying grain-stems into bundles
3.1.10. Donkeys arriving at a grain field to be loaded with sheaves
3.1.11. Filling or closing sacks of sheaves near a grain field
3.1.12. Loading donkeys with sacks of sheaves, and transporting sheaves on donkeys
3.1.13. Throwing tied or untied sheaves onto a stack ready for threshing
3.1.14. Donkeys, cattle or sheep trampling grain-stems on a threshing-floor
3.1.15. Winnowing, stacking winnowed grain or chaff, and/or decorating stacks of grain

This appears to be a nicely flowing sequence and the progression within the decorations can be traced along the walls of the tombs that contain them. An 'instruction manual' for agricultural production in the afterlife may have been necessary; if so, then tomb decorations would have been placed in an optimal position to recount these guidelines. It would be expected, therefore, that those scenes depicting the process of agriculture should follow a specific sequence. (see Figure 31: Collage depicting the agricultural sequence).

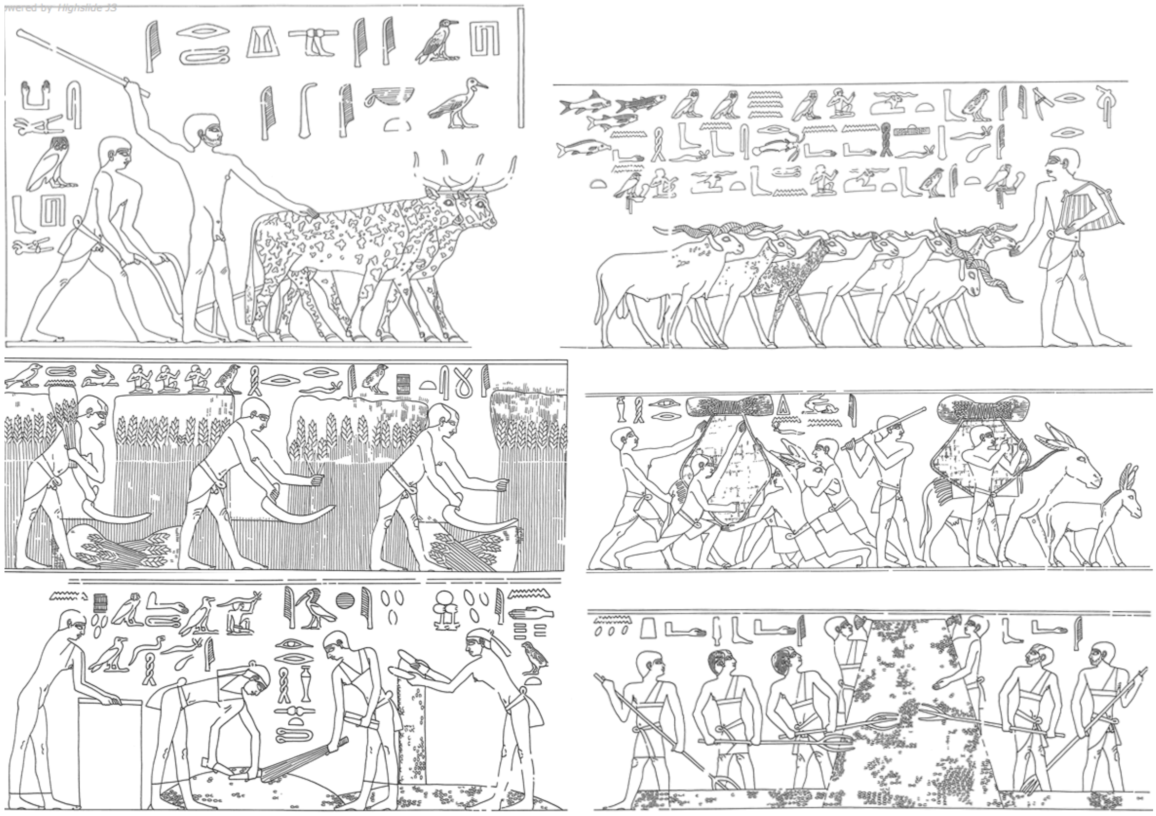
---

751 http://archaeologydataservice.ac.uk/archives/view/oee_ahrc_2006/queryThemes.cfm?section=details&theme=3.1&CFID=31a6a0ea-f5d6-4391-8c19-9e4828e22377&CFTOKEN=0 (May 12, 2016).

752 Kanawati, *Tomb & Beyond*, 88. See Murray, *Cereal Production*, 515–526, for a summary of the process in its entirety.

Within the tomb of Ty, for example, almost the entire progress of activities of the agricultural cycle has been depicted,[753] enabling anyone to follow the sequence and complete the activities themselves – a complete 'narrative', is presented.[754]

Figure 31: Collage depicting the agricultural sequence



Modified from OEE Scene-details Database, http://archaeologydataservice.ac.uk/catalogue/adsdata/arch-686-1/dissemination/gif/Agriculture/3_1.gif (May 12, 2016).

With regard to the representations of barley and flax harvesting, most provincial tombs display the harvesting sequence in the correct order, in some form of visual narrative.[755] For the production of linen, flax needed to be harvested 'green' whereas barley was harvested 'dry' in order to facilitate the ease of removal of the crop.[756] The correct sequence is shown

753 Wild, *Ti*, II, pls. 78–79 [A, B] (details), 112–113; and III, pls. 136–139 [A, B] (details), 151–154.
754 Siebels, Agricultural Scenes, 55–64.
755 See, for example, the commentary in Davies, *Sheikh Saïd*, 19–23.
756 Siebels, *Agriculture*, 118–119.

in Old Kingdom tombs at Sheikh Said,[757] Meir,[758] Deir el-Gebrawi[759] and at El-Hahawish.[760] If the artists were careful to indicate the correct order of harvesting, then it is reasonable to suspect that their other renditions may have been completed with a similar accuracy.[761]

Changes to the proportion of representation of agriculture

According to the 'A River In Drought' hypothesis as outline in Chapter Four, a diminishing amount of available water would have led to less irrigation water available for cultivation. Attestations for the agricultural sequence become less regular from the time of Niuserra onwards and continue their relative decline into the Sixth Dynasty with the proportion of all scenes depicting agricultural practices declining (see Table 15: Agriculture sequence: Overall proportion pre- and post Niuserra).

Table 15: Agriculture sequence: Overall proportion pre- and post Niuserra

Agricultural Sequence	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall Proportion	6.0%	5.5%	5.3%

If the composition of decorative programmes was *not* affected by a changing environment, then it would be expected that no significant change would be noticeable in the data, but during the Sixth Dynasty, the proportion had declined significantly (in statistical terms) from before the time of Niuserra. The combined data relating to those decorations indicate a small but statistically meaningful decline in the relative importance of this aspect of everyday life into the Sixth Dynasty (see Figure 32: Agricultural sequence: proportion change over time). Considering the cornerstone role of agriculture in the society, this is a significant factor that needs further investigation.

757 Davies, *Sheikh Saïd*, pl. 16.

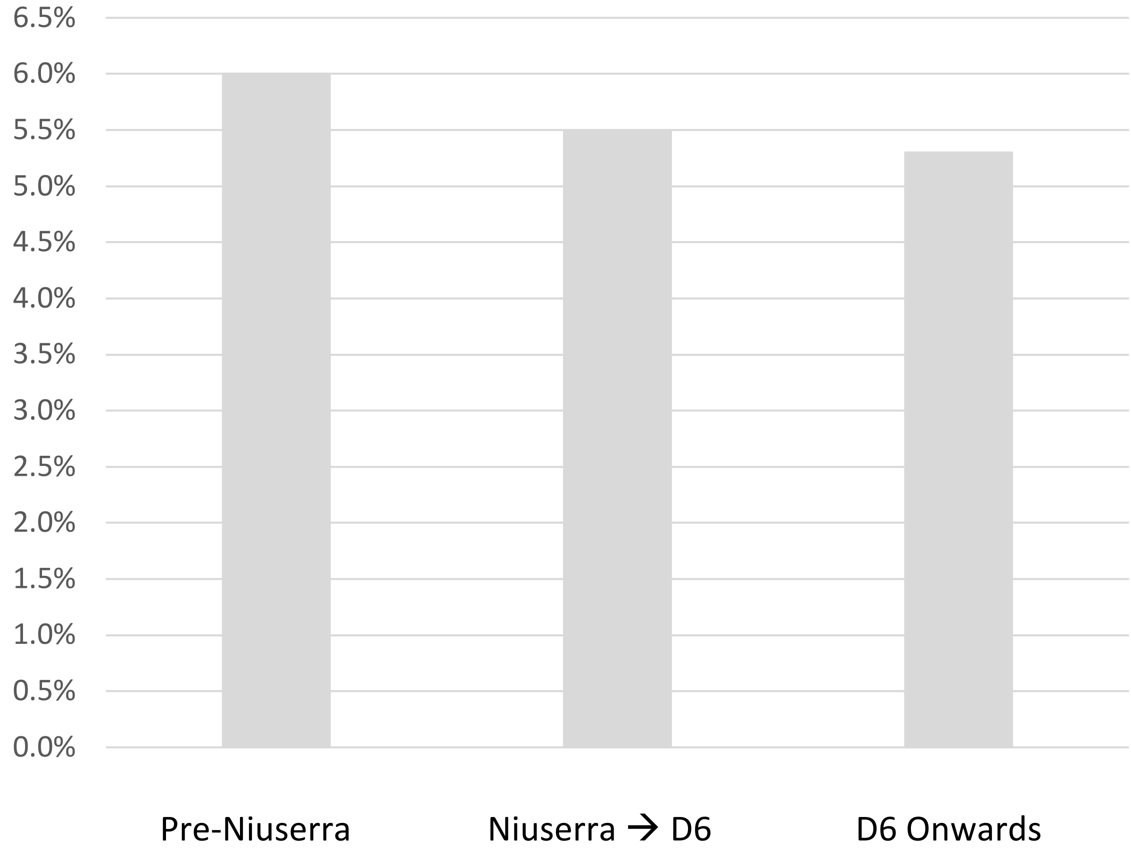
758 For the tomb of Pepyankh the Black, see Blackman & Apted, *Meir* V, pl. 22, updated in *Kanawati & Evans*, *Meir* II, pls. 83–84. For the tomb of Pepyankh the Middle, see Blackman, *Meir* IV, pl. 14, updated in Kanawati, *Meir* I, pl.84.

759 For the tomb of Ibi, see Kanawati, *Deir El Gebrawi II*, 42–43; though the image in Davies *Deir El Gebrâwi* II, pl. 6 is less damaged. For the tomb of Djau:Shemai, see Kanawati, *Deir el-Gebrawi* III, pl. 14–15, where the colour photography indicates artist has depicted then stalks green.

760 For the tomb of Hesimin, see Kanawati, *El-Hawawish* IV*,* fig. 18.

761 Murray, *Cereal Production*, 507.

Figure 32: Agricultural sequence: proportion change over time.



Cultivation and A River In Drought

The decline in the apparent importance of cultivation may be explained by the application of the A.R.I.D. hypothesis. Since agriculture relied on the regular inundation to provide a fertile floodplain:[762] if the river did not overflow its banks, reducing its potential benefits to cultivation,[763] the this would have resulted in a lower yield. In times of a less reliable river, it would become, therefore, more important to utilise what water was available in the most effective manner. The impetus to use water more efficiently, for example raising water significantly above low water to aid in the formation of more permanent irrigation channels, was one of the factors driving the adoption of the shadouf in later times.[764]

762 Hildebrand & Schilling, *Early Nile Agriculture*, 92–93.
763 Murray, *Cereal Production*, 513.
764 Haldane & Henderson, *Egyptian Shadouf*, 308. Much commentary about Egyptian irrigation is related to time frames later than those occurring in this investigation, see for example, the commentary on techniques and technologies of irrigation in Murray, *Cereal Production*, 513–515.

Barley versus Wheat

Barley (*Hordeum vulgare*) and emmer wheat (*Triticum dicoccum*) have been domesticated for almost 11,000 years.[765] They spread from the Near East to North Africa,[766] with the oldest known sample dated to about 6,500 years ago, but perhaps a little earlier.[767] In Egypt, the archaeological record suggests that the domestication of wheat occurred before that of barley.[768] Wheat is more nutritious than barley, but if barley is not de-husked, its food value increases.[769] While there is a significant negative difference in the nutritional values of the wild versus domesticated version of each of the cereals,[770] it is more important to compare the differences between the two cereals when assessing their use during changing environmental circumstances. As yet, there seems to be no evidence of a genetic change in barley or wheat in response to a changing environment.[771]

Changing environmental circumstances may be the reason that, since textual evidence from the late Old Kingdom suggests that barley had become comparatively more significant than wheat.[772] Despite the cereals being of different species, there does not appear to have been any distinction between barley and wheat artistically.[773] An apparent archaeological abundance of this grain over emmer in certain areas may be an indicator of a larger number of kept animals, rather than human dietary preferences, however, so this factor is needed to be incorporated into future investigations. With increasingly sophisticated technology, the ability to observe more precise changes in the archaeo-botanical record will enable a clearer understanding of any changes to the agricultural cycles that may represent adaptive changes to a changing environment.[774]

---

765 Zohary & Hopf, *Domestiction of Plants*, 105, 174–176; Zeder, *Origins of Agricultur*e, 221–235.
766 Mascher et al., *History of Barley*, 1091–1092, figs 2 & 3.
767 Perhaps at least 7,000 years: Madella et al., *African Domestic Cereals*, 6, updating Wendrich et al., *Fayum Neolithic*, 999–1002.
768 Wetterstrom, *Foraging & Farming*, 203–213.
769 Eitam et al., *Barley Flour Production*, 5.
770 Hebelstrup, *Wild versus Domesticated Grains*, 1–4.
771 Mascher et al., *Barley Genomics,* 1092.
772 Dr Joyce Swinton, Macquarie University (*pers. comm. from a work in preparation).*
773 Murray, *Cereal Production*, 512.
774 Day, *Botany meets Archaeology*, 5807.

Barley More Reliable Than Wheat?

Despite emmer wheat displaying a high pest and disease resistance and with a relatively good tolerance to stress,[775] barley may have been appreciated as a more versatile crop, with husked barley making good livestock feed.[776] Barley is a more flexible crop, usable for fodder, food and brewing;[777] perhaps this versatility led to its increasing use,[778] with barley seen as more valuable for its brewing potentialities than its nutritional value.[779] There does not appear, however, any direct correlation between the availability of cereal and its 'price';[780] one reason perhaps why attempting to guarantee supply became more problematic for administrations at the time.[781]

While wheat is a better competitor in ideal conditions, with a greater yield and a more easily harvestable seed,[782] barley displays particular properties that make it more attractive when the environmental circumstances are less than ideal. As cultivation became more difficult due to a decrease in surplus water, wheat production declined[783] but barley production seems to have increased. Barley tolerates greater ecological extremes than wheat and can thrive in poor soils with low nutrition levels.[784] Compared to wheat, barley is more resilient in disturbed environments,[785] allowing it to more rapidly recover in soils turned over by foraging cattle, for example. Wild barley was found in a broader geographical range than wild varieties of wheat, and cultivated barley can endure a wider range of environmental conditions than wheat,[786] a situation to be expected if the Nile did not flood as regularly. With an irregular supply of water and an increasingly arid habitat, perhaps the environmental situation now favoured barley cultivation over wheat.[787]

---

775 Bilalis et al., *Mediterranean Innovation*, 328–329.
776 Kumar, *Health at Hierakonpolis*, 41.
777 McCorriston, *Barley*, 82, 86–88.
778 Willems et al., *Wadi Zabayda*, 315.
779 Katz & Voight, *Bread & Beer*, 23–34;
780 Murray, *Cereals*, 528, identifying that the laws of supply and demand appear to have been suppressed.
781 Bard, *Archaeology of Ancient Egypt*, 138–139, 176–177.
782 Ladizinsky, *Wild Cereals Collection*, 264–267.
783 Murray, *Cereals*, 506, summarising the role of cereals in the maintenance of a stable society.
784 McCorriston, *Barley*, 86–87; Hillman & Davies, *Domestication Rates*, 157–159.
785 Zohary, *Barley's Nature & Origin*, 27–31.
786 Zohary & Hopf, *Domestiction of Plants*, 39–47, 51–58.
787 Sherratt, *Water, Soil & Seasonality*, 319.

Flax Failures?

Despite the origin of flax being unclear,[788] there exists almost ten thousand years of archaeological history of this resource.[789] Not a native to Egypt, with most evidence suggesting that it arrived in Egypt from the Levant in Pre-dynastic times,[790] flax was established in a time when excess water was more readily available, and was well-known before Pharaonic times.[791] As a taxable commodity, flax made its presence felt in the archaeological record.[792]

While the new technique of spinning thread for cloth would be depicted early in the Middle Kingdom,[793] this was not practiced earlier; and a decline in quality of weaving and a decrease in quantity of flax production during the First Intermediate Period has been noted.[794] The 'retting' of linen, where the outer bark is removed from the material, required large amounts of running water.[795] Poor soil nutrition, for example, results in a coarser linen,[796] making it a less desirable commodity. The demand for such products should not have diminished,[797] so other factors must be suggested to explain this drop-off.

Flax's need for high soil moisture suggests that its growing circumstances may have been hindered during the time frame of our investigation.[798] Flax requires minimum disturbance to maximise its yield.[799] A low-disturbance environment would become less likely as the river became weaker and more human and animal activity disturbed the ecotone. Flax experiences 'drought-stress', leading to a decline in productive output during periods of low water supply,[800] and suffers when the water supply is slightly saline.[801]

---

788 Nag et al., *Flax Overview*, 807.
789 Zohary & Hopf, *Domestiction of Plants*, 105–106, map 1.
790 Vogelsang-Eastwood, *Textiles*, 269.
791 Germer, *Flora Pharaonischen*, 101; Lucas & Harris, *Materials & Industries*, 143.
792 Currie et al., *Agricultural Productivity*, 44; Bard, *Archaeology of Ancient Egypt*, 138–139, 176–177
793 Vogelsang-Eastwood, *Textiles*, 269–270; Elsharnouby, *Linen*, 15.
794 Tata, *Egyptian Textile Industry,* 78.
795 Elsharnouby, *Linen in Ancient Egypt*, 5–6.
796 Vogelsang-Eastwood, *Textiles*, 270.
797 Tata, *Egyptian Textile Industry*, 58.
798 Nag et al., *Flax Overview*, 807–808; Moghaddam et al., *Salinity & Flax,* 564; Heller & Byczyńska, *Environmental Factors & Flax*, 26, 30–31, 37.
799 Bilalis et al., *Mediterranean Innovation*, 327–328.
800 Heller & Byczyńska, *Traits of Flax Fiber*, 27, 31–34.
801 Moghaddam et al., *Flax Salinity Response*, 571.

Flax's relatively small genome size[802] suggests that it does not have the intrinsic variability of other crops more readily able to adapt to changing environmental conditions. As an environment becomes increasingly saline, another consequence of a low Nile suggested by the A.R.I.D hypothesis, the flax plant experiences significant delay in its germination and growth phases.[803] All these requirements may have led to an interruption in the flax-making process as a riverine 'drought' took hold and may explain why its depictions decreased over the time frame under investigation.[804]

802 Brown et al., *DNA & Archaeobotany*, 212, table 1.
803 Moghaddam et al., *Salinity & Flax,* 572–573.
804 Swinton, *Resources*, 156–158.

6.2 – Gardens, Orchards and A River In Drought

An appreciation of the type of horticulture undertaken or represented in tomb scenes has implications for our understanding of the culture and the ongoing expression of continuity and change.[805] Initially, the role of an ancient Egyptian garden was to simply provide fruit and vegetables, irrigating it with water from the Nile. The earliest gardens were composed of planting beds divided into grids by earthen walls, so the water could soak into the soil rather than run off.[806] Gradually as the country became richer, gardens evolved into pleasure gardens, with flowers, ponds and alleys of fruit and shade trees.[807] By the time of the Old Kingdom, temples, palaces and private residences had their own gardens, and models of gardens were sometimes placed in tombs so their owners could enjoy them in their afterlife.[808]

Garden design theory has been theorised as a combination of three basic aspects: meaning, function and form.[809] Secular gardens were located near the river or canals and were used mainly for growing vegetables. The function of temple gardens was to provide floral, vegetable, and animal offerings and provisions.[810] It is thought that the primary motivator in garden design in ancient Egypt was the representation of its symbolic attributes,[811] with some becoming quite large, and many developing into expressions of individual power. The symbolic function, or its meaning, of tomb gardens was to be available to the spirit of the deceased as a place of shade and refreshment, and to that end they were sometimes illustrated on the walls inside the tomb.[812]

---

805 Jones, *Garden Cultivation*, 171–172.
806 Wilkinson, *Symbolism & Design*, 10–13; Verner, *Ptahshepses*, 67, photos 55–6, pl. 34.
807 To trace this development, see Zohary & Hopf, *Old World Plant Domestication.*
808 Baridon, *Les Jardins*, 103; Wilkinson, *Symbolism & Design*, 4–6.
809 Wilkinson, *Symbolism & Design*, 1.
810 Wilkinson, *Symbolism & Design*, 2.
811 Wilkinson, *Symbolism & Design*, 1. Garden design evolves: from pages 14–15 and in endnotes #3–#6, Wilkinson identifies how garden design can be shown to have progressed from functional to symbolic in many cultures, from the Japanese to the Renaissance, and into the Reformation. It is logical to presume a similar progression in ancient Egypt.
812 Wilkinson, *Symbolism & Design*, 4.

The gardens of each king were different, suggesting these were designed to emphasise different attributes of the king.[813] For example, King Snefru's garden pool was big enough for a boat containing 20 oarsmen;[814] perhaps this is an example of a garden pond whose design foundation had graduated to beyond the simply functional.

Gardens and Orchards at the End of the Old Kingdom

Much that has been written about ancient Egyptian gardens relates to a time later than the Old Kingdom;[815] in describing the design, form and function of Egyptian gardens, Wilkinson uses those of Hatshepsut as his model, with fewer than six lines devoted to Old Kingdom gardens.[816] These gardens that he comments upon represent a sophisticated later stage in the evolution of garden design and do not indicate the progression of this evolution.[817]

However, they may be helpful in developing an understanding of the impetus behind the original roles and designs of earlier gardens.[818] While walls curving around individual fruit trees may seem decorative, this feature has been shown to have had the function of allowing a beneficial micro-habitat to develop for each tree:[819] distinct microhabitats for individual organisms increases the odds of them reaching productive maturity.[820] Gardening was hard work, and much effort was also needed to keep birds from eating the crops, with many ingenious traps devised to catch the feathered invaders.[821]

---

813 According to Wilkinson, *Symbolism & Design*, 2, 5, Niuserra, for example, raised song birds in his Sun Temple; this is disputed by Dr. L. Evans, Macquarie University, Sydney, (*per. Comm:* Aug 13th, 2019).

814 Wilkinson, *Symbolism & Design*, 2.

815 Fewer than six lines in Wilkinson, *Symbolism & Design*, specifically mention Old Kingdom examples, and then only in generalisations.

816 The examples outlined in Wilkinson, *Symbolism & Design*, 6–10, date to either the Middle or New Kingdom. The shadouf, for example, is not an Old Kingdom tool. Temple gardens, as represented in the Middle Kingdom, are not a common Old Kingdom feature. Similarly, royal pleasure gardens and private personal gardens date from the New Kingdom.

817 Wilkinson, *Symbolism & Design*, 14, identifies a continuity in design from the Middle Kingdom to the Roman era. This suggests that Old Kingdom garden and orchard attributes may be inferred from those later designs with a relative degree of comfort.

818 Wilkinson, *Symbolism & Design*, 9, for example, describes the winding of walls around fruit trees.

819 Australian National Botanic Gardens, Centre for Australian National Biodiversity Research, 'Microhabitats', https://www.anbg.gov.au/lichen/ecology-habitats-micro.html (Sept. 2, 2016).

820 For the importance of micro-habitats for plant success in arid zones, see Callaway, *Positive Interactions,* 306–349, Holmgren et al., *Plant Communities*, 1966–1975, and Norfolk et al., *Arid South Sinai,* 659–669.

821 See Baridon, *Les Jardins*, 97. The netting and trapping of songbirds. OEE Scene types 5.2, 5.3 and 5.4 describe exactly these activities.

Perhaps other means of growing food became more dependable and this may explain the relatively sudden increase in depictions of orchards and gardens.[822] Possibly it was a more efficient use of water to direct it in a more precise manner: adding water to an orchard or garden guaranteed more control over the water supply. Decorations depicting orchard and gardening scenes appear to be only recent additions to the tomb decoration repertoire by the late Old Kingdom. Very rapidly, through the latter parts of the Fifth Dynasty, these scenes became relatively more popular. By the start of the Sixth Dynasty, however, garden scenes' relative importance began to decline, by almost one-third compared to the what was depicted at the end of the Fifth Dynasty (see Table 16: Gardens and orchards: Overall proportion pre- and post Niuserra).

<u>Table 16: Gardens and orchards: Overall proportion pre- and post Niuserra</u>

Gardens, orchards etc.	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall Proportion	0.4%	3.5%	2.5%

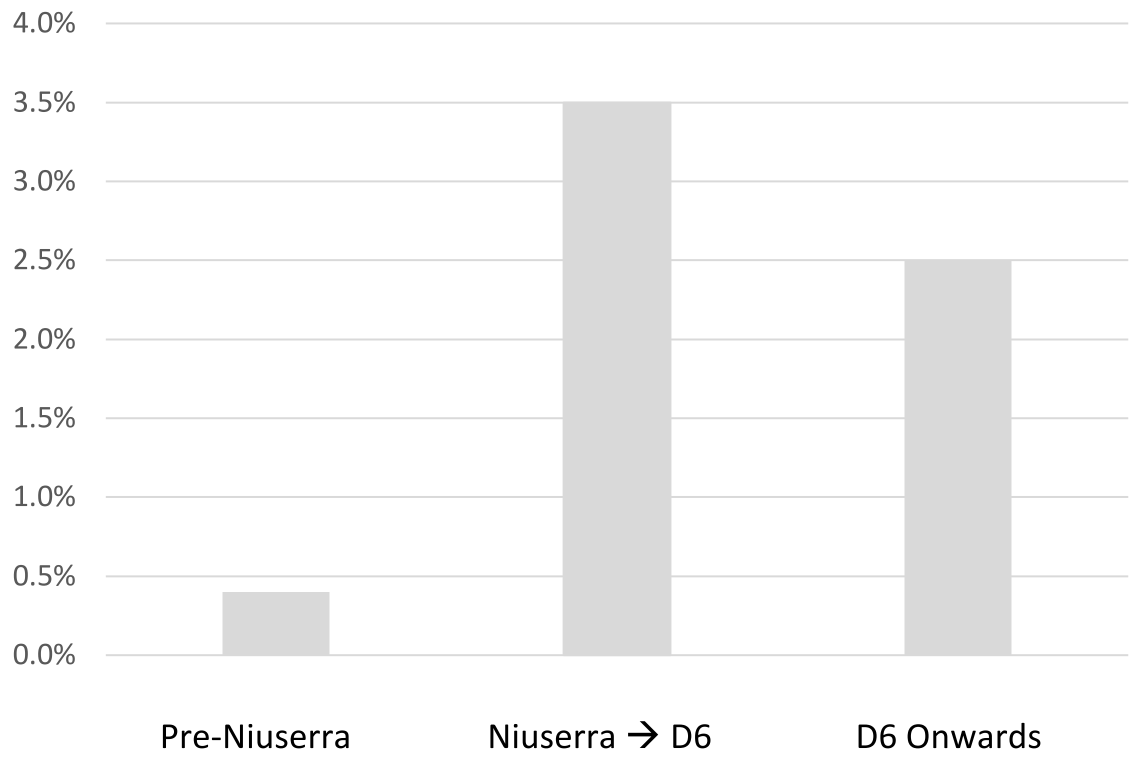
While garden and orchard scenes make up a minimal proportion of overall scene types, the fact that they were introduced at all should be seen as meaningful. Since these tomb scenes were added to the tomb decorative repertoire at a time when ecological science has suggested that drought and famine should have been impacting upon the society, they must have had some significance (see Figure 33: Gardens, orchards and the growing of food: proportion change over time). The fact that their proportion increased so significantly during the Fifth Dynasty could be interpreted as indications of significant importance being attributed to this activity. The decline afterwards may be attributable to the changing environmental situation making these activities increasingly difficult to maintain. An underlying structural element in all garden design was the relationship to and the use of water.[823] Without water, the structures designed to make use of it fail. If the river did not provide an inundation as 'usual', then the likelihood of a garden or orchard failing increases.

---

822 Murray, *Fruits, etc.,* 615–616.
823 Wilkinson, *Symbolism & Design*, 14.

All of the decorations classified in the OEE Database as depicting the watering of a garden[824] date from the time of Niuserra and onwards, as do those that depict irrigation channels,[825] indicating the perceived importance of a ready supply of water. However, if knowledge of earlier irrigation activities had persisted in the culture, for example as depicted in the representations that van Lepp suggest are depicting irrigation channels,[826] then these activities should have enabled gardens and orchards to be maintained. Perhaps there was not enough water available for rudimentary irrigation.

Figure 33: Gardens, orchards and the growing of food: proportion change over time



An interpretation could be that the tomb owner wanted to identify himself as someone so helpful to his community that he accepted the economic burden involved in running a garden in such lean times. An alternative possible interpretation is that the extravagance of a

---

824 Scene type 6.2 *Watering a garden*.

825 Scene type 6.3 *Cultivating and harvesting vegetables in a garden*; Scene detail: 6.3.8. *Irrigation trenches in a garden, depicted frontally*. Examples include the tombs of Fetekta in Barta, *Abusir* V*,* 79, 93–94, figs. 3.10, 3.16; Mereruka/Meri in Duell, *Mereruka* I, pls. 20–21; and Niankhnesut in Kaiser, *Ägyptisches Museum Berlin*, 32 [295], Abb. 295.

826 Van Lepp, *Artificial Irrigation?* 197–209, suggesting evidence of irrigation canals being represented on Pre-Dynastic Art.

functioning garden in times of a water shortage indicates a tomb owner broadcasting that he is so powerful that water scarcity was another's concern.[827]

In trying to relate the decoration themes to the hypothesis under investigation, it is important to note that only one of the gardening scene types in the OEE Database (6.4. *Growing papyrus or lotuses in a man-made garden pool*) could be related to anything other than the simple process of maintaining a successful food garden. The scene types may in fact display a narrative tracing the steps needed to result in a bountiful garden,[828] with the tomb of Niankhkhnum and Khnumhotep, for example, depicting the sequence from Hoeing to Watering to Harvest.[829] Perhaps the gardening sequence represents another example of a narrative-type 'instruction manual' for a time when there is enough water to start gardening again.

The Growing of Lotuses

If the A.R.I.D. hypothesis is correct, then the growing conditions for lotuses would have deteriorated. The first depiction of the gathering of lotus dates to the late Fifth Dynasty.[830] Interestingly, the growing of lotuses in a 'garden' enters the iconography during the time frame under investigation and is first recorded in the tomb of Niankhkhnum and Khnumhotep, dating to the time of Niuserra.[831] Does the inclusion of this scene type indicate the lotus's increasing scarcity as consequence of an environmental circumstance changing to a situation less conducive to its growth? This may have forced the adoption of cultivated lotus for religious activities.

---

827 With thanks to Dr Ronika Power, who made this suggestion in discussion on Apr. 24, 2015.

828 The database has conveniently ordered them in that sequence: 6.1. Hoeing, to prepare or maintain a garden, 6.2. Watering a garden and 6.3. Cultivating and harvesting vegetables in a garden.

829 Moussa & Altenmüller, *Nianchchnum und Chnumhotep*, 76–77, Taf. 20-1, Abb. 8.

830 Moussa & Junge, *Two Craftsmen*, 40, pl. 11.

831 Moussa & Altenmüller, *Nianchchnum und Chnumhotep*, 76–77, Taf. 20-1, Abb. 8. Coincidently, the garden containing lotus also contains other materials.

6.3 – THE KEEPING OF RECORDS

With a less successful agricultural output, the surplus upon which good government relied, declined. As a consequence, administrative changes were needed. In the literature, these changes have been discussed widely, and primarily focus on reforms instituted from the reign of Niuserra onwards.[832] Despite the best intentions, the reforms do not seem to have made the government more effective.

Declining agricultural output may also explain the increasing relative presence of representations of recording and punishing that began to be associated with agricultural and growing scenes.[833] From the time of Niuserra onwards, depictions of administrative activities, such as measuring, recording, and sealing of produce, decline in abundance. (see Table 17: Record-keeping: Overall proportion pre- and post Niuserra).

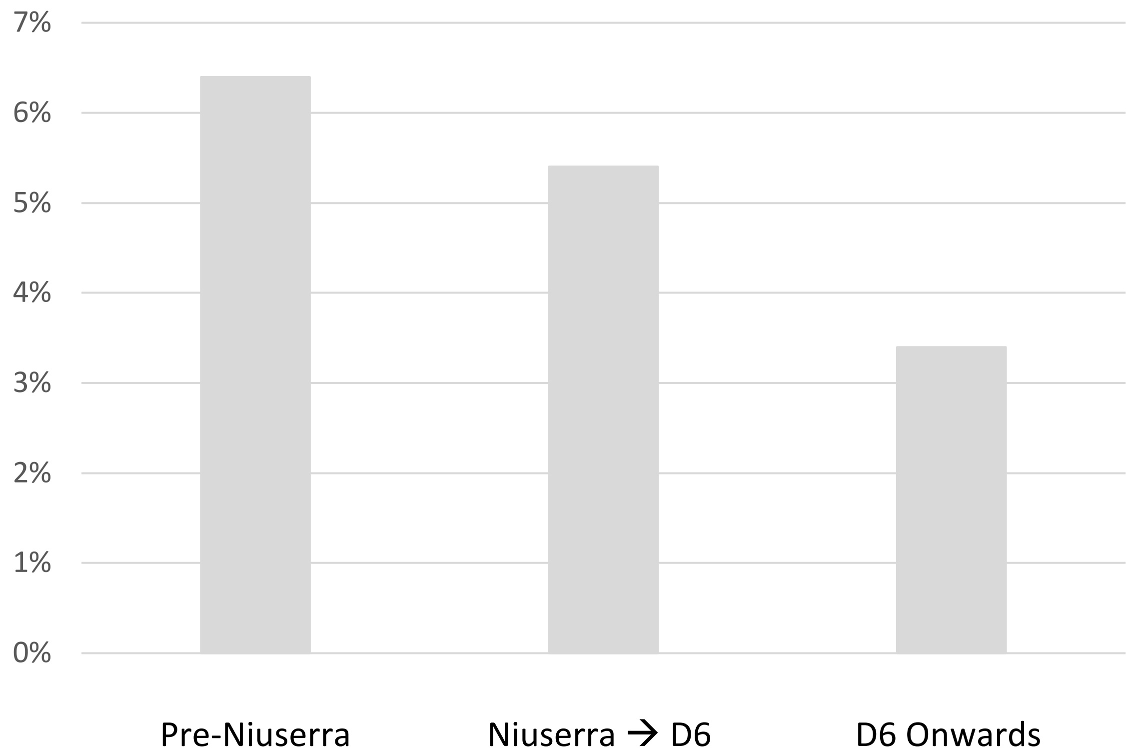
Table 17: Record-keeping: Overall proportion pre- and post Niuserra

Record-Keeping	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall Proportion	6.4%	5.4%	3.4%

Of all scenes depicted before the time of Niuserra, one-sixteenth of them depicted scenes with themes relating to the keeping of records. If improved efficiency was important, then from the time of Niuserra onwards, it would be expected that depictions of administrative activities, such as measuring, recording and sealing of produce should have increased in their relative importance. It would be expected that, in times of finite resources more oversight would have been needed; yet this does not seem to be the case (Figure 34: Record-keeping: proportion change over time). This proportion declined significantly over the time frame of this investigation. With such a rapid decrease in representations of record keeping and storage it is possible to infer that there was such a small amount of surplus available for redistribution that supervision did not make any worthwhile effect. With less to distribute, the people may have returned to subsistence-level agriculture, which is difficult to tax.

832 Krejčí, *Niuserra Revisited*, 513; Bárta, *Niuserra Innovations*, 105.
833 Müller-Wollermann, *Crime & Punishment*, 228–235.

Figure 34: Record-keeping: proportion change over time



The Storage and Distribution of Food Types

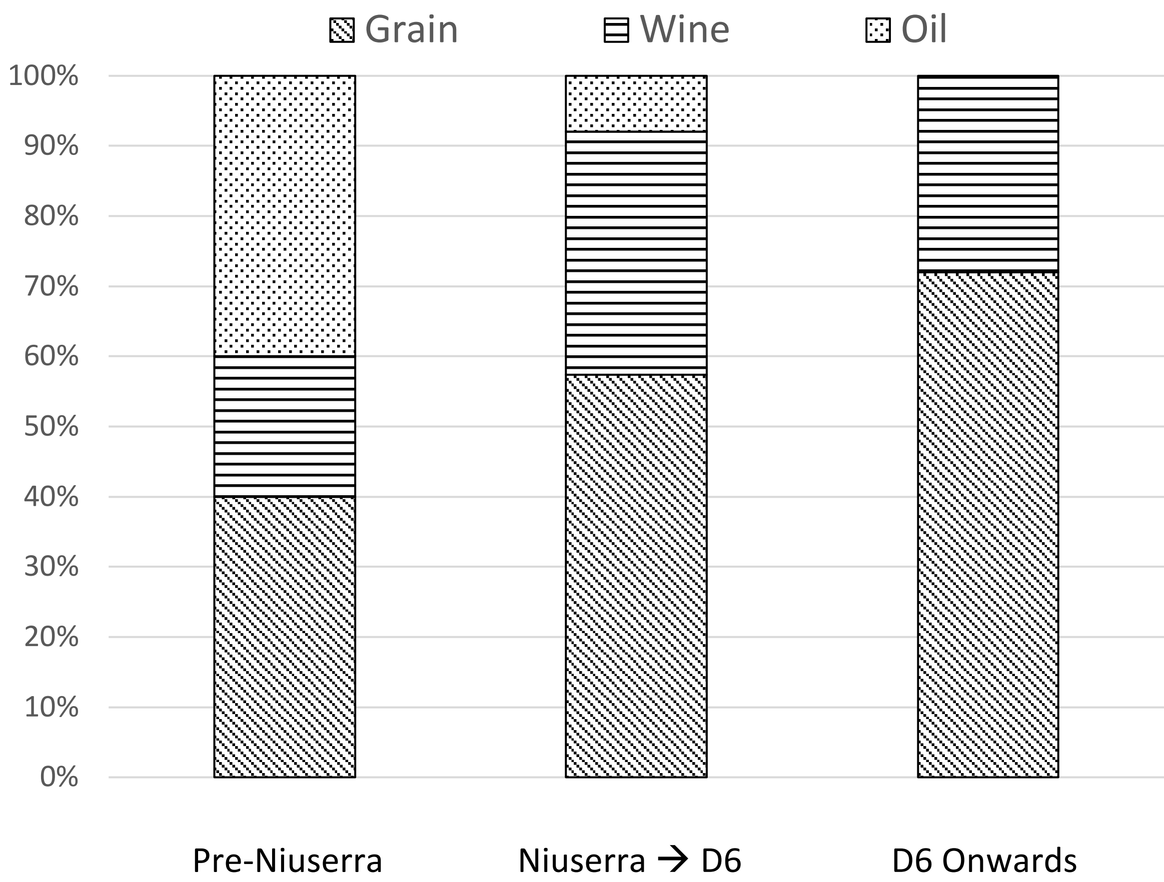
When food storage and distribution scenes are examined by produce type, a clearer picture emerges. In comparative terms, the relative proportion of scenes related to wine and oil declines, whereas those depictions representing the administration of grain increase twelve-fold (see Table 18: Recorded produce: Relative proportion pre- and post Niuserra).

Table 18: Recorded produce: Relative proportion pre- and post Niuserra

Relative proportion of recorded foodstuffs	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Grain	40%	58%	72%
Wine	20%	35%	28%
Oil	40%	8%	0%

By the time of the Sixth Dynasty, of those decorations depicting the recording of major produce, those relating to grain became even more relatively significant. Before the time of Niuserra, two-fifths of the depicted of all stored foodstuffs portrayed grain. By the end of the Old Kingdom, almost three-quarters of attestations of recorded foodstuffs depicted grain(see Figure 35: Recorded foodstuffs: proportion variance change over time).

Figure 35: Recorded foodstuffs: proportion variance over time



This clearly suggests an increasing preoccupation with the amount of grain available, with oil becoming less regularly depicted, declining to a lack of attestations at all by the end of the period under investigation. This allows for the inferences to be made that accurate records of agricultural produce (and more importantly, seed grain for the next season) had become a more significant consideration to the elite.

Indicators of Food Stress: Punishment Scenes

Very few tombs depict the actual beating of managers and administrators, so it is difficult to assign any significance to the numbers, however, what it symbolises is important. The depictions of estate managers being beaten is first recorded in the tomb of Tepemankh,[834] dated by Harpur to Dynasty Five, to either Neferefra or Niuserra.[835] A slight preponderance of reward and punishment scenes may be linked to the increasing interference of the latter Fifth Dynasty kings in their efforts to improve the efficiency of the bureaucracy and to increase the harvest (see Table 19: Punishment and reward: proportion pre- and post Niuserra).

Table 19: Punishment and reward: proportion pre- and post Niuserra

Punishment & Reward	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall Proportion	0.9%	1.2%	0.5%

Most depictions occur in the Memphite region, and mostly in the tombs of the viziers.[836] The overall proportion of scenes displaying the punitive side of rendering of accounts peaked from the time of Niuserra until the start of the Sixth Dynasty, however they are still a low value. However, these Fifth Dynasty efforts appear to have diminished by the Sixth Dynasty. We could interpret these representations as representing the punishment of individuals who, due to incompetence, corruption or disloyalty,[837] have failed to ensure adequate management of the agricultural system.

Table 20 (Punishment as a relative proportion of record-keeping scenes) shows the relative proportion of record-keeping scenes where the main focus is upon punishment. When compared to the mild remonstrance displayed in some late Fifth Dynasty tombs, such as that of Kahai,[838] the scenes depicted on the walls of the Sixth Dynasty tomb of Mereruka display a harsh brutality whose appearance contrasts jarringly to some of the beautiful compositions

834 Smith, *Origins Unidentified Reliefs*, 516, fig. 5; MMA, *Egyptian Art*, 404–405, fig. 126.
835 Harpur, *Decoration*, 169, figs. 160–166.
836 Harpur, *Decoration*, 220.
837 Shafik, Disloyalty & Punishment, 181–191.
838 Lashien, *Kahai*, pl. 12a.

in the same tomb.[839] The importance attributed to the administrative minutiae related to the issue and recording of seeds may be an indicator of an increasingly struggling agricultural system. This may explain the increasing violence inflicted upon those officials who roused Mereruka's ire.[840] The scenes on the tomb walls of Khentika also display this unforgiving reality.[841]

Table 20: Punishment as a relative proportion of record-keeping scenes

Punishment	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Percentage of all record-keeping scenes	12%	22%	12%

The punishment theme appears in the later provincial tombs of Pepyankh the Middle and Pepyankh the Black at Meir,[842] where the figures to be punished appear quite fearful and are represented prostrate to receive their beatings. This is depicted also in the tombs of Hesimin and Theti-iker at El-Hawawish,[843] Henqu II and Ibi at Deir el-Gebrawi.[844] At the site of Sheikh Said, the only tomb to hint at punishment during the rendering of accounts is that of Meru/Babi,[845] which is the latest tomb at that locality, dated to the time of Pepy II. Punishment and humiliation of errant managers may indicate how serious this breach must have been,[846] in the tomb of Khunes at Qubbet el-Hawa, the estate manager is further degraded by apparently having his head pressed down into the dirt.[847]

---

839 Duell, *Mereruka*, pl. 37–38, updated in Kanawati, *Mereruka & Teti*, pls. 112a–c.

840 Kanawati, *Mereruka*, 59.

841 James and Apted, *Khentika,* pl. 9; updated in Kanawati, *Mereruka & Teti*, pl. 115.

842 Blackman & Apted, *Meir* V, pl. xxii [1] and Blackman, *Meir* IV, pl. xv, respectively. For later images see Kanawati & Evans, *Meir* II, pl. 83a and Kanawati, *Meir* I, pl. 83, though the quality has declined since Blackman's time – see Kanawati, Meir I, p. 49.

843 Kanawati, *El-Hawawish* IV, 21, figs. 12–13 and Kanawati, *El-Hawawish* I, fig. 9, respectively. See also Thompson, *El-Hawawish*, 232.

844 Davies, *Deir el Gebrâwi* I, pl. 8, updated in Kanawati *Deir el-Gebrawi* II, pl. 50; Davies, *Deir el Gebrâwi* II, pl. 9, updated by Kanawati, in *Deir el-Gebrawi* I, pl. 55 and *Mereruka & Teti,* pl. 113.

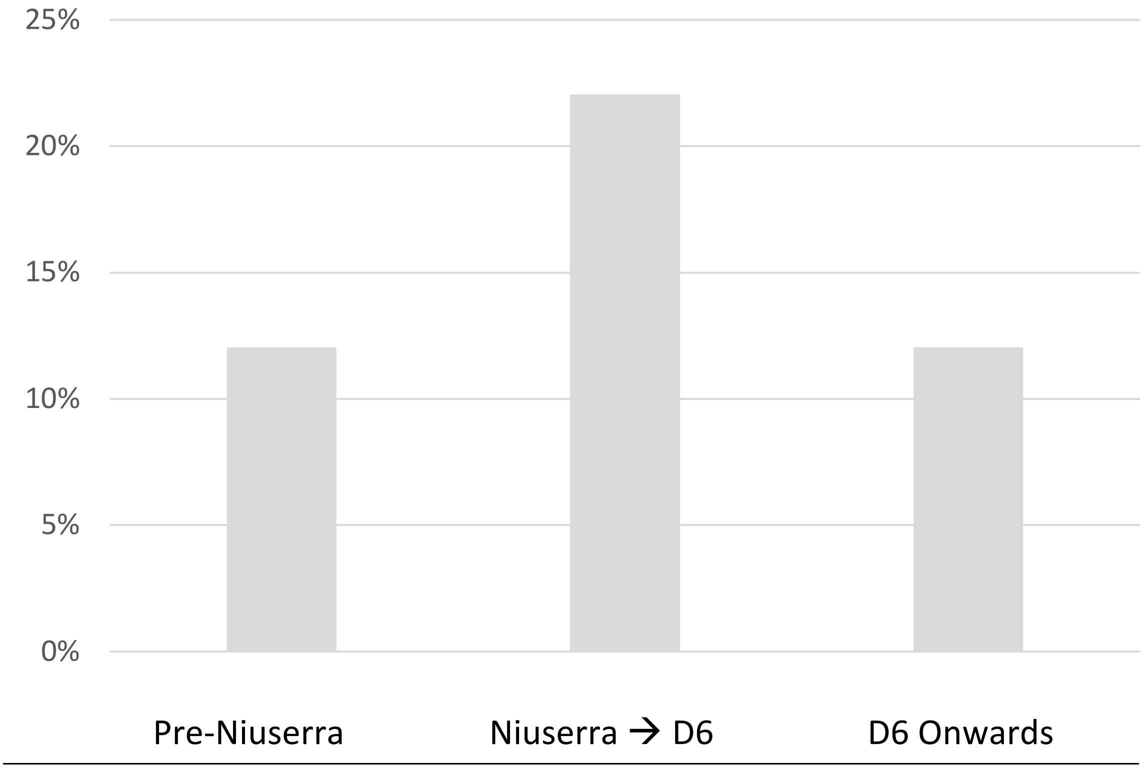
845 Davies, *Sheikh Saïd*, pl. xvii.

846 Just who was influencing whom? Hesimin's tomb, if dated correctly (see Kanawati, *El-Hawawish* IV, 10) may be a more likely candidate for the influence of Ibi's tomb decoration than that of Theti-iker or Mereruka; see Kanawati, *Deir el-Gebrawi* II, 37, n. 210.

847 de Morgan, *Cat. des monuments* I, p. 160 [left]. See also Harpur, *Decoration*, 220 and the commentary in Kanawati, *Deir el-Gebrawi* II, 36–37.

Earlier southern provincial tombs, at the site of El-Hammamiya, for example, do not depict decorations with this theme, despite these locations having the potential of less successful agricultural prospects. As food surpluses became less reliable, the increasing severity of these representations may be depicting the hardening resolve of administrators to husband this important resource. These matters were serious enough for the king to re-assign a designated tomb, while leaving the previous owner's name on the outside as a reminder of his disgrace. The unfortunate Ishfu, at Saqqara, for example,[848] was 'punished' in this manner for a misdemeanour of his brother's. However, it is interesting to compare the changing proportion of punishment scenes to that displayed for the decline in representations of agriculture (see Figure 36: Punishment as a percentage of record-keeping change over time).

Figure 36: Punishment as a relative proportion of record-keeping change over time



[848] Shafik, *Disloyalty & Punishment,* 182, identifying the tombs of Ishfu and Seankhuiptah at Saqqara, as examples; 185–186, suggesting more.

As noted previously, representations of the storage of agricultural produce decline in total abundance over the time frame in question, following the same trend as that in the aforementioned figure.

Indicators of Food Stress: Granary Shape Changes

While most discussion on granaries is dated to timeframes later than those under investigation,[849] some depictions do exist dating to the Old Kingdom. Dome-shaped granaries are attested in Old Kingdom reliefs from about the time of Niuserra: these are higher and appear more constrained than those depicted earlier, which display a low base, easily reached by the workers. This change of granary shape may indicate changes in the social order, with the higher dome-shaped granaries appearing more difficult to access (and steal from?).[850] This may be another sign of more care taken in the husbandry of this resource. The granaries depicted in the tombs of Ankhtify and Sobekhotep at el-Mo'alla illustrate men climbing ladders to deposit the grain. While at the end of the time frame of the current investigation, this may indicate an increased care in response to famine or the stockpiling of foods as an indicator of war preparation.

---

[849] Murray, *Cereal Production*, 526–528.
[850] Harpur, *Decoration*, 220.

Summation: Chapter Six

Changing Climate: Changing Cultivation

The basic points arising from this chapter include:

⇒ As the river became weaker, less alluvial soil was delivered to the land making large scale cultivation more problematic.

⇒ Less water availability caused irrigation to become less efficacious.

⇒ The rapid decrease in the number of tomb scenes depicting garden and orchards may be an indication of a practical response to a deficiency of available excess water.

⇒ Gardens and orchards, while providing some substantial produce, would not have provided food of the necessary volume to replace that decrease in grain production that developed as a result of water shortage.

⇒ Despite the increased vigilance and agricultural stewardship, suggested by the increased punishment scenes, agricultural success appears to have weakened.

The changes in distribution and abundance of tomb decoration themes may be used to trace the changing agricultural chronicle of the society over the time frame under investigation.[851] A pictorial narrative can be observed depicting how the society responded to changing ecological circumstances leading to a different biological imperative developing within the river. Oil, for example, seems to disappear from the pictorial record, perhaps indicating a lack of success in growing it or a decline in international trade due to the increasing susceptibility of the land to the growing aridity. With declining water availability, the ability to produce excess agricultural products would have declined.[852] Since agricultural output appeared to decline, new sources of food may have become increasingly important; so alternative resources would have been needed. The consequences of a declining agricultural sector will be discussed in more detail in the following chapters.

---

851 Janick, *Origins of Horticulture*, 28.

852 Morenó García, 'Irrigation/Irrigations in Pharaonic Egypt: The Interplay between Institutions and Particulars', lecture presented at the Twelfth Annual University of Chicago Oriental Institute Seminar Series: 'Irrigation in Early States: New Directions' (Mar. 3, 2016).

Chapter Seven

Fishing and A River in Drought

Note: An abridged version of this chapter has been published:
Burn, J. W. 2015. 'Climate change, fishing and the Nile: Changes in fishing techniques and technologies at the end of the Old Kingdom.' In Bárta, M. and J. Janak (eds.) Profane Landscapes, Sacred Spaces, Proceedings of the eponymous Conference held by the Czech Institute of Egyptology, Prague, 26–27 June 2014, Prague.
https://doi.org/10.1558/equinox.29015

7.0 – Introduction

As noted in Chapter Five, tomb decoration themes associated with fishing increased significantly in both abundance and overall proportion of total scenes from the latter half of the Fifth Dynasty and through the Sixth Dynasty. While this assertion may seem counter-intuitive given that the investigation is referring to changes relating to the concept of some form of drought, it has been shown that if the river did not overflow its banks, then the nutrients that remained would have increased the nutrient load within the river itself.

In this section, the relationship between the river's proposed nutrient retention and an increase in its fishing stocks will be investigated. If the observed increase in abundance of scenes representing fishing and fishing-related techniques, technologies and activities is a reflection of what was truly happening to society at the time, then the hypothesis of 'A River In Drought,' suggesting changing nutrient levels changing the environment may be able to explain those changes.

7.1 – Fishing Techniques and Related Technologies

Notwithstanding the fish's propensity to generate unpleasant smells,[853] there appears to have been no taboo on its use; the proscription reported by Herodotus, and often quoted… "…*it is not permitted to their priests to taste of fish*"[854] dates from Hellenistic times, well beyond the time frame of this investigation. Despite Bates claiming "…*it is not a noble food*…"[855] fish appears to have been widely consumed.[856] There may, however, have been some regulations pertaining to who ate it.[857] Fishes may even have been worshipped at Elephantine, as the "*architect or bringer of the flood*",[858] though it seems that no fish were mummified until much later than the era under investigation.[859]

In Chapter Five, the rapid increase in proportion of scenes depicting tomb owners fishing and fowling in the marshes was identified, with its apparent importance inferred. The significant change in proportion of the number of scenes depicting the tomb owner spearfishing and fowling may have been influenced by the adoption of royal iconography by the elite, a process started during the time in question. One fish, the Nile perch (*Lates niloticus*), lives in the deeper waters of the river and the other, the Nile tilapia (commonly identified as *Tilapia niloticus*[860]), is found in shallower, more brackish waters,[861] nor do they inhabit the same locales,[862] Because most of the figures depicted in tombs are of the elite,[863] and many of the fish depicted on the end of the spear belong to species that do not inhabit areas conducive to spearfishing, these scenes have been interpreted in a symbolic context; with Brewer and Friedman suggesting that the fishing and fowling stance mirrors that of smiting scenes.[864] Since most of the studies about the fishing techniques that were used to catch the ichthyologic species have been based mainly on the funerary iconography, a

853 Brewer & Friedman, *Fishing*, 15.
854 Herodotus, *Histories* 7 is dated to the Hellenistic era.
855 Bates, *Ancient Egyptian Fishing*, 211. See also Linseele & Zerboni, *Done with Fish*, 237.
856 Ikram, *Choice Cuts*, 35–36.
857 Blackman, *Meir* V, 32; Brewer & Friedman, *Fishing*, 15. Willems et al., *Al-Shaykh Sa`id*, 321, in their survey, suggest some fishes were reserved for those of higher status.
858 Edel, *Kult im Elefantengau*, 35–42.
859 Vogelsang-Eastwood, *Textiles*, 296.
860 The proper scientifc name is *Oreochromis niloticus,* however the name in the text above is the most commonly one used in Egyptological literature.
861 To read more substantiol description of these fish see: Froese, et al. *Lates Niloticus* and *Oreochromis niloticus*, in http://www.fishbase.org/home.htm (16 Nov. 2015)
862 Woods, *Marshes*, 5; Brewer & Friedman, *Fishing*, 11.
863 Non-elite spearfishing is only depicted twice in Old Kingdom tombs, compared to 93 elite depictions.
864 Brewer & Friedman, *Fishing*, 21; Gamer-Wallert, *Fischkult*, 128–130;

religious symbolism has been inferred.[865] While there are many fishing scenes on Old Kingdom tomb walls, very few funerary offering scenes depict fish,[866] or offering lists mention fish,[867] so fish may have been reserved for workers and lower-ranking courtiers and not for consumption by the highest officials.[868]

Spearfishing

Despite its limited efficiency, spearfishing is attested throughout the archaeological record of ancient Egypt and dates from the earliest times.[869] Perhaps, then, those representations of spearfishing could be more associated with leisure than religion. Whether this imagery depicts actual spearfishing or something more symbolic is a matter for further development by future research. Whatever the reason, however, spearfishing is a representation of the active collection of food. Despite some localised differences, many artists deviated from the traditional composition.[870] There are numerous spearfishing scenes found in the provincial cemeteries dating to the late Fifth Dynasty at Akhmim, and the early to mid-Sixth Dynasty at Deshasha, Deir el-Gebrawi, Zawiyet el-Maiyetin, Quseir el-Amarna, Meir, Dendera and Aswan,[871] as well as at the late Sixth and early Eighth Dynasty provincial cemeteries of Deir el-Gebrawi, Meir, Akhmim, Dendera, Thebes, Qasr el-Sayad, Kom el-Ahmar, El-Gozeriya, Mo'alla, Gohaina, El-Hagarsa and El-Mahasna.[872]

Techniques and Technologies

Many scenes depicted in the latter half of the Old Kingdom have elicited responses from commentators who have recognised similar fishing behaviours among the more modern consumers of Nile resources,[873] indicating a historical accuracy with regard to the techniques

---

865 Robins, *Interpreting Egyptian Art*, 50–52; Binder, *Fishing & Fowling,* 116. For the most recent summary, see Soria-Trastoy, *Fishing Tackle Analysis*, 13.

866 Brewer & Friedman, *Fishing*, 12. Of the 46 incidences attested by Harpur, 29 date from the time of Niuserra to the end of Dynasty 5, with 59 dated to the Sixth Dynasty.

867 Bates, *Ancient Egyptian Fishing*, 210, indicating that the archaeology suggests it was peasant food.

868 Ikram, *Meat Processing*, 656; Kanawati, *Tomb & Beyond*, 93.

869 von den Driesch, *Fish Archaeozoology*, 87; Brewer & Friedman, *Fishing*, 21–22.

870 Vischak, *Locality & Community*, 238. Woods, *Marshes*, 214–216, identifies numerous examples of variations and/or errors where traditional components of scenes may have been letft out.

871 Woods, *Marshes*, 192–193.

872 Woods, *Marshes*, 191–192.

873 Bates, *Ancient Egyptian Fishing*, identifying modern parallels to those behaviours depicted, 220–221, 241, figs 85 & 86, and 251. See also Rzóska, *Palaeo-Ecology*, 336–346.

and technologies depicted, with Patersom and Chapman noting the "*potent ecological force*" displayed by fishing in its potential to produce cultural and environmental impacts.[874] Despite some difficulty in identifying the exact species in some of the depictions, it is still possible to trace the changes in depictions of fish and fishing as a whole.[875] Tracing the adoption of new techniques and technologies, the role of fish and fishing within the resource base of the Old Kingdom has been summarised and updated by Swinton[876] and Soria-Trastoy.[877]

The earliest attestation of an individual presenting a fish for examination by another individual is dated to the early Fourth Dynasty, in the tomb of Rahotep.[878] However, representations of fishing and its associated techniques and technologies are relatively rare until the time of Niuserra in the Fifth Dynasty, after which they become increasingly common until the end of the Old Kingdom. By that time, the proportion of depictions representing fishing had almost doubled from that of the first six reigns of the Fifth Dynasty.

Table 21: Fishing & associated technologies: Proportion pre- and post Niuserra			
Fishing etc.	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall Proportion of all tomb scenes	10.7%	14.1%	20.0%

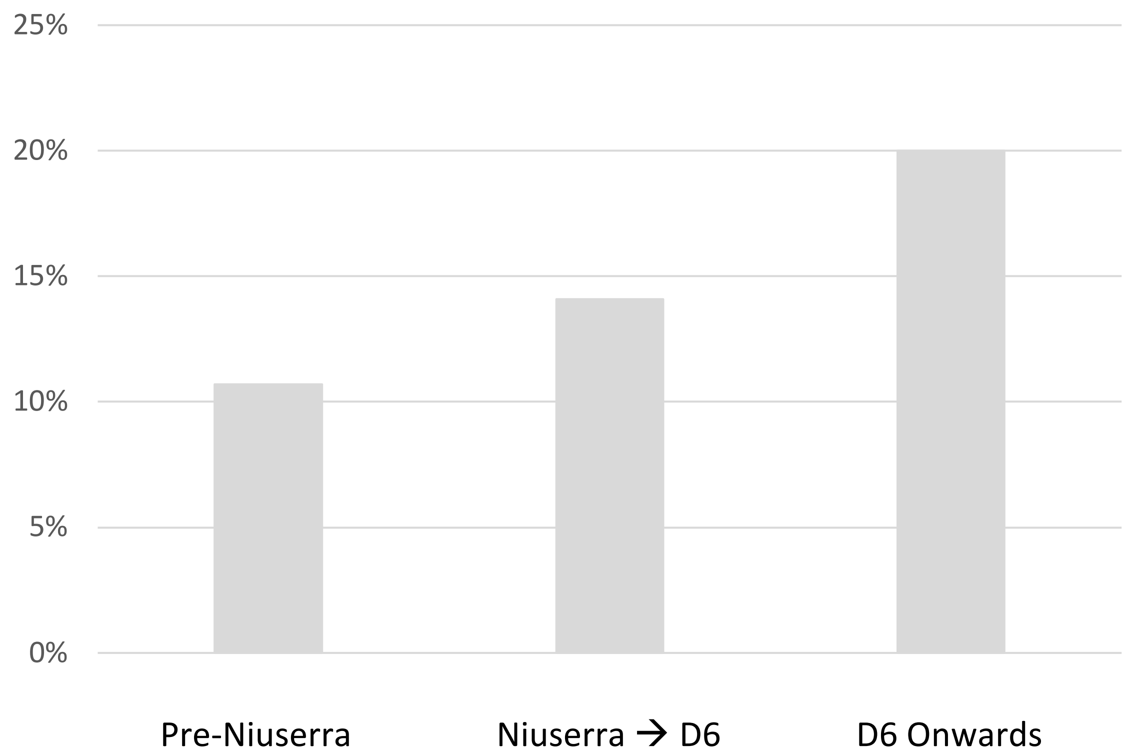
The number of scenes representing all forms of fishing and related technologies increased from less than one-seventh (~14%) of all scene types attested at the end of the Fifth Dynasty to one-fifth (~20%) by mid-Dynasty 6 (see Table 21: Fishing and associated technologies: Proportion pre- and post Niuserra).

Importantly, depictions of "*Fishermen registering their catch for distribution by scribes*" (OEE Scene Type database category 1.24) enter the repertoire at this time. This apparent importance is noted in the Sixth Dynasty, because it is at that time that the only two recorded

874 Paterson & Chapman, *Nile Perch*, 308. See also Bates, *Ancient Egyptian Fishing*, 203.
875 van Elsbergen, *Fischerei*, 133–137.
876 Swinton, *Resources*, 181–182.
877 Soria-Trastoy, Fishing Tackle Analysis and "Fishing tackle in ancient Egypt. A historical and archaeological study from a diachronic point of view" (PhD Thesis; University of Cadiz).
878 Harpur, *Maidum*, 104, 114, 209–210, fig. 95, pls. 54–55.

attestations of fisherman accounting for their catch to scribes occur.[879] If the environmental situation were such that a 'drought' resulted in the rapid growth of biomass in the river, as proposed, then the proportion of marshland should increase even more than expected. While it may seem counter-intuitive to suggest that an aquatic activity like fishing increased in perceived importance during a 'drought', (see Figure 37: Fishing and associated technologies: Proportion change over time), then the change can be explained as part of the new societal emphasis upon taking advantage of the river's changing environmental circumstances.

Figure 37: Fishing and associated technologies: Proportion change over time



Bunbury and Jeffreys suggest that the Egypt of the Pre and Early Dynastic period would have been considerably more 'marshy' than it is today.[880] This suggest that conditions for fish populations would have been more favourable in these times. As the water's edges become more densely populated with aquatic plants such as reeds and papyrus, sources of food for bait-fish increases as does potential refuge areas for them increase.[881] This then

879 von Bissing, *Gem-ni-kai*, Taf. 18–19; Altenmüller, *Mehu*, Taf. 34, 36–37.
880 Bunbury & Jeffreys, *Ancient Landscapes,* 66; Stanley & Warne, *Delta Geological Evolution*, 628–34.
881 Paterson & Chapman, *Nile Perch*, 316.

impacts upon the predator/prey behaviour within fish populations,[882] which could in turn lead to changes in the fishing culture of the local human populations.[883] As larger fish become increasingly attracted to growing numbers of baitfish, the benefit of an increase in fishing activity increases. Linseele and Zerboni, for example, in their investigation of fish consumption in upper Sudan, identify changes in fishing strategies and exploitation that occurred as a result of changing environmental conditions such as a weaker river and more extensive plant growth along the edges.[884] As environmental stress[885] or rates of exploitation increase,[886] the expected size of fish should decrease due to the increased rates of fishing that apparently occurred. This contrasts significantly to data collected from an earlier time when the river was flowing more swiftly, where the bones were fewer in number but larger in size, suggesting they were from open-water fishes.[887]

If the rise in fishing-related scenes in the Old Kingdom was a reflection of environmental changes at the time, then the A.R.I.D. hypothesis could explain changes not only in the artistic record but also in the archaeological record. While identifying the actual species of some fishes in the archaeological evidence poses difficulties,[888] the proportion of fish bones at a site gives an indication of the importance of fish as a source of protein.[889] Over the time frame in question, an increase in the abundance of fish bones in refuse dumps has been anecdotally noted in a number of archaeological sites, for example Edfou[890] and Deir el Barsha,[891] suggesting the increasing prominence of fish in the diet of the local communities:[892] unfortunately, this data has yet to be published. It corresponds to artistic evidence indicating an increased emphasis upon the preservation of fish.[893]

---

882 Paterson & Chapman, *Nile Perch*, 315.
883 Paterson & Chapman, *Nile Perch*, 308.
884 Linseele & Zerboni, *Done with Fish*, 237–238.
885 Luff & Bailey, *Catfish Growth Structures*, 821–822.
886 Luff & Bailey, *Catfish Growth Structures*, 831–832.
887 Linseele & Zerboni, *Done with Fish*, 235–238.
888 Greenwood, *Nile Fish Fauna*, 127–133; Stewart, *Fossil Fish*, 678; Linseele & Zerboni, *Done with Fish*, 236.
889 Nash, Aquatic Animals, 456–457; Sahrhage, *Fishing in Ancient Egypt*, 922; Thompson et al., *Ancient Egyptian Palaeodiet*, 453.
890 Nadine Moeller and Gregory Marouard, both of the University of Chicago, have noted this trend, with G. Marouard suggesting that the average size of bone remains has ddecreased (pers. comm.)
891 Marleen de Meyer, University of Leuven. (pers. comm.)
892 Luff & Bailey, *Catfish Growth Structures*, 831–832.
893 Linseele & Zerboni, *Done with Fish*, 235, summarising previous research in this area.

Some studies provide a wide-ranging overview of ancient Egyptian dietary patterns; however, the data is taken from widely disparate eras, with some studies not displaying data from the Old Kingdom,[894] or presenting data from only one location or from only one tomb.[895] This is unfortunate in that it only allows for a generalist conclusion such as "*no discernible change over the entire history*"[896] to be made, not allowing for potential changes within smaller time frames. Further investigation into fish remains in settlement archaeology is warranted,[897] a theme that will be further articulated in the Discussion.

Adaptations to Fishing Performance and Practice

The A.R.I.D. hypothesis proposes that some food-gathering behaviour would have changed over the period under investigation. At a time when other indicators suggest that ancient Egypt was (supposedly) in the grip of a severe and long-term drought, the summary artistic data presented so far in this study suggests that there was an increase in both the amount and variety of marshland-themed decorations, as well as those scenes depicting fishing and fishing techniques and technologies. For the purposes of our discussion, the OEE Scene-details Database classifications have been grouped into four fishing technique 'groups' (see Table 22: Fishing technique groups: change in overall proportion).

Table22: Fishing technique: change in overall proportion

Technique Groups	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Seine/Dragnets	4.7%	3.8%	3.5%
Traps & other nets	0%	2.1%	2.8%
Angling	0%	1.2%	2.1%
Spearfishing (non-elite)	0%	0%	2.0%

894 Thompson et al., *Ancient Egyptian Palaeodiet*, 454, table 1, for example, does not include data from before the New Kingdom.

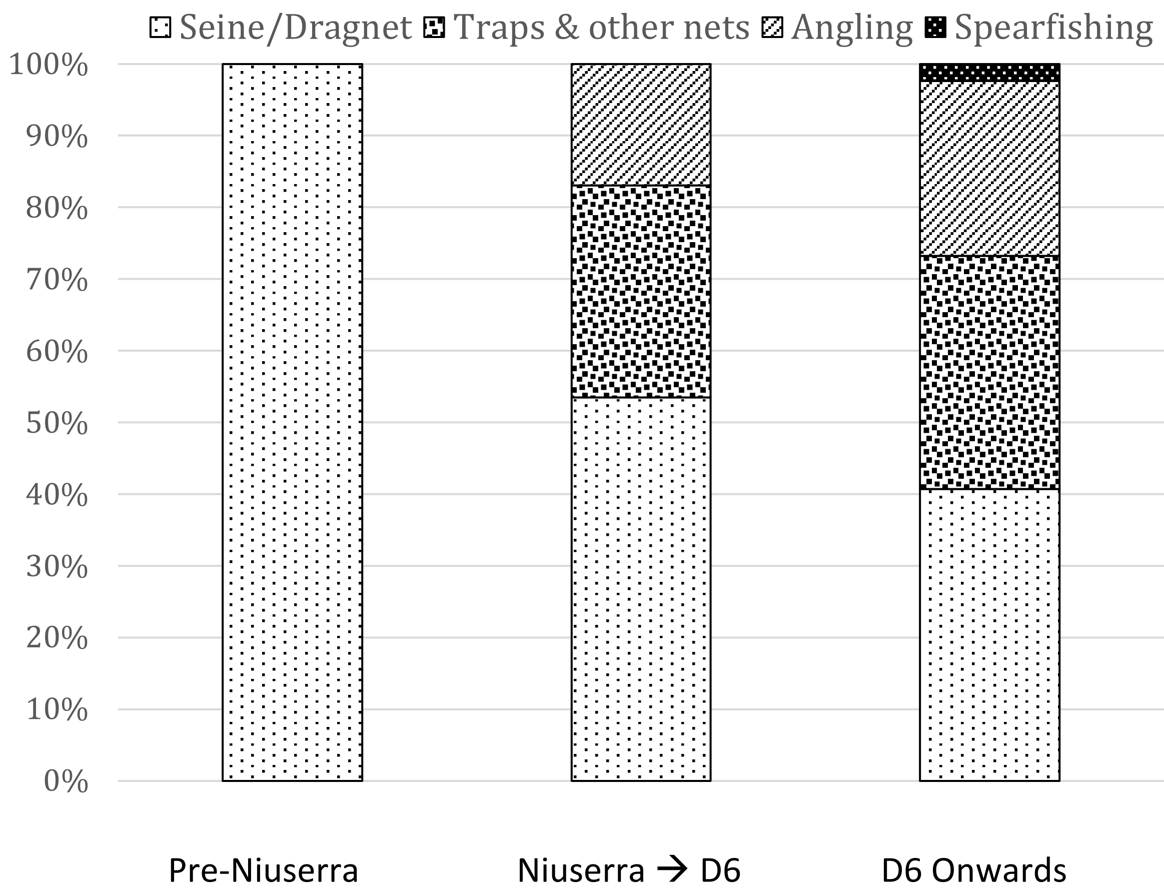
895 Thompson et al., *Ancient Egyptian Palaeodiet*, 455, table 2, for example, does include some Early Dynastic data and some from the Old Kingdom, but these are limited to 10 and 6 samples respectively, taken from only one site from each period.

896 Thompson et al., *Ancient Egyptian Palaeodiet*, 461. See also Touzeau et al., *Ancient Egyptian Diet*, where a similar conclusion was made without providing evidence from the end of the Old Kingdom or the First Intermediate Period, the era of most concern to this investigation.

897 Stewart, *Fossil Fish*, 678; Osman & Kloas, *Catfish Water Quality*, 390–391.

Of all the fishing and related scenes depicted before the time of Niuserra, the only non-elite representations were scenes depicting seine/dragnet activities. From the time of Niuserra till the end of the Fifth Dynasty, only about 55% of the fishing scenes depicted were of this theme, declining to only about 40% during the Sixth Dynasty, while the majority of representations are scenes depicting small groups or individuals in the act of fishing using various techniques. (see Figure 38: Fishing technique groups: percentage change over time).

Figure 38: Fishing technique groups: percentage change over time.



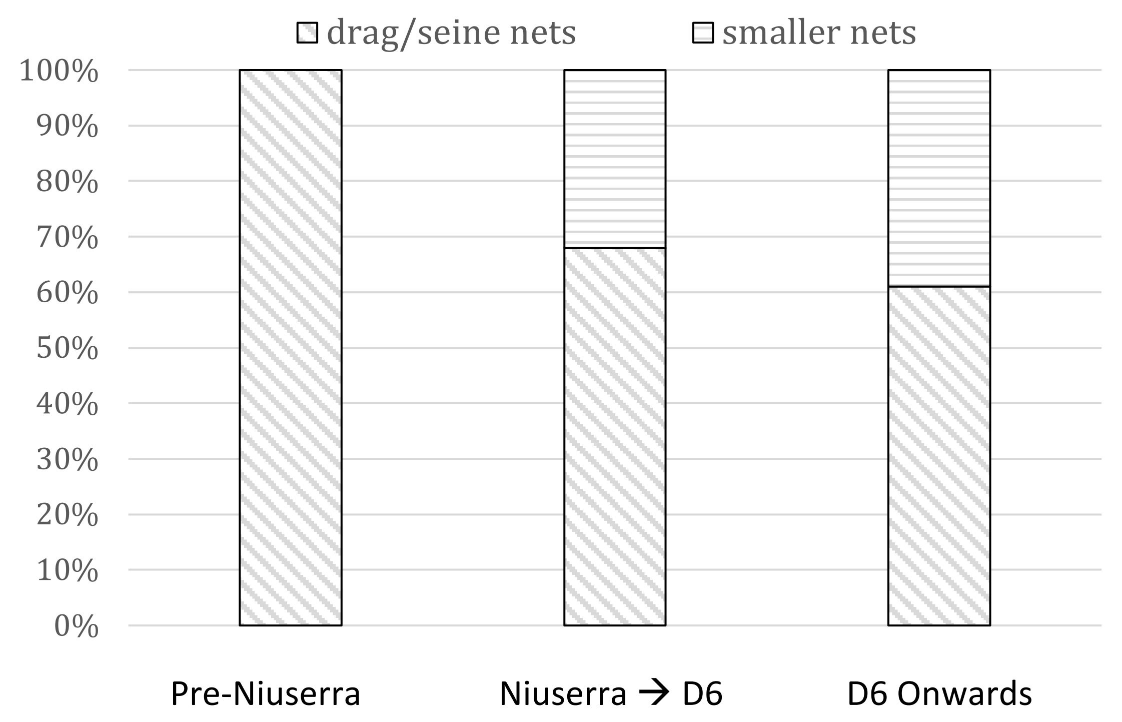
As a consequence of changing environmental circumstances, the increasing variety of habitats that would have developed, as suggested by the A.R.I.D. hypothesis, may explain the increasing assortment of techniques and technologies adopted and adapted at this time, including representations of non-elite individuals spearfishing.[898]

[898] For example, the incomplete scene in Duell, *Mereruka II*, pls. 127–128.

7.2 – The Narrative of the Nets

From the time of Niuserra onwards, other techniques are added to the artistic lexicon. Large nets set from boats enter the repertoire at the time of Niuserra, first attested in the tomb of Ptahshepses, at Abusir.[899] Large nets appear to be always set from boats, for example those found in the tombs of Ptahshepses and Mehu (late Pepy I) at Saqqara,[900] have up to eight individuals depicted involved in the activity. Small nets and traps as well as representations of individuals fishing without nets are added to the scene type collection at this time. Small nets and traps require fewer people to operate, whereas large, seine, and dragnets described require many more men. Of all decorations depicting nets, representations of smaller nets increased proportionately across the time frame under investigation (see Figure 39: Net depiction: proportion change over time).

Figure 39: Net depiction: proportion change over time



899 Vachala, *Ptahshepses,* 138–139 [J1112 + 1113 (2613)].
900 Altenmüller, *Mehu*, 136, Taf. 35 [a].

The significant increase in the number and proportion of images representing certain fishing techniques and technologies can perhaps be explained by the same forces that saw representations of seine and drag nets decline at the same time. Despite the use of smaller cast nets having been recorded in ethnographic studies along more southern parts of the modern Nile,[901] this activity has not been recorded on surviving tomb walls.[902] The upkeep of the apparatus of fishing must have been a continuous endeavour.[903] Evidence of the construction, repair and maintenance of nets is found in the archaeological record before Dynastic times,[904] yet representations of these activities were only introduced into the iconographic record at about the time of Niuserra.[905] Smaller and more diverse nets enter the decorative programme from the time of Niuserra onwards, with the tomb of Niankhkhnum and Khnumhotep, for example, containing depictions of all the types of fishing techniques and technologies in the OEE database.[906]

Dragnetting

As identified earlier, and worthwhile mentioning here, the only fishing techniques using nets depicted before the time of Niuserra were those portraying large seine or drag nets. Drag /seine net scenes depict many men working in unison to haul up the harvest: both Ptahshepses and Mehu, among others, also depict this activity.[907] Depictions of seine or dragnetting significantly decrease in proportion over the time frame in question, (see Table 23: Dragnet and seine net: proportion change over time), whereas a variety of new fishing techniques and technologies enter the decorative programme.

Table 23: Dragnet and seine net: proportion change over time

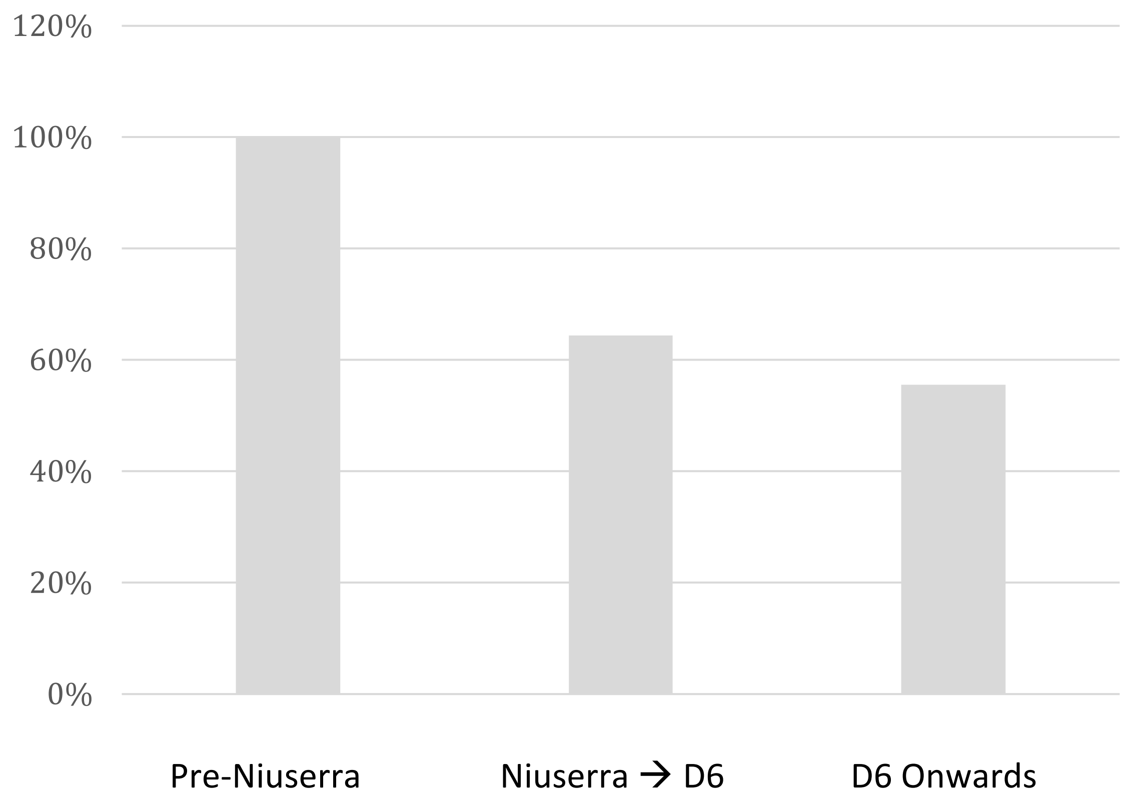
Drag/seine nets	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Relative proportion of all net scenes	100%	64%	56%

901 Elster & Jensen, *Fishery Investigation*, 91.
902 Brewer & Friedman, *Fishing*, 41.
903 Greenwood, *Kenyan Fishes*, 56.
904 van Neer, *Prehistoric Fishing*, 49–53; Barich, *People, Water & Grain*, 47–48.
905 Soria-Trastoy, *Fishing Tackle Analysis*, 13–18.
906 Moussa & Altenmüller, *Nianchchnum & Chnumhotep,* 96–101, Taf. 30–32, Abb. 12–13.
907 Vachala, *Ptahshepses*, 130–131 [A559 + J466], 132-3 [C814], 134-5 [E820-2, E1438], 136-7 [I138, J635, J563, J482]; Altenmüller, *Mehu*, 136–137, Taf. 32 (part), 31 [a] (part), 35 [a] (part), 35 [b].

Of all the scenes associated with fishing technologies, dragnets and seine nets decline from accounting for all of the net-based representations depicted before the time of Niuserra, to about two-thirds of the sample by the time of Niuserra to the end of Dynasty Five. From Dynasty Six onwards, they comprise just over one-half of the representations.

Some of the important requirements for successful dragnet or seine net operation include relatively open spaces of water in which to lay out the nets, and a waterway edge clear enough to drag the net onto shore. It seems that seine netting occurred when the water was at its lowest,[908] but with no inundation and a comparative increase in vegetation, perhaps a lack of wide, open-water spaces made this activity more difficult. A decline in representations of these activities (see Figure 40: Drag and seine net: Relative proportion change over time) can be explained by the hypothesised ecological processes of declining open-water spaces and increasing marshland too shallow or plant-clogged for net utilisation.

Figure 40: Drag and seine net: Relative proportion change over time



908 van Neer, *Prehistoric Fishing*, 54.

With an increase in vegetation along the riverbanks, it would also seem problematic to land a large seine net without entanglement. While an increasing emphasis on fishing was displayed on tomb walls,[909] dragnet scenes as a proportion of total fishing scenes declined, and slight changes in the composition can be recognised.[910] Despite the decline in overall abundance of dragnet scenes, however, the portrayed size of the actual dragnet itself increased, taking up more room within the tomb,[911] and the numbers of haulers also tended to increase.[912] In the tomb of Ty, (from the time of Niuserra), the dragnet haulers number twelve, compared to nineteen in one scene and twenty-three in another in the tomb of Mereruka, (from the time of King Teti) for example.[913] An increased nutrient load in the river should increase the overall fish biomass. Therefore, improved catches would be expected, so the nets should be fuller, leading to the haulers requiring extra assistance.[914]

With the decline in the relative number of scenes depicting dragnetting, another feature enters the iconography: from the time of Niuserra onwards, some dragnet figures are depicted with a strap across their shoulders,[915] presumably to aid them in their hauling. This addition to the decorative repertoire may indicate that these larger dragnets were being increasingly set away from the riverbank, away from the entanglement of the encroaching marshes. On land, friction between feet and the ground provide enough leverage to aid the fishermen in hauling in their nets. From personal observations of modern fishermen in Kenya and Uganda,[916] these straps are commonly worn by fishermen hauling large nets onto boats, to compensate for the lack of purchase that solid land may give. The use of the strap may suggest that the catch was bigger, and the strap added stability and provided extra leverage which helped the haulers land their catch. Dragnet haulers wearing supportive straps are also depicted in the Giza tombs of Iynefert,[917] Khufukhaef II,[918] Senedjemib/Mehi,[919] and Sekhemka;[920] and the Saqqara tombs of Akhethotep,[921]

---

909 See commentary in Kanawati & Abder-Raziq, *Waatetkhetor*, 21.
910 Harpur, *Decoration*, 143–145, traces some of the developments in representation.
911 Harpur, *Decorations*, 189–196.
912 Harpur, *Decorations*, 179, 259.
913 Wild, *Ti,* II, pls. 40–41, Duell, *Mereruka* II, pls. 43, 55; Kanawati *Mereruka & Tet*i, pls. 107, 110.
914 With appreciation for this suggestion from Dr L. Evans, Oct. 24, 2018.
915 Harpur, *Decorations*, 189, identifying Memphite tombs with haulers wearing supportive straps.
916 From the author's four months of travel though the southern African continent. See also Bates, *Ancient Egyptian Fishing*, 208–209, 258–262, and commentary in Kanawati, *Deir el-Gebrawi* III, 30.
917 Schürmann, *Ii-nefret,* Abb. 9 [a, b], 21.
918 Simpson, *Kawab*, pls. 36[a], 37[a], figs. 43, 47, 49.
919 Brovarski, *Senedjemib* I, pls. 115–116, figs. 114–116.
920 Simpson, *Western Cemetery* I, pl. v [c-e], fig. 4.
921 Ziegler, *d'Akhethetep*, 82–84, 142–143.

Irenkaptah,[922] Ty,[923] Ptahhotep/Iyniankh,[924] Mereruka,[925] Waatetkhetor,[926] Niankhkhnum and Khnumhotep,[927] Nebkauhor/Idu,[928] Hetepherakhti,[929] Kaemrehu.[930] Tombs further south displaying the use of straps by dragnet haulers include In-snefru-ishtef from Dahshur,[931] Werirni from Sheikh Said,[932] Pepyankh the Black,[933] Pepyankh the Middle[934] and Nyankhpepy[935] from Meir, and Ibi[936] and Djau[937] from Deir el-Gebrawi.

Large Nets set from Boats

Depictions showing the setting of large nets from boats enter the artistic lexicon from the time of Niuserra.[938] Perhaps the adoption of large boat-set nets may have been a transitional strategy to maintain the 'industrialised' process of large-scale fishing. These include the tombs of Ptahshepses,[939] Ty,[940] Kagemni[941] and Mehu.[942] The combined tomb of Niankhkhnum and Khnumhotep also displays this scene.[943] Further south, the tombs of Ibi[944] and Djau/Shemai[945] at Deir el-Gebrawi also portray this scene type. In the tomb of Waatetkhetor at Saqqara, the haulers are shown standing, not on a boat, but depicted on a

---

922 McFarlane, *Irukaptah*, pls. 16, 41, 46.
923 Wild, *Ti,* II, pls. 90 [A, B] (details), 91 [A] (detail), 123. See also Woods, *Marshes*, 87, n. 67; 114, n. 109; 117, n. 143.
924 Hassan, *Saqqara* II*,* figs. 36–7, pl. 77 [A].
925 Duell, *Mereruka* II, pl. 55 = Scene Two.
926 Kanawati & Abder-Raziq, *Waatetkhetor*, pl. 56, updating Wreszinski, *Atlas* III, Taf. 95.
927 Moussa & Altenmüller, *Nianchchnum & Chnumhotep*, Taf. 31, 36 [b], Abb. 12.
928 Hassan, *Saqqara* I, pls. 5 [A], 24 [A].
929 Mohr, *Hetep-her-akhti*, fig. 29, pl. 1.
930 Mogensen, *Le Mastaba*, fig. 3, pl. 1.
931 de Morgan, *Dahchour* II, pl. 23.
932 Davies, *Sheikh Saïd*, pl. 12.
933 Blackman & Apted*, Meir* V, pls. 30, 60 [2].
934 Blackman, *Meir* IV, pl. 8.
935 Blackman & Apted, *Meir* V, pl. 13.
936 Davies*, Deir el-Gebrâwi* I, pl. 4.
937 Davies, *Deir el-Gebrâwi* II, pl. 5.
938 See, for example, Vachala, *Ptahshepses*, 130–137, figs. A559, C814, E820, E822, E1438, I138, J635, J563, J466, J482; Moussa & Altenmüller, *Nianchchnum und Chnumhotep*, 96–97, Taf. 31, 36 [b], Abb. 12; Wild, *Ti*, II [1], pls. 90, 91, 123; von Bissing, *Gem-ni-kai,* I, 14, 20, Taf. 19, 21; Altenmüller, *Mehu*, 136–137, Taf. 31, 32, 35a, 35b; Davies, *Deir el-Gebrâwi* I, 12–13, pl. 4, updated in Kanawati, *Deir el-Gebrawi* II, 29, pl. 45.
939 Vachala, *Ptahshepses*, 138–139, [J1112 + 1113 (2613)].
940 Wild, *Ti*, II, pls. 77 [A] (part), 61.
941 von Bissing, *Gem-ni-kai* I, 14, 20 [4749], Taf. 18–19.
942 Altenmüller, *Mehu*, 136, Taf. 35 [a].
943 Moussa & Altenmüller, *Nianchchnum & Chnumhotep*, Taf. 31, Abb. 12.
944 Davies, *Deir el-Gebrâwi* I, suggests the possibility, 14, pl. 6. Kanawati's re-investigation (*Deir el-Gebrawi* II, 29, pl. 47) confirms this suggestion.
945 Kanawati, *Deir el-Gebrawi* III, 30.

structured surface[946] that does not appear to be the riverbank, with the surface apparently supported by another structure; a similar depiction occurs in the tomb of Werirni at Sheikh Said.[947] The right-most figure hauling in the net is on his knees and lifting, rather than pulling, the net: this suggests that the hauler is on a boat, not the land. Similar representations are shown in the later tombs at Meir of Pepyankh the Middle,[948] where the haulers appear in front of, not within, the papyrus band. The scene in the tomb of Niankhpepy the Black,[949] where there is no representation of plants at all, perhaps indicates that the fishing is done beyond the plant zone; and Pepyankh the Black,[950] who also does not depict plants.[951]

At Deir el-Gebrawi, the tombs of Ibi[952] and Djau/Shemai[953] also display similar indicators of fishing from a boat, not the land. The addition of large nets to the decoration repertoire may suggest that fishing was increasingly carried out away from a riverbank that had become increasingly clogged and impenetrable, and this increasing reliance on large nets may have necessitated a change in the techniques of using them.

The Need to Re-classify all Large Nets used for Fishing?

To avoid obstruction from blockages below the surface, floats are important.[954] Similarly, perhaps in response to the increased obstruction that would be present below the surface in a plant-clogged river, some nets are now not depicted with sinkers.[955] If no sinkers are needed, neither are floats. Kanawati identifies that this phenomenon is depicted in a number of tombs dating from mid- to late Dynasty 6,[956] which is interesting because the earlier tombs of Gehesa/Nebi and Theti/Ikr do depict these accoutrements.[957]

---

946 Duell, *Mereruka* II, pl. 43, 55; updated by Kanawati & Abder-Raziq, *Waatetkhetor*, pl. 56.
947 Davies, *Sheikh Saïd*, pl. 12. The detail is less clear in the nearby tomb of Serfka, pl. 5.
948 Blackman, *Meir* IV, pl. 8; updated in Kanawati, *Meir* I, 37, pl. 79.
949 Blackman & Apted, *Meir* V, pl. 13; updated in Kanawati et al., *Meir* III, 45, pl. 69.
950 Blackman & Apted, *Meir* V, pls. 30, 60 [2]; updated in Kanawati & Evans, *Meir* II, 50, pl. 90.
951 Note, however, that Kanawati, does not suggest these interpretations.
952 Davies, *Deir el-Gebrâwi* I, pl. 4, where the figures at the end appear to be lifting, not dragging, the net.
953 Davies, *Deir el-Gebrâwi* II, pl. 5, where the haulers are depicted in a large boat.
954 Duliková, *Ankhires at Abusir*, 10.
955 Kanawati, *El-Hawawish* I, fig.12; Kanawati, *El-Hawawish* II, figs. 21–22.
956 Kanawati, *El-Hawawish* II, 45, no. 169.
957 Kanawati, *El-Hawawish* VII, fig. 30 and Kanawati, *El-Hawawish* I, fig. 12, respectively.

The representations changed at around the same time as suggested by the A.R.I.D. hypothesis. While this may be just carelessness on behalf of the artist, it may also be an indication of accuracy on his part. Perhaps this explains why the numbers of haulers decreases as the nets became smaller in order to fit into the diminishing areas of open water. A more careful analysis of all dragnet scenes may identify if the nets themselves are drawn from land or boat-set, as some of the scenes classified as those identified as one particular type of large net, either seine or drag may need to be re-classified.[958]

958 Woods, *Marshes*, 388, for example, presents a slightly different classification to Harpur.

7.3 – Angling, Trapping and Small Nets

As a consequence of a changing environment, it is possible that fishing transformed from a pleasurable activity[959] to a necessary one (see Table 24: Angling, traps and nets: Niuserra onwards).

Table 24: Angling, traps and nets: Niuserra onwards

Name	**Date**	LARGE NET	ANGLING	SMALL NET	FUNNEL TRAP	BASKET TRAP
Ramaka	V.6					X
Ptahshepses	V.6L-7	X			X	
Niankhkhnum/Khnumhotep	V.6L-7	X	X	X	X	X
Hetepherakhti	V.6-8E		X			X
Ty	V.7-8E	X	X		X	X
Kaemnefert	V.7-9E		X	X		
Senezemib : Inti	V.8M-L		X	X		
Akhethotep	V.8L-9E		X	X		
Hesimin (M 22)	V.8-VI.1		X			
Khenut	V.9		X			
Iynefert : Shanef	V.9		X			
Senezemib : Mehi	V.9		X	X		
Seshseshet : Idut	V.9		X	X		
Ptahhotep : Thefu	V.9L		X	X		
Seshemnefer [IV]	V.9-VI.1M		X			
Nefer [I]	V.9-VI.1			X		
Nimaetre	V.9-VI.1		X	X		
Kagemni : Memi	VI.1E-M	X	X	X	X	
Mereruka : Meri	VI.1M		X	X	X	X
Snefruinishtef	VI.1?		X	X		X
Hesi	VI.1L-2E		X	X	X	
Uzahat..Nefer..Sheshi	VI.1L-2E		X			
Nikauisesi	VI.1L-2E		X			
Kairer	VI.2			X		X
Mereri	VI.2E		X			
Meryre-meryptahankh : Nekhebu	VI.2		X			
Mehu	VI.2M-3?	X	X		X	X
Tomb G 97	VI.2L-3		X			
Bawi (?)	VI.2-4E		X			
Seshemnefer : Ifi	VI.2-4?			X		
Ibi	VI.4E	X	X	X	X	
Djau:Shemai	VI.4L		X	X		
Pepyankh : Heny-kem	VI.4-5		X	X		
Kahep : Theti-iker	VI.5-6		X	X		
Shepsipumin : Kheni	VI.6		X	X		
Unisankh	VI.6		X			

959 Davies, *Deir el-Gebrâwi* I, 12; Harpur, *Decoration*, 181, n. 131; Decker, *Sport & Games*, 158–167; Kanawati, *Tomb and Beyond*, 92–94.

New Scene Types: New Techniques and New Technologies

As a consequence of changing environmental circumstances leading to the development of more varied habitats, the adoption of smaller nets and nets more suitable to narrower channels can be explained by the application of the A.R.I.D. hypothesis outlined in Part B. A greater variety of techniques and technologies was adopted to utilise this resource more effectively. A number of new fishing techniques entered the decoration lexicon in the reign of Niuserra – angling, new net forms and new types of traps (funnel and basket). In the Fifth Dynasty, a new type of marsh composition was introduced into royal and elite decoration, known as a 'composite fishing and fowling scene'.[960] Woods identifies a royal relief dating to the time of Userkaf but points out its adoption by the elite was not until the mid-Fifth Dynasty.[961] Perhaps the increasing instances of the removal of wives from the composition of spearfishing scenes from the mid-Fifth Dynasty onwards[962] is an indicator of the less-than-gratifying aspects of the activity and a focus on the necessity of the task.

Fishing equipment appears to be less complex and less sophisticated from the time of Niuserra onwards, suggesting minimal maintenance. The types of traps depicted are smaller and need fewer people to operate them effectively. The contention is not that it was impossible to use dragnets, seine nets or large nets, rather that in many places along the river, it was more convenient to use smaller, more manoeuvrable ones. The representation of hand nets, which are quite effective and do not require many operators,[963] changed little from the Old Kingdom to the Middle Kingdom.[964] Depictions of funnel traps in the tomb of Ptahshepses,[965] basket traps in the tomb of Ty,[966] hand-held nets in the tomb of Kagemni[967] and large nets in the tomb of Mehu,[968] for example, all depict activities that could be undertaken by a smaller group, rather than the larger body of men who needed to be organised for dragnetting or seine netting.

---

960 Harpur, *Decoration*, 140.
961 Woods, *Marshes*, 13, Appendix 3: #4.
962 Woods, *Marshes*, 54. See Roth, *Absent Spouse.*
963 Brewer & Friedman, *Fishing*, 40.
964 Brewer & Friedman, *Fishing*, 38–39.
965 Vachala, *Ptahshepses*, 138–139 [J1092].
966 Épron & Daumas, *Ti*, I, pl. 9.
967 von Bissing, *Gem-ni-kai* I, Taf. 4 [1, 2].
968 Altenmüller, *Mehu*, 136, Taf. 35 [a].

Interestingly, the combined tomb of Nianchchnum and Khnumhotep depicts all of the new fishing technologies as well as those more traditional. Even the tomb of Ty, from the same era, only depicts four of the new activities. It is not until the Sixth Dynasty that tombs are prepared depicting more than two of these new scene types. The large tombs of Kagemni and Mereruka depict most of the new fishing technologies as well as the more traditional dragnetting scene. Similarly, at Saqqara, the tomb of Hesi, despite its small size, contains most of these themes, as does the tomb of Mehu. At Dahshur, the tomb of Snefru-in-ishtef displays indications of a more individualised fish acquisition programme, including the use of large and small nets, hand held nets, as well as scenes depicting a (non-elite) individual angling.[969] Further south, the tomb of Ibi, at Deir el-Gebrawi, also portrays these innovations, and includes illustrations of the use of funnel nets.[970]

Smaller Traps take Advantage of New Channels

If a rapid growth of papyrus and reeds at the edges of the river took place, as Chapter Four proposes, large dragnets would have been difficult to land on the increasingly crowded riverbanks. Smaller dragnets that could be pulled onboard rivercraft may have been adopted, necessitating the fishermen to venture further towards the middle of the river. Individuals unwilling to venture so far from safety may have been forced to adapt or modify the apparatus that they were currently using to take advantage of the new situation.

It is possible that the adoption of the funnel trap was a pragmatic response to the increasing number of smaller canals and secondary channels developed as a result of a weakening river. Smaller, more manageable traps and nets may have been a more pragmatic option for people relying on fish meat as one of their major sources of protein. Intriguingly, of those individuals identified above, all contain a funnel trap scene in addition to scenes depicting the setting of large nets from boats.[971] Mereruka's tomb contains one of these scenes, as does the tomb of Hesi.[972]

---

969 Borchardt, *Cat. Caire* II, Bl. 103 [CG 1771]; de Morgan, *Dahchour*, II, pl. 24. The detail is very unclear, and the current author is reliant on the original authors' descriptions.

970 Davies, *Deir el-Gebrâwi* I, 12–14, pls. 4, 6, 11; updated in Kanawati *Deir el-Gebrawi* II, 28–29; pls. 7–10, 45–46.

971 Vachala, *Ptahshepses*, 138–139 [J1092]; Moussa & Altenmüller, *Nianchchnum & Chnumhotep*, 100, Taf. 31, Abb. 12; Wild, *Ti,* II, pls. 77 [B], 61; von Bissing, *Gem-ni-kai* I, 13–14, 20 [43–6], Taf. 17–18; Altenmüller, *Mehu,* 140–141, Taf. 35 [a], 38; Davies, *Deir el-Gebrâwi* I, 14, pl. 6.

972 Duell, *Mereruka* I, pls. 42–43, 45; Kanawati & Abder-Raziq, *Hesi*, pls. 21–22, 24–25.

An area for further investigation may be the increased likelihood of the adoption of an attendant (incidental?) form of aquaculture during this time of riverine nutrient enrichment. This will be discussed further in Chapter nine, where the role of cattle in the development of 'incidental aquaculture' will be discussed.

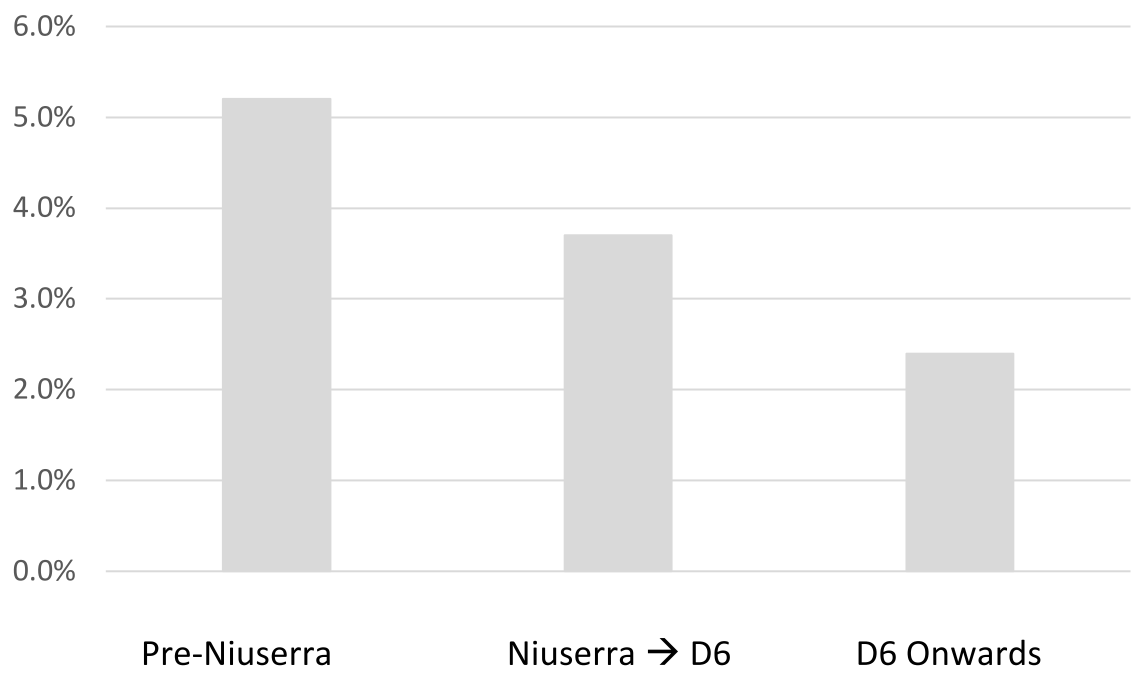
7.4 – Fighting Boatmen

The image of the fighting boatman is one of the typical marshland scenes depicted in ancient Egyptian tomb paintings,[973] (see Table 25: Boatmen depictions: proportions pre- and post Niuserra). While it may represent a sport or physical activity,[974] others suggest a deeper symbolic meaning, that the scene is thought to represent.[975] There are two basic scene types: those depicting boatmen returning peacefully and those depicting fighting or jousting. ,

Table 25: Boatmen depictions: proportions pre- and post Niuserra

Boatmen depictions	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of overall attestations	5.2%	3.7%	2.4%

Figure 41: Boatmen depictions: proportion change over time



[973] Harpur, *Decoration*, 141–155 and 339–350, tables 6.19–6.24. For an excellent overview of such depictions in the Old Kingdom, see Bolshakov, *Boatmen Jousting*, 30–37.

[974] Montet, *Les scenes*, 81; Vandier, *Manuel* V, 510–531; Decker, *Bildatlas zum Sport*, 533–545; Harpur, *Decoration*, 153.

[975] Bolshakov, *Boatmen Jousting*, 37–39.

Interestingly, in the light of the A.R.I.D. hypothesis, the overall proportion of scenes depicting boatmen decreases over the time frame in question with the overall proportion of decorations that depict boatmen declining to less than half of the proportion before Niuserra (see Figure 41: Boatmen depictions: proportion change over time). This rapid decline in representations may suggest a decreasing relative importance to the tomb owner This may also indicate that this activity may have diminished as a consequence of a less open, more crowded river. However, it would be expected that a more crowded river should have led to increased competition for open space and precipitated more aggressive responses in the boatmen.[976] Before the time of Niuserra, the majority of scenes representing boatmen depict them returning peacefully. From the time of Niuserra onwards, there is a significant decrease in the proportion of scenes depicting boatmen engaged in peaceful interactions (see Table 26: Boatmen activities: proportion pre- and post Niuserra).

Table 26: Boatmen activities: proportion pre- and post Niuserra

Boatmen Activities	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Overall	5.2%	3.7%	2.4%
Fighting	1.3%	2.0%	1.2%
Peacefully Returning	3.9%	1.7%	1.2%

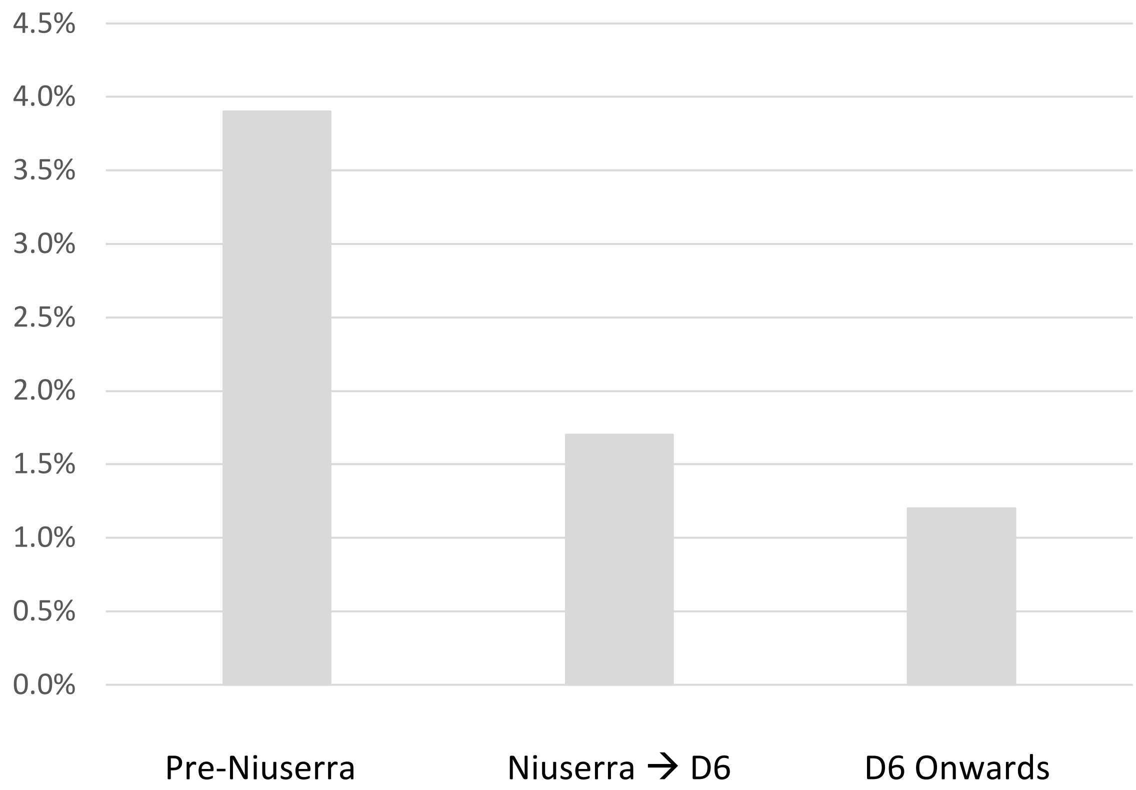
Boatmen and A River In Drought

As the overgrowth of papyrus clumps and reed mats entered the river proper, they would have restricted clear passage for any large watercraft using them, just as the proposed space restrictions would have limited the use of large nets. Using the term 'fighter' to describe boatmen fighting or jousting may seem inappropriate, as it suggests something beyond friendly rivalry and competition (see Figure 42: Boatmen fighting: proportion of boatmen

[976] For example, the following tombs display one of the boat crew having ended up in the water; Duell, *Mereruka* II, pl. 13; Kanawati & Abder-Raziq, *Unis Cemetery*, II, pl. 62; Moussa & Altenmüller, *Nianchchnum & Khnumhotep*, pls. 74–75; Simpson, *Kaiemnofret*, pl. G; Moussa & Altenmüller, *Nefer & Kahay*, 26, pls. 10–11; Brovarski, *Senedjemib*, I, 44, figs. 38–39. Gardiner, *Ancient Athletics*, 8, calls it a sport but describes the pole as a 'weapon'.

returning peacefully over time). However, with less open space, perhaps there developed increased competition for clear water in which to fish or lay the larger nets which were the most common form of nets depicted before the time of Niuserra. It may be that good-humoured rivalry developed into something more antagonistic as fishing intensified as a major resource activity.

Figure 42: Boatmen fighting: proportion of boatmen returning peacefully over time



Whether the representations were metaphoric or more visceral, the composition changed over the time frame in question.[977] Perhaps competition for resources and space occurred alongside the competition to be the first crew to deliver the gifts to the tomb owner. Perhaps the testicular manipulation depicted in some tombs[978] is an indication of the increasing fierceness of the competition for resources.

977 Harpur, *Decorations*, 154–155; Woods, *Marshes*, 43–45.

978 For example, see Kanawati, et al., *Inumin*, pls. 17, 48; El-Khouli & Kanawati, *Saqqara* II, pl. 40; Kanawati & Woods, *Artists*, 56, pl. 99; Kanawati, *Mereruka & Teti*, 40–41, pls. 70 [a–b].

7.5 – Catfish, Drought and Art

The only fish represented from a (mostly) top-down, as opposed to a side-on, view, is the 'walking' catfish (*Clarias gariepinus*); with both eyes of this catfish usually represented in Egyptian art.[979] The other two main catfish species depicted in Egyptian art are the 'African' catfish, *Synodontis schall*, and the 'upside-down' catfish, *Brachysynodontis batensoda,* more commonly identified as *Synodontis batensoda* in Egyptological literature; and these are always represented side-on.[980]

Upside-down and top-down/both-eyes catfish scenes

The upside-down catfish is drawn in an eccentric manner, allowing it to be distinguished from other catfishes in wall scenes.[981] Depiction of upside-down catfish appears to have begun during the reign of Niuserra.[982] The image displayed on the walls of the tomb of Waatetkhetor shows the animal upside down at the surface of the water.[983] While some of this creature's main food sources are on the surface of the water, it is important to note that the surface of the water, the boundary between the air and liquid environments, also contains a higher concentration of oxygen.[984] Catfish have an organ that allows them to live for short periods of time on air. Some of the catfish species have been noted as 'air gulpers',[985] which allows them to break the surface of the water for some small amount of time: this behaviour may have been interesting enough to have resulted in its peculiar representation on the walls.[986]

It would be expected that the greater number of smaller secondary channels would have experienced a faster-than-normal diminution in the levels of oxygen, leading to more instances of catfish gathering at the surface. Contamination due to excess nutrients could

---

979 For example, Duell, *Mereruka*, pl. 43 and Kanawati & Abder-Raziq, *Hesi*, pl. 53.

980 Evans, *Animal Behaviour*, 103.

981 For example, as depicted in Davies et al., *Saqqara Tombs*, pl. 25. Chapman & Mackay, *Copeia*, fig. 2, produces an artistic impression of this species' characteristic behaviour. See also Brewer & Friedman, *Fishing*, 67–69; Evans, *Animal Behaviour*, 163–166; Boulenger, *Fishes of the Nile*, 382.

982 See Woods, *Marshes,* 380, Appendix 3: #175, for the life span of this particular scene type.

983 Duell, *Mereruka*, pl. 43; updated by Kanawati & Abder-Raziq, *Waatetkhetor*, pl. 56.

984 Chapman et al, *Swimming Upside Down*, 130–135.

985 Brewer & Friedman, *Fishing*, 60; Evans, *Animal Behaviour*, 48.

986 Brewer & Friedman, *Fishing*, 69; Woods, *Marshes*, 402–403. See Evans, *Animal Behaviour,* 48, n.88, 89, 90, for an exploration of the perspective of the view.

have also become a source of distress.[987] Increasingly crowded waters, due to the papyrus/reed bloom that developed in a weakening river, could have led to a decline in oxygen content, forcing the catfish to migrate between now unconnected secondary channels.[988] Despite the potential formation of environmental oxygen stress due to increasing nutrients in the water, recent experimental work has demonstrated that the average body size of catfish increases in response to the presence of certain 'contaminants' in the water supply.[989]

The catfish's omnivorous diet improved its odds of finding food and adapting to changing food webs,[990] increasing its presence within the local ecosystems. While the catfish's higher chances of surviving inhospitable micro-habitats may have given it an adaptive advantage,[991] its improved success may have resulted in it becoming, through simple probability, a larger part of the diet of the Egyptian population.[992] Noted was the significant number of catfish bones recorded in an archaeological context, a huge proportion compared to other types of fish.[993] This conclusion has already been drawn by Luff and Bailey, suggesting that the bone records in spoil heaps point to an increasing role of that particular species as a source of protein.[994] This evidence may corroborate the evidence of increasing catfish representations.

Catfish Depictions and A River In Drought

If the hypothesis under investigation is valid, then the consumption of catfish would have increased and should be more noticeable in the archaeological record. Interestingly, in modern day Botswana, in times of a low river, the catfish becomes the main source of fish protein.[995] Catfish representations increased perhaps due to their behaviour becoming more idiosyncratic and notable. A potential catfish-related indicator of a changing environment is described in the tomb report of Ankhires, dating to late Fifth Dynasty, from Abusir. Perhaps this explains why the instances of upside-down depictions increase over the time

987 Chapman et al., *Limnological Observations,* 1821–1826.
988 Habib & Samah, *Catfish Protein Synthesis*, 555; Sabri et al*., Catfish Infections*, 897. Awadan et al., *Parasitic Catfish Disease,* 20.
989 Mona et al., *Catfish Supplementary Feed*, 5–6.
990 Awadan et al., *Parasitic Catfish Diseases*, 17.
991 Verreth et al., *Catfish Digestive System*, 296–297; Mona et al., *Catfish Supplementary Feed*, 1.
992 Luff & Bailey, *Aquatic Basis Ancient Civilisations*, 100–113.
993 Duliková, *Ankhires at Abusir*, 27.
994 Luff & Bailey, *Catfish Growth Structures*, 831–832.
995 Steward et al., *River Runs Dry,* 204.

frame in question – the artists were simply drawing what they saw.[996] Another response of some catfish species to low levels of oxygen in waterways might be observable in their propensity to 'migrate', catfish being able to 'walk' on their pectoral fins.[997] Evans suggests that it is when they are observed in this act of locomotion, that the two eyes become obvious and may explain why they are represented in this manner.[998] Fortunately for catfish, their ability to survive out of water for at least twelve hours[999] may have given them the capability to escape from water becoming increasingly uninhabitable. If the A.R.I.D. hypothesis is valid, 'walking' behaviour would have become more frequently observed[1000].

---

996 Evans, *Animal Behaviour,* 103–104.
997 Johnels, *Catfish Terrestrial Locomotion*, 122–129.
998 Evans, *Animal Behaviour,* 48, n. 88.
999 Stewart, *Fossil Fish*, 683.
1000 Stanley et al, *Nile Flow Failure,* 395–402; Brewer & Friedman, *Fishing*, 60.

SUMMATION: CHAPTER SEVEN

An Increasing Reliance upon Fishing

The significant points arising from this chapter include:

- ⇒ A river that retains its nutrients increases its biological potential, which encourages plant growth.
- ⇒ This leads to an increase in organisms that use plants for food and/or shelter, which, in turn, results in an increase in these organisms' predators.
- ⇒ Over the time frame in question, a greater population of fish would develop, making the harvesting of these organisms a more rewarding endeavour.
- ⇒ The greater availability of fish for harvest would have required fishing techniques to adapt to the new habitat and encouraged adaptation to the use of more suitable technologies such as smaller nets and traps.
- ⇒ Progressively clogged river margins would have decreased the effective use of large nets that required many operators, such as seine and drag nets.
- ⇒ The relative proportion of representations of smaller less human intensive technologies coincides with this time.
- ⇒ The mounting abundance of fish bones, as an overall proportion, in refuse dumps in a number of archaeological sites suggests that fish as a ready source of protein had become progressively more important.
- ⇒ This dietary change, as suggested in the archaeological record may be evidence of a response to changing ecological circumstances.

It could be inferred that as large dragnetting endeavours had begun to decrease, perhaps the organisational skills or administrative apparatus needed to initiate such activities would also diminish. It could be suggested that fishing had become a less 'industrialised' process with an increasing emphasis upon family or small-group-oriented actions. The data suggests that fishing required smaller groups of people, perhaps to avoid overcrowding the secondary channels that had developed. It could be inferred that a changing emphasis in the diet had come about as a result of a changing environment.

CHAPTER EIGHT

WATERFOWL AND A RIVER IN DROUGHT

Note: an abridged version of this chapter is currently in press.
See Burn, J. W. 2019 (in press). 'Old Kingdom Tomb Decoration Changes as an Indicator of a Changing Riverine Ecology?' in Proceedings of the Old Kingdom Art and Archaeology Conference, Milan, May 8–12, 2017, Milan.

8.0 – INTRODUCTION

As a food resource, birds were a significant supply of protein. In Chapter Five it was identified that the proportion of representations depicting birds and activities related to them declined slightly over the time frame in question. If a changing environment resulted in expanded marshlands as suggested by the analysis in Part B, then data suggesting a decline in bird depictions seems to be inconsistent with the hypothesis under investigation. Perhaps more detailed analysis of the data is needed.

In this chapter, the distribution and abundance of those depictions relating to birds will be studied in more detail to scrutinise the changing role of birds as a food resource. In order to clarify the results obtained, this chapter will attempt to look towards those birds that may have been directly affected by a changing riverine habitat and will focus especially upon the already identified apparent increasing importance of poultry.

8.1 – Avian and Associated Attestations

Birds have played an important role in ancient Egypt: in religious[1001] and symbolic roles[1002] as well as by other more pragmatic means.[1003] The utilitarian relationship of avians to the ancient Egyptian culture has been meticulously summarised by Bailleul-LeSuer,[1004] tracing the economic role of this important resource group throughout Dynastic times. In a similar manner to the way in which depictions of the agricultural cycle appear to be an 'instruction manual', clap-netting seems to be 'instructional' in its portrayals; indeed, the overall process of clap-netting can be understood by amalgamating these types of scenes from many tombs.[1005]

Earlier, in Chapter Five, it was noticed that the relative proportion of scenes produced during the Sixth Dynasty whose themes were linked by their associations to avians decreased by about three percent (3%) compared to the proportion attested in the previous dynasties, a change that is not statistically significant. However, if we were to look at the changes across a few more boundaries, a clearer picture may emerge (see Table 27: Proportion change in avian representations: pre- and post Niuserra).

Table 27: Proportion change in avian representations: pre- and post Niuserra

Avian & associated scenes	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of All Scenes	6.4%	8.4%	7.9%

From before the time of Niuserra compared to Niuserra onwards, there is a significant change. The proportion of decorations depicting avian subjects as a whole increased by a third during the time of Niuserra and the latter stages of the Fifth Dynasty, then declined

---

1001 Bailleul-LeSuer, *Avian Resources*, 1–14.

1002 Cíałowícz, *La naissance d'un royaume*, 217–218; Patch, *Egyptian Art*, 44–46; Hendrickx et al., *Early Falcons*, 129.

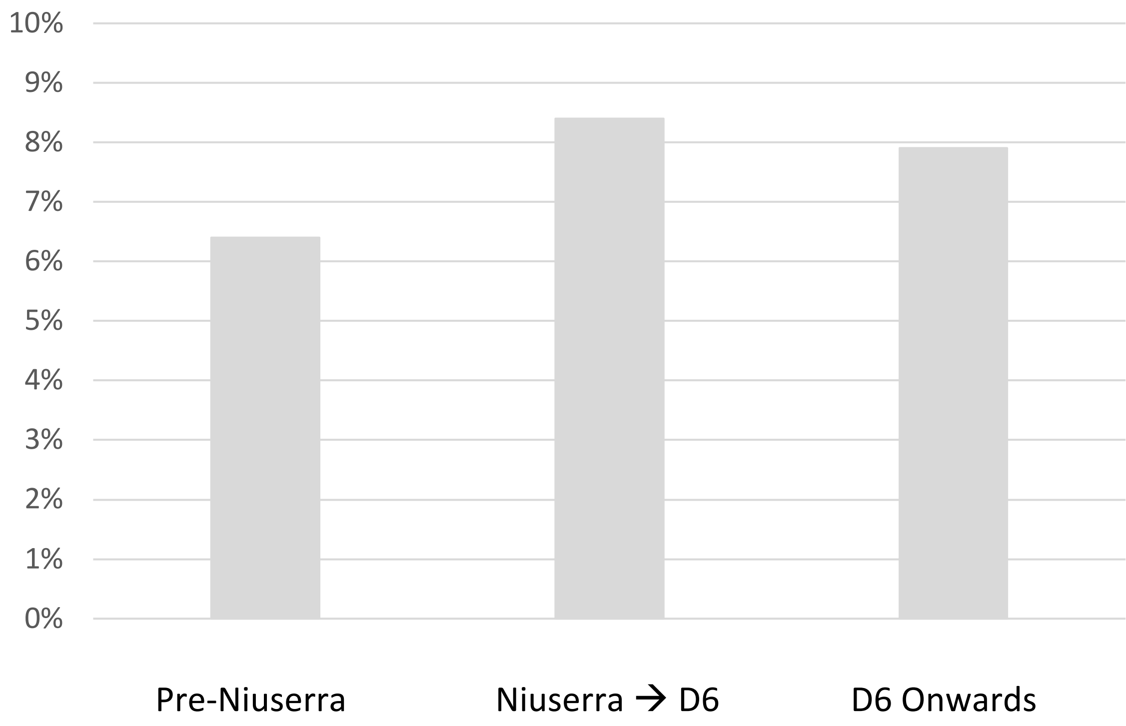
1003 For example, as sources of meat, eggs and feathers, as incidental guard birds and as accidental gardeners and insect-eaters: see Vernus & Yoyotte, *Bestiaire*, 342–427; Bailleul-LeSuer, *Avian Resources*, 2; Ikram, *Choice Cuts*, 24.

1004 Bailleul-LeSuer, R., *Avian Resources*.

1005 Mahmoud, *Vögel im Alten Reich*, 155–162.

slightly during the Sixth Dynasty (see Figure 43: Avian representations: proportion change over time). Before the time of Niuserra only two tombs contained images of the trapping of songbirds; these were the early Fifth Dynasty tombs of Sekhemkare and Rawer, at Giza.[1006] During the time of Niuserra, the total attestations whose themes related to birds and poultry increased, compared to earlier times.

Figure 43: Avian representations: proportion change over time



As well as a slight increase in overall proportion, new themes entered the repertoire with pigeons, for instance, joining the bird procession at this time.[1007] From the time of Dynasty Six onwards, however, this proportion declined once more, but not to the levels seen before the time of Niuserra. Notably, the trapping of songbirds in orchards using hand-set traps began to be attested early in Dynasty Six, in the tombs of Mereruka and Hesi at Saqqara.[1008]. It is worth recalling that the overall proportion of scenes depicting orchard scenes declined over this same time frame: perhaps the use of smaller, more manageable nets may be indicating smaller orchards.

1006 See Hassan, *Gîza* IV, 110–111, fig. 57, and Hassan, *Gîza* I, p. 33, pl. 34 [3], respectively.
1007 MMA, *Handbook*, 31, fig. 11 (part).
1008 See commentary in Harpur, *Miscellaneous Reliefs*, 35–36, fig. 5, for Mereruka, and Kanawati & Abder-Raziq, *Hesi*, 34, pls. 27, 29, 56.

Earlier, it was suggested that as some marshland plants become more numerous and larger, they provide a greater diversity of habitats for bird species. It would be expected, therefore, if decorations changed in response to changing cultural behaviours, that more depictions of birds and their capture should have been identified. This was not the case. However, within the avian category, there appears to exist two distinctly different type of bird categories: poultry (the waterfowl) and others, each with different behavioural characteristics and habitat requirements. Considering its different habitat settings and distinctive behaviour patterns in relation to the river, the poultry class may be seen to be an individual class of resources on its own. The main members of the poultry family associated with Old Kingdom tomb decorations are not chickens,[1009] but geese and ducks, along with similarly related waterfowl.[1010]

Poultry Proportions

It was deemed worthwhile, therefore, to observe the changes in numbers of avian attestations with and without poultry (see Table 28: Avian versus poultry attestations: pre- and post-Niuserra). The overall proportion of scenes depicting an avian theme, without the presence of poultry, decreases by almost one-half during the Sixth Dynasty. At the same time, those scenes depicting poultry-related themes more than double, while those depicting the various netting activities occurring in garden and orchards, for example, decline.

Table 28: Avian versus poultry attestations: pre- and post-Niuserra

Avian vs poultry	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
All avian incl. poultry: proportion all scenes	6.4%	8.4%	7.9%
Poultry only: proportion of all scenes	1.3%	2.2%	4.7%
Poultry: proportion of all avian scenes	20%	26%	60%

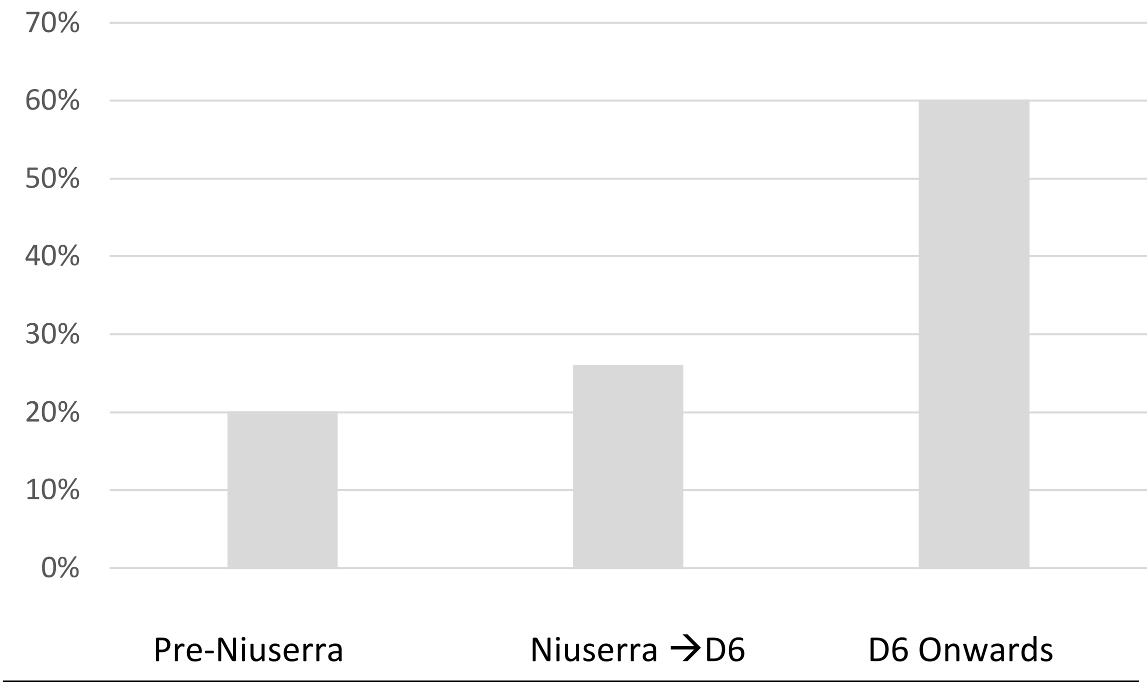
[1009] Despite some commentators identifying the ‘quail chick’ hieroglyph as a baby chicken; see Coltherd, *Domestic Fowl*, 218–219; Houlihan & Goodman, *Birds*, 54.

[1010] Houlihan & Goodman, *Birds,* 54; Luff, *Ducks*, 519.

8.2. – The Parable of Proliferating Poultry

Chickens, the most commonly assumed member of the poultry family, are a late-comer to the archaeological record,[1011] with their remains found in Late Period Elephantine,[1012] and domestic breeding of them becoming significant during times much later than covered by this investigation.[1013] While poultry was always a significant part of the Egyptian diet, documented since Predynastic times,[1014] some impetus must have spurred their increased presence in the elite tomb decoration programme in the Old Kingdom. The rapid increase in the numbers of tomb scenes depicting fowling *and* fishing in the same scene indicates the increasing importance attributed to fowling.[1015] Of all attestations relating to the subject of avian resources, only one-fifth of the attestations before Niuserra represented the poultry subset.

Figure 44: Poultry within avian attestations: proportion change over time



1011 Coltherd, *Domestic Fowl*, 217–23.

1012 von den Driesch & Peters, *Störche über Elephantine,* 667, Taf. 5; Darby et al, *Gift of Osiris*, 1; Coltherd, *Fowl in Ancient Egypt*, 217–23; Ikram, *Choice Cuts*, 26.

1013 MacDonald & Edwards, *Chickens in Africa*, 584–90; Bailleul-LeSuer, *Avian Resources*, 411, 419. For a slightly earlier date, see comments in footnote n.70 of Bailleul-LeSuer's dissertation.

1014 Ikram, *Meat Processing*, 656.

1015 Harpur, *Decoration*, 257.

This proportion rose to more than one-quarter from the time of Niuserra to well over one-half by the time of Dynasty 6 (see Figure 44: Poultry within avian attestations: proportion change over time). In bird procession scenes in the tombs of Waatetkhethor[1016] and Ibi[1017], for instance, it is difficult to identify birds that are not aquatic.

Waterfowl Depictions and A River In Drought

It has been shown that representations of orchards and gardens decreased over the time frame in question. Consequently, it seems reasonable that attestations of animals associated with orchards and gardens would also lessen in number over the same time frame, explaining the decrease in depictions of songbirds, for example. It remains important to investigate why a rapid increase in the apparent importance of poultry took place at that time.

Previously, it has been noted that, by the time of the Sixth Dynasty, the preponderant subject in tomb decorations with an avian theme seemed to be poultry. The rapid decline in non-poultry avian depictions, as well as the even more rapid increase in tomb decorations depicting poultry, can be explained in relation to the A.R.I.D. hypothesis. It is easily possible to relate the increase in poultry scenes to the ecological changes postulated. If the river changed properties, then the redistribution of abundance of some plant species should have changed the habitat of the riverbank. As the river underwent a change in its volume, and hence its power, the habitats attached to the river should also have experienced a departure from the accustomed situation. If a change in the distribution and abundance of some plant species occurred, then the ecosystem would have experienced instability until a new natural equilibrium was achieved. An environment with characteristics now favouring papyrus and reeds over bulrushes and lilies would have altered the balance of the food webs associated with the river.

The ecosystem must have also changed as a consequence, with the identified archaeological changes occurring in response. Poultry animals such as geese and ducks are happily omnivorous and can quite successfully forage for themselves.[1018] Geese browse on grass,[1019]

1016 Kanawati & Abder-Raziq, *Waatetkhethor*, pls. 62, 65–66.
1017 Kanawati, *Deir el-Gebrawi* II, 30, pls. 11–13, 47–58, 68.
1018 MacDonald & Blench, *Geese*, 529.
1019 https://poultrykeeper.com/keeping-geese (Aug. 7, 2017).

so an increase in grasses and juvenile reeds at the river's edge would have enhanced their diet diversity and lessened the amount of feed they needed to source elsewhere. An increase in dense and moist vegetation on or around the river's edge would also benefit their survivability. Ducks enjoy a bug-heavy diet,[1020] contentedly eating worms and bugs that are found as predators on important cereal crops, so inadvertently helping weed an area and act as living pesticides. An increase in poultry numbers as an aid to agricultural production during times of pastoral stress seems once again perfectly feasible.

Poultry Becoming a More Significant Resource

The archaeological remains of geese and the relative largeness of an individual's size, compared to their keepers in artistic representations,[1021] as shown in the tombs of Merefnebef and Kahai at Saqqara,[1022] for example, suggest the animal would have represented a significant protein source.[1023] Providing ready access to feed, or force- feeding them, would have made the animals more massive, reducing their ability to fly long distances.[1024]

A decline in available water for orchards and gardens would have led to a decrease in availability of the avian occupants of these regions. Songbirds and other birds attracted to the invertebrate pollinators of these plants would have diminished in numbers. On the unsolidified boundaries of the river, waterfowl would have been increasingly attracted to the expanding variety of aquatic food webs that would have been developing.[1025] On the more solid banks of the river, geese and ducks would have found more opportunities to graze and forage as the margins between the land and river enlarged. Enhanced opportunities would have led to rapid population growth of the waterfowl, providing greater prospects for hunting or harvesting them, and perhaps explaining the rapid increase in the number of representations depicting this activity.[1026]

1020 https://poultrykeeper.com/keeping-ducks (Aug. 7, 2017).
1021 Boessneck, *Riesige Hausgänse*, 105–10.
1022 Myśliwiec, et al., *Merefnebef*, 151, pls. 22, 70d; Lashien, *Kahai*, pl. 39a, b. For an example at the end of this era going into the next, see Vandier, *Mo'alla*, fig. 14.
1023 Kiple & Ornelas, *Geese*, 529–531.
1024 Zeuner, *Domesticated Animals*, 467–468; MacDonald & Blench, *Geese*, 530; Mannermaa, *Goose Domestication*, 3096–3097.
1025 Luff, *Ducks*, 519.
1026 Harpur, *Decorations*, 257.

8.3 – Avian Predators

An overgrown riverbank, with taller stands of reeds and denser overhanging thickets of papyrus, would have provided a greater refuge from airborne predators, perhaps allowing a boost in the overall numbers of the avifauna populations.[1027] It would be expected that, with an increase in avian numbers, a commensurate increase in the populations of their predators would have developed. Common mammalian predators of riverbank and marshland bird species are the genet (*Genetta genetta)*[1028] and the mongoose (*Herpestes ichneumon),*[1029] which is slightly larger.[1030] This similarity in size and structure has led to some confusion in the identification of the two types of predators by previous researchers. In distinguishing between the representations of genets and mongooses, this study has followed the guidelines outlined out by Evans.[1031]

The Genet and the Mongoose

Genets are abundant in vegetated areas,[1032] especially beside watercourses,[1033] and while they can climb,[1034] most of their prey is caught at ground level.[1035] An increase in plant cover would be expected to have benefited their behaviours by providing greater hiding places. Similarly, with an increased biomass extending protection to nesting and burrowing birds, avian population growth would have provided the genet with more opportunities to harvest eggs and young birds. The mongoose, a terrestrial hunter, preferred covered waterways;[1036] however, it displays an aptitude to adapt to many varieties of wetland conditions.[1037] The mongoose hunts mainly during the day,[1038] as opposed to the nocturnal genet,[1039] but still

---

1027 Guisan & Thuiller, *Species Distribution,* 993–1009.
1028 Gaubert et al., *Genetta genetta*, 1.
1029 Do Linh San et al, *Herpestes ichneumon*, 1–2.
1030 Hoath, *Field Guide*, 88–90; Estes, *Behavior Guide,* 298–302.
1031 Evans, *Animal Behaviour*, 36, n.43, 208–214.
1032 Haltenorth-Diller, *Field Guide*, 188; Larivière & Calzada, *Genetta genetta*, 3.
1033 Virgós & Casanovas, *Genet Habitat Selection*, 169–177; Gaubert, et al, *Genetta genetta*, 4.
1034 Estes, *Behavior Guide,* 281; Wemmer, *Comparative Ethology*, 13.
1035 Schliemann, *Viverrids*, 518.
1036 Özkurt, *Egyptian Mongoose*, 486.
1037 Barros et al., *Egyptian Mongoose Expansion*, 5–6.
1038 Haltenorth & Diller, *Field Guide*, 201–202; Estes, *Behavior Guide*, 298.
1039 Lariviére & Calzada, *Genetta genetta*, 3.

prefers to remain in cover.[1040] It is unable to climb,[1041] despite some depictions of it doing so,[1042] so relies on food on the ground or within its reach.[1043] Food items are usually taken into dense cover to be eaten.[1044] An increase in plant cover would have aided the hunting activities of mongooses, as well as protecting them from larger predators.[1045] Perhaps this indicates that mortality to water birds may have more frequently arrived on four legs rather than two?

Avian Predator Depictions and A River In Drought.

Evans identified the genet in a number of marsh scenes in tombs dating from the late Fourth to the late Sixth Dynasty.[1046] Of the scenes where she clearly identified the predator, only one of the scenes dates to Dynasty 4; the remainder date from the time of Niuserra onwards. Interestingly, of the Old Kingdom tomb decorations identified by her as including depictions of the Egyptian mongoose, only one dates to before the time of Niuserra.[1047]

Both these predators would have been in direct competition with human hunters for waterfowl.[1048] This may explain why the depictions of these animals focus primarily on their hunting of waterfowl,[1049] an (increasingly) important source of food for the local population at the time. However, in depicting a potential rival, the artists represented both mongooses and genets as able to climb, a physical unlikelihood in the case of the mongoose that has been noted by a number of scholars.[1050] Evans points out that, while mongooses are not thought to climb at all,[1051] she posits that perhaps scholars are misinterpreting these representations and the portrayals of the animals on papyrus stems is not depicting them 'climbing' but perhaps moving away through the vegetation, deeper into it.[1052] If the images

---

1040 Estes, *Behavior Guide*, 299; Özkurt, *Egyptian Mongoose*, 484; Barros et al., *Egyptian Mongoose Expansion*, 11.
1041 Delibes, *Herpestes ichneumon*, 356–357.
1042 Evans, *Animal Behaviour,* 43–45, discusses errors of representation and provides an alternative interpretation.
1043 Estes, *Behavior Guide*, 299; Kingdon, *East African Mammals*, 180.
1044 Ben-Yaacov & Yom-Tov, *Egyptian Mongoose,* 39, 48.
1045 Lariviére & Calzada, *Genetta genetta*, 3; Galantinho & Mira, *Occurrence of Genet*, 680–681; Martínez-Jauregui et al, *People & Predators*, 241–242.
1046 Evans, *Animal Behaviour*, 41, where she identified twenty-three instances.
1047 Evans, *Animal Behaviour*, 41–42.
1048 Admasu et al, *Genetta in Farmlands*, 160–162; Delibes, *Herpestes ichneumon*, 357.
1049 Evans, *Animal Behaviour,* 43.
1050 Houlihan, *Ti Swampland Scene*, 20; Evans, *Animal Behaviour*, 42–43.
1051 Evans, *Animal Behaviour,* 42–43.
1052 Evans, *Animal Behaviour,* 44, n. 68–69 explains succinctly the artistic principle justifying her assertion.

of these animals on single stalks is to be taken more literally, they could represent the creatures walking on flattened papyrus stalks, a consequence of papyrus that has grown to larger-than-normal heights, has fallen over and acts as a floating ramp on the water.[1053] This mat would act as excellent cover for birds, increasing the hunting potentialities for the mongooses present. Interestingly, Evans now believes that during this time, Egyptians began to use these animals in hunting activities, with these animals partly domesticated; she suggests that the representations of these animals with straps around them suggests they have been trained.[1054]

[1053] Britton, *Papyrus Swamps*, 450; Thompson & Hamilton, *Peatlands*, 334–335.
[1054] *Pers. comm.* 15th Aug, 2019; (publication in preparation)

8.4 – Changes in Art: Fowling in the Marshes

As noted in Chapter Seven, from the time of Niuserra and into the Sixth Dynasty, some decorations depicted fowling activities in front of a very crowded papyrus thicket with a congested composition. Before that, the arrangement of the thicket seemed rigid and formulaic.[1055] In the tomb of Nebemakhet at Giza (Late Fourth Dynasty), the papyrus stems are regularly spaced and the birds atop lined up as if in a queue.[1056] Also increasingly prevalent over this time frame is the depiction of the thicket with fewer stems represented than umbels:[1057] this presentation enters the artistic repertoire mid-Fifth Dynasty and continues through the Old Kingdom.[1058] The tomb of Khunes at Zawiyet el-Maiyetin, for example, depicts many fewer stems than umbels, allowing the placement of more bird images within the thicket.[1059] Also noteworthy is that in this tomb, the birds appear more agitated than examples depicted in earlier tombs.

Fowling Scenes and a Cluttered Papyrus Thicket

In some instances, the artist has represented the papyrus thicket with stems separated and unevenly spaced, rather than touching and forming a wall or backdrop.[1060] Woods notices this as unusual and associates this characteristic more with provincial art,[1061] noticing that most of these compositions date to the latter half of the Old Kingdom. While this may seem illogical within an argument for more congested papyrus thickets, the opening of spaces within the thicket has now allowed the artist to fill the gaps with birds and their land-based predators. The fowling scene spreads more widely along the wall, presenting to the viewer an impression of vast width and great depth, emphasising more heavily the resources available *within* the papyrus thicket.

1055 Harpur, *Decoration*, 199–201.
1056 Hassan, *Giza* IV*,* 138, fig. 79.
1057 Woods, *Marshes*, 175, plus examples: n.226. For a detailed summary, see appendix 3, n.136.
1058 Woods, *Marshes*, 361.
1059 LD II, Band IV, pl. 106a. Noteworthy is the massive height of the thicket compared to the individual fowling. Here also are observed papyrus stalks drooping due to their mass or height.
1060 Harpur, *Decoration*, 265 [8]; GAP: Photo #C12741_NS (Mohammedani Ibrahim: Jan. 20, 1931).
1061 Woods, *Marshes*, 175. In n.226, similar instances are suggested.

In the Sixth Dynasty tombs of Seankhuiptah, Nikauisesi and Hesi at Saqqara,[1062] and Pepyankh the Black at Meir,[1063] for example, the birds are represented within the thicket, showing the viewer the varied offerings available within that habitat. Similarly, the tomb of Merefnebef, at Saqqara, for example, depicts the tomb owner preparing to throw a stick into a very chaotic scene of high papyrus thickets, staggered rows of umbels and birds represented haphazardly within.[1064] The large sturdy vessel from which Ibi, at Deir el Gebrâwi, is fowling and fishing may be another indication of the growing significance of these activities.[1065]

Therefore, it is suggested that the representations of fewer and wider papyrus stalks allow the viewer to better see the bounty offered inside the thicket.[1066] These images contrast well with those spearfishing scenes of the latter Old Kingdom where the papyrus thicket is not represented at all, suggesting perhaps that these two activities occurred at different places within the marshes. While Iyenefert at Giza does not have an extant spearfishing scene, his fowling activities appear in a crowded papyrus thicket, the pleasure cruise scene depicted nearby in more open waters.[1067]

Poultry Farms

Poultry farms became a significant decorative feature in the tombs of the late Fifth Dynasty, starting with the tomb of Ty,[1068] and continuing into the Sixth Dynasty. Very few examples are found in the provinces: Pepyankh the Black at Meir[1069] depicts one, as does Ibi at Deir el-Gebrawi.[1070] Kanawati suggests this theme is mostly encountered at Saqqara in the Teti Cemetery,[1071] however, the tomb of Ptahshepses at Abusir also contains this depiction.[1072]

1062 Kanawati & Abder-Raziq, *Neferseshemre & Seankhuiptah*, pls. 69, 76; Kanawati & Abder-Raziq, *Nikauisesi*, pl. 50; and Kanawati & Abder-Raziq, *Hesi*, pl. 54, respectively.
1063 Blackman & Apted, *Meir* V, pl. 28, updated in Kanawati & Evans, *Meir* II, pl. 88.
1064 Myśliwiec et al., *Merefnebef*, pls. 21, 63–65.
1065 Kanawati, *Deir el-Gebrawi* II, 27, pls. 7–10, 45–46.
1066 Evans, *Animal Behaviour*, 73–76; Woods, *Marshes*, 227.
1067 Schürmann, *Ii-nefret*, pl. 6 (fowling), pl. 21 (pleasure cruise).
1068 Harpur, *Decoration,* 114; Wild, *Ti,* II, pls. 6–8.
1069 Blackman & Apted, *Meir* V, 31, pl. 22 [2], updated in Kanawati & Evans, *Meir* II, 36–37, pl. 83a.
1070 Davies, *Deir el-Gebrâwi* I, p. 21, pl. 16, updated in Kanawati, *Deir el-Gebrawi* II, 51, pls. 53, 72.
1071 For examples, see Kanawati & Abder-Raziq, *Hesi*, pls. 27, 56; Kanawati & Abder-Raziq, *Nikauisesi*, pl. 49; Kanawati & Abder-Raziq, *Mereruka*, pl. 48; Kanawati & Abder-Raziq, *Meryteti*, pls, 14, 48; Harpur & Scremin, *Kagemni*, figs. 13, 14.
1072 Vachala, *Ptahshepses,* 164–165, pl. 13.

The development of poultry farms from the time of Niuserra onwards may be explained as another cultural adaptation to take advantage of the changing environmental situation. As the growing marshland provided habitats more favourable to waterfowl, the pragmatic response would have been to organise and exploit this increasing resource. Scenes depicting the force-feeding of poultry began during the reign of Niuserra and continued throughout the Sixth Dynasty.[1073] Force-feeding of waterfowl would have increased their mass more rapidly and this depiction coincided with their increasingly frequent appearance in offering procession scenes. It would have had the secondary benefit of making the heavier waterfowl less likely (or able) to escape.

1073 First recorded in Vachala, *Ptahshepses*, 164–165 [C262 (1208)].

Summation: Chapter Eight

A Perception of Predominating Poultry

The main points developed in this chapter include:

- ⇒ Over the time frame in question, as representations of orchards and gardens decreased a corresponding decrease in depictions of those birds that were exploited from these resources was observed.
- ⇒ Over the same time frame in question, poultry/waterfowl was depicted with increasing regularity and became significant part of the elite tomb decoration programme.
- ⇒ New scenes types, such as the poultry yard and the poultry procession were added to the lexicon.
- ⇒ Representations of the major predators of the waterfowl entered the tomb scene repertoire at the same time.
- ⇒ An increase in the marshlands led to an apparent increase in the relative importance of the waterfowl.

If the river changed properties as suggested, then the re-distribution of abundance of some plant species should have changed the habitat of the riverbank. Birds better suited to moist riverine boundaries and whose nesting sites were protected from aerial predators by overhangs and who benefited from an increase in fish numbers, would have taken advantage of these changes. As numbers and varieties of waterfowl increased, it would be expected to be accompanied by a corresponding increase in the numbers of predators drawn to this population boost. Local Egyptian consumers of riverine products would have noticed an increase in four-legged predator numbers and, as they became an increasingly annoying competitor, their relative significance would have been duly amplified. The same influence that saw the decline of orchard/garden birds drove the increase in waterfowl species such as duck and geese. This led to their habituation and eventual domestication through the use of poultry yards, even to the practice of force-feeding. This same stimulus saw the rise to prominence of the fowling scene, with its associated significance most likely drawn from the underlying ecological need to hunt waterfowl.

CHAPTER NINE

THE RISE OF CATTLE AND

A RIVER IN DROUGHT

9.0 – INTRODUCTION

The proportion of tomb wall scenes whose main subject is cattle and pastureland themes increased across the time frame under investigation. According to the A.R.I.D hypothesis outlined in Chapter Four: A River In Drought, would have a slowing or weakened river becoming more congested with an abundance of grasses and reeds within and alongside the river. As the riverbank habitat flourished, due to an influx of nutrients, cattle and other herbivores would have found huge amounts of riverside nutrients available. The surroundings should have become more agreeable to those individuals within society that relied on pastoralism as a major source of wealth. These conditions should have provided increased amounts of fodder for cattle. The rapid increase in depictions of cattle can be explained by the society taking advantage of this bloom in resources. An increase in scenes depicting cattle, both big and small, may indicate that, as agriculture, gardening and pomiculture declined, society may have come to rely increasingly upon mobile wealth.

In this chapter, the increase in pastureland attestations will be investigated in greater depth. An explanation of why reeds and papyrus grasses would encourage pastoralist activity will be presented. An explanation of why pigs appeared to have declined in relative importance compared to Pre- and Early dynastic times will be suggested. The increasing presence of goats and their role in a changing ecology will be proposed and the idea of an increasing reliance on 'mobile wealth' among the elite will be advanced.

9.1 – The Developing Importance of Cattle

Perhaps the ready availability of wild grains to the early users of the Nile valley[1074] was one of the reasons behind the late adoption of agriculture in Egypt compared to other Middle Eastern civilisations.[1075] It seems this adoption was not undertaken in response to a changing climate but an apparently conscious decision to take advantage of the regular flood.[1076] Similarly, the first significant addition of cattle to the resource mix was apparently made as a result of society's adaptation to the seasonal offerings of the river.[1077] As the inundation became more unreliable, especially in the south, cattle rearing seemingly was adopted in response to climate change.[1078]

Cattle and A River In Drought

The rise of cattle as an adaptation to environmental change seems a valid response to an increasingly unreliable river system. Cattle can move to where the feed is. Cattle herds as mobile wealth storage systems may have been a natural response to changing ecosystems that necessitated a lesser reliance on agriculture. From the reign of Niuserra, themes related to cattle-raising and pastureland activities increased significantly, continuing into and throughout the First Intermediate Period[1079] (see Table 29: Cattle and pastureland scenes: pre- and post Niuserra).

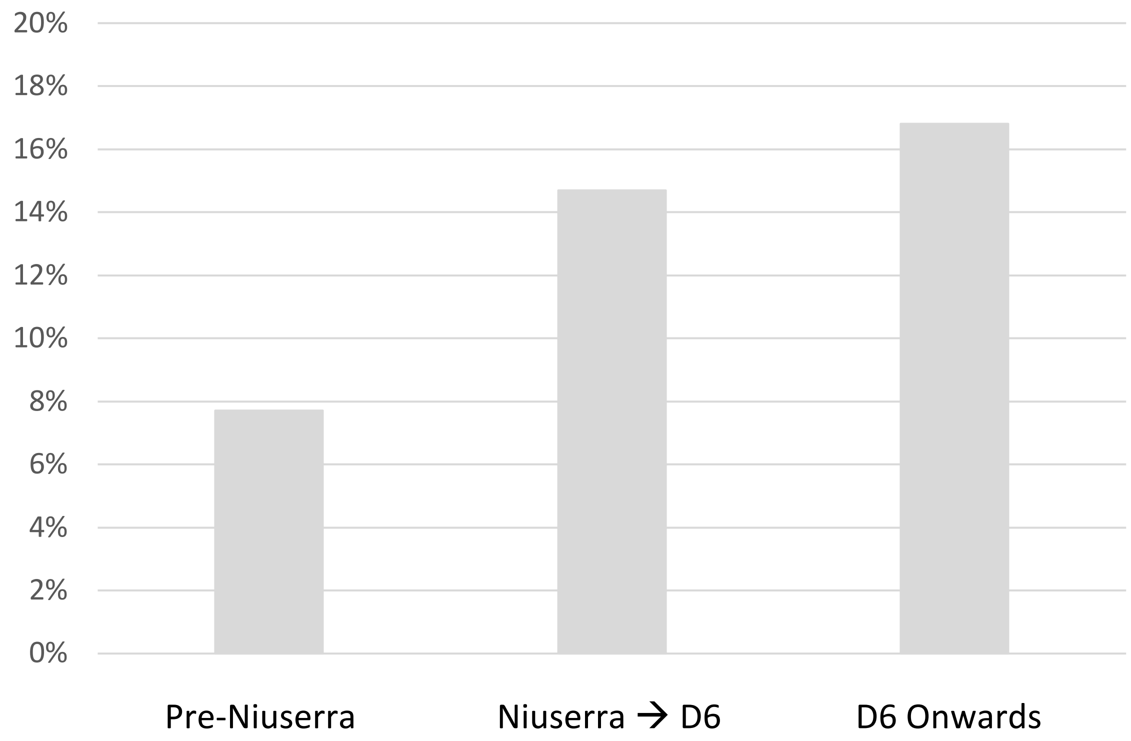
Table 29: Cattle and pastureland scenes: proportion pre- and post Niuserra

Cattle & pastureland scenes	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of overall attestations	7.7%	14.7%	16.8%

[1074] Midant-Reynes, *Egyptian Prehistory*, 141.
[1075] Hartung, *Livestock Production*, 22–23.
[1076] Midant-Reynes, *Egyptian Prehistory*, 138.
[1077] Midant-Reynes, *Egyptian Prehistory*, 137.
[1078] Barich, People, Water & Grain, 128; Wright, Human Holocene Termination, 7–9.
[1079] Hagseth, *Livestock Transport*, 51. See also Burn, 'Rise of the Late Old Kingdom Cattle Barons: Mobile Wealth as Security in Insecure Times?' (in preparation).

It appears that pastoral activities became increasingly important to the tomb owners as the Old Kingdom progressed. The proportion of images representing pastureland-related decorations increased to more than one-sixth of all attested scenes by the end of the Old Kingdom (see Figure 45: Cattle and pastureland scenes: proportion change over time).

Figure 45: Cattle and pastureland scenes: proportion change over time



As a consequence of an increasing role for cattle in the food chain, it could be expected that the products of cattle would also be depicted in increasing frequency (see Table30: Meat depictions: pre- and post-Niuserra). This appears to be the case and coincides with greater finds of cattle products in a number of archaeological settings.[1080] Depictions of the preparation and cooking of red meat increased over the time frame under investigation. This data coincides with archaeological evidence suggesting an increasing relationship between the consumption of beef and social status, commented upon by Bárta and Ikram.[1081] Even though scarcer numbers of cattle may suggest that their ownership represented status, status seemed to be related to the number of cattle.

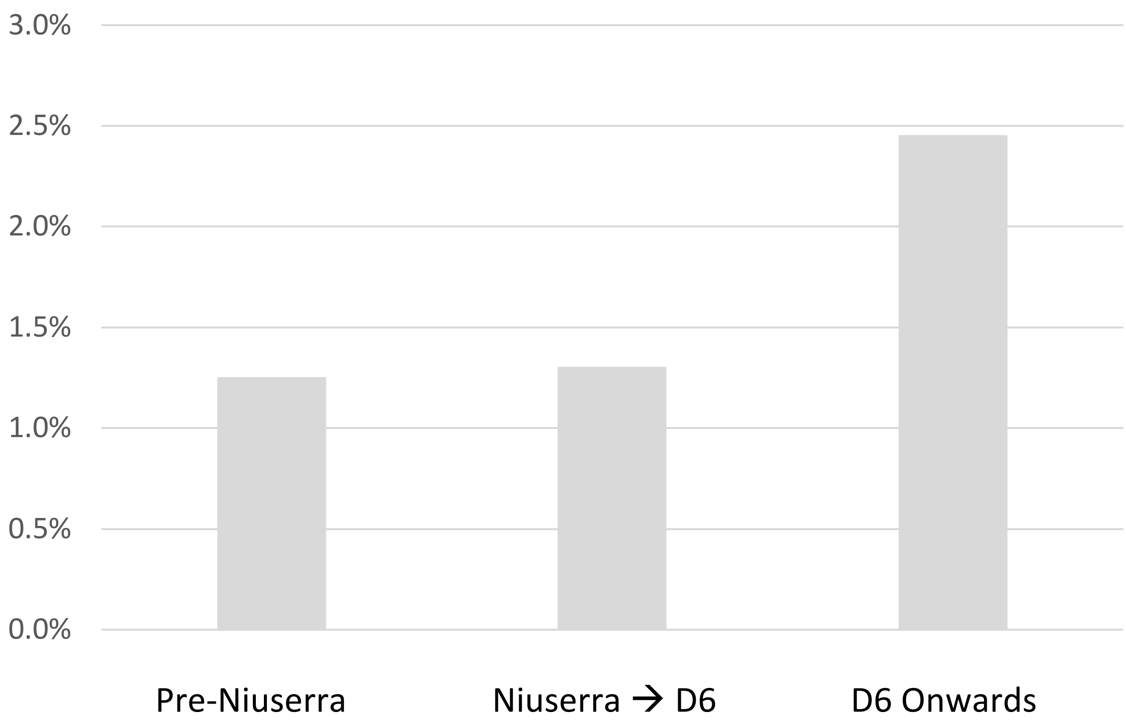
[1080] Helck, *Pork Consumption*, table 1; Ikram, *Choice Cuts*, 35–36; Willems et al., *Wadi Zabayda*, 308–325; Vymazalová and Arias Kytnarová, *Sheretnebty*, 41; Duliková, *Ankhires at Abusir*, 27.

[1081] Respectively, Bárta et al., *Hetepi*, 159; Ikram, *Choice Cuts,* 14.

Table 30: Meat Depictions: proportions pre- and post Niuserra			
Meat Depictions	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of overall attestations	1.25%	1.30%	2.45%

Despite the small absolute number of scenes, the fact that the proportions of these representations had almost doubled by the end of the Old Kingdom should be seen as an important indicator (see Figure 46: Meat depictions: proportion change over time). As bio-archaeological dating methods become more precise, it should be possible to trace these changes in the diet more precisely.[1082]

Figure 46: Meat depictions: proportion change over time



Increasingly sophisticated testing regimes within the field of settlement archaeology should be able to note if these proportional changes to the visual representational record were manifested in a similar change in the average diet, as evidenced by the apparent increase of

[1082] Wing, Animals as Food, 57.

fish and fowl in the average diet.[1083] Developing techniques now enable the identification of particular proteins, so the ability to distinguish between the type of protein ingested (cattle vs. fish vs. waterfowl) is now a possibility.

Cattle Depictions and A River In Drought

Cattle depiction abundance numbers relate to the wall scenes of the tombs of the elite class, so this may skew the data when comparing the proportion of meat in the diet of the entire population. However, the investigation is looking for evidence of an adjustment as a result changing environmental conditions. Despite developing into a successful symbiosis between humans and those animals they exploited for various resources,[1084] pastoralism, can sometimes lead to negative modifications to the surrounding landscape, usually with land clearing a major concern.[1085] In the case of a 'drought-stricken' Nile, however, it would seem that the opposite may have been true. According to the A.R.I.D. hypothesis, since the inundation failed to occur, the rising nutrient load remaining within the waterway would have led to a substantial growth of papyrus and reeds, from which the animals that fed on these plants would benefit. While herbivores, including cattle, are not particularly favourably disposed towards eating mature reeds and grasses; immature plants are more palatable;[1086] with both papyrus and reeds responding favourably to regular cropping, which seems to encourage regrowth of new tender shoots. Typhae, are more palatable than both of these plants,[1087] so would have been eaten more rapidly; perhaps this is another reason for its suggested decline at this time. Since large herbivores can have an important impact upon the quality of a local habitat,[1088] for example, changing the floral mix and causing erosion, one could expect that if the A.R.I.D. hypothesis is valid, then a greater proportion of pastoral representations would have been produced. As the environmental situation changes, the increased adoption of pastoralism as a strategy seems an obvious pragmatic solution.[1089] A similar pattern has been identified as having developed in the Sahara.[1090]

1083 Sterner, *Herbivores Effect on Algae*, 605–607. As the evidence suggests that fish became a more substantive protein source at this time, the same may be true for the more elite amongst the population – see Chapter 12.
1084 Hartung, *Livestock Production*, 20.
1085 Hughes, *Deforestation Viewed*, 439.
1086 Evans, *Animal Behaviour*, 87.
1087 Zahran & Willis, *Vegetation of Egypt*, 298; Shaltout & *Ahmed, Plant Life*, 117.
1088 Ashley & Liutkus, *Tracks, Trails & Trampling*, 31.
1089 Hassan, *Climate & Cattle*, 61–86.
1090 Jelinek, *Pastoralism & Social Stratification*, 41–44.

Bullfighting

Cattle appear to have become a more prized commodity in the latter years of the Old Kingdom: this is attested by the proximity of the tomb owner's image to representations of fighting bulls.[1091] No bullfighting scenes are attested in the Memphite region; these scenes are limited to provincial sites only,[1092] and the images become more vibrant and animated the further south one travels. The role of bull fighting may have been in order to identify the strongest bull with which to breed the next generation.[1093] At Deshasha, in the tomb of Iteti/Shedu, a bull is being tossed into the air.[1094] In the Dynasty 6 tombs of Ibi and Djau/Shemai at Deir el-Gebrawi,[1095] the weaker bull is being flipped over by the power of the prime bull. Other sites depicting bullfighting include those of el-Qasr wa-'l-Saiyad[1096] and Qubbet el-Hawa.[1097] The tomb of Pepyankh the Black also depicts this theme,[1098] where two bulls fight "*rearing and bellowing with rage*";[1099] perhaps this violence was the model for later depictions. The largest number of bullfighting scenes at one necropolis are those depicted at El-Hawawish,[1100] where the losing bulls are also airborne.[1101] The most violent depictions, which include those where a horn is piercing the vanquished, are located in El-Hagarsa.[1102] Perhaps this violence and physicality is a testament to the harsher, more arid conditions experienced in Upper Egypt, and to the increasing importance attached to this resource.

1091 Kanawati, *El-Hawawish* IV, 18–19; Galan, *Bullfight Scenes*, 81, 93.

1092 Smith, *HESPOK*, 218–219; Harpur, *Decoration*, 41, 263; Kanawati, *Bullfighting*, 56; Galan, *Bullfight Scenes*, 81–96.

1093 Kanawati, *Tomb & Beyond*, 90.

1094 Petrie, *Deshasheh*, pl. 18, updated in Kanawati & McFarlane, *Deshasha*, pls. 18 [a], 51.

1095 For Ibi, see Kanawati, *Deir el Gebrawi* II, pl. 52, updating Davies, *Deir El Gebrâwi* I, pl. 11. For Djau/Shemai, see Kanawati, *Deir el Gebrawi* III, pl. 72, updating Davies, *Deir El Gebrâwi* II, pl. 9.

1096 See Säve-Söderbergh, *Hamra Dom* for the tombs of father, Thauty, pl. 31, and son Idu/Seneni, pl. 8.

1097 The tomb of Khunes: de Morgan, *Cat. des monuments* I, 160–161.

1098 Blackman & Apted, *Meir* V, pl. 32, updated in Kanawati & Evans, *Meir* II, pls. 55b, 92.

1099 Kanawati & Evans, *Meir* II, 54, pl. 92, updating Blackman, *Meir* V, pl. 32.

1100 Thompson, *El-Hawawish*, 64–65.

1101 In the tombs of Hesimin: Kanawati, *El-Hawawish* IV, figs. 8, 11 and *El-Hawawish* VII, fig. 3 [c]; Theti-iker: Kanawati, *El-Hawawish* I, fig. 10; Shepsipumin/Kheni: Kanawati, *El-Hawawish* II, fig. 20; and Rehurausen: Kanawati, *El-Hawawish* VII, fig. 15. Tomb K 21 also contains a bull-fighting scene (Kanawati, *El-Hawawish* VIII, fig. 24) but the bull is not depicted as tumbling.

1102 In the tombs of Mery: Kanawati, *El-Hagarsa* I, pls. 12 [a, b], 43; Wahi: Kanawati, *El-Hagarsa* III, pls. 1, 2 [a], 3 [upper], 20, 22–24; Mery-aa: Kanawati, *El-Hagarsa* III, pls. 9 [a], 11, 37, 39.

9.2 – Fording Scenes in A River In Drought

Cattle crossing scenes have been interpreted as fording a canal or stream to, one would assume, move to a source of food.[1103] The overall proportion of the many representations of this theme increased over the time frame under investigation, suggesting that depictions of moving cattle between varied food sources alongside the river became more important to tomb owners over time (see Table 31: Cattle fording and feeding scenes: proportion pre- and post Niuserra).

Table 31: Cattle fording and feeding scenes: proportion pre- and post Niuserra

Fording & feeding	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of overall attestations	2.1%	2.8%	3.5%

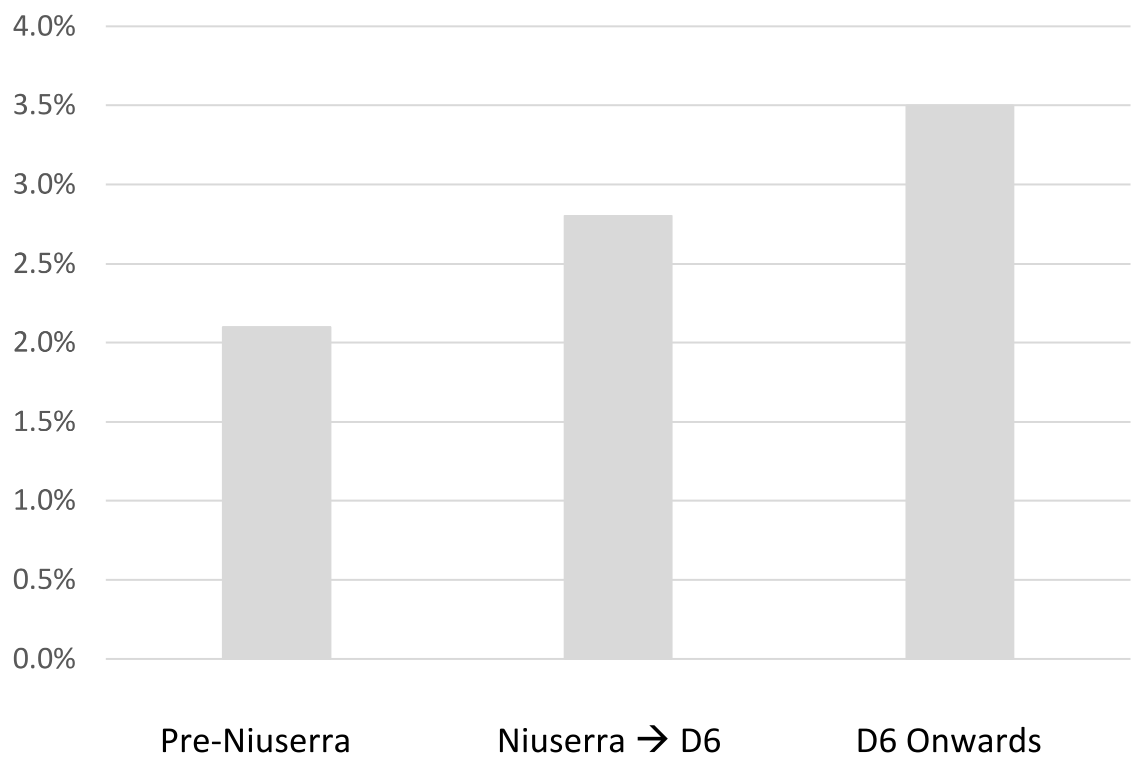
Fording Impacts

Perhaps, since food was more readily available, the cattle were moved more regularly to take advantage of it. Since the younger parts of rapidly growing plants are more toothsome, the cattle may have needed to be moved more often than previously, in order to take advantage of the high-quality nutrition in newly growing shoots.[1104] The foraging pathways would have remained open more consistently, becoming temporary trails for the duration of the season,[1105] similar to the fording impacts of the hippopotamus (see Figure 47: Cattle fording and feeding scenes proportion change over time). It is also interesting, that scenes depicting the threat of crocodiles upon fording cattle increase in number at this stage;[1106] with some of the where the crocodiles are depicted in pairs could easily represent the situation where each on is one his 'territory' on either side of a narrow secondary channel

1103 Harpur, *Decoration*, 199.
1104 Evans, *Animal Behaviour*, figs. 7-5, 7-6 and 7-7, depict cattle eating marshland plants.
1105 McCarthy et al., *Hippo Impact*, 44; Deocampo, *Hippo Structures*, 217.
1106 Evans, *Animal Behaviour*, 127–128.

Producing the trail may have helped open waterways between different pools, enabling water to move more freely and avoid localised stagnation.[1107] While cattle do not live within waterways as hippopotamus do, their herd-size is larger, leading to similar impacts on the riverine ecosystem overall.[1108] Trampling of plants breaks up the vegetation's physical structure,[1109] as well as increasing the rate of decomposition and facilitating more rapid microbial attack;[1110] providing further impetus for plant diversity as other faster growing species may be able to take a hold before the damaged species recover.[1111] It may also suggest that cattle were undertaking more fording activities due to an increase in secondary channel formation as a consequence of a weaker-than-normal river.

Figure 47: Cattle fording and feeding scenes proportion change over time



1107 McCarthy et al., *Hippo Impact*, 54–55.
1108 McCarthy et al., *Hippo Impact*, 49; Ashley & Liutkus, *Tracks, Trails & Trampling*, 31.
1109 Silliman et al., *Livestock as Control Agents*, 10; Brundage, *Grazing as Management*, 61.
1110 Brundage, *Grazing as Management*, 51–52, summarising this avenue of research.
1111 Steward et al., *River Runs Dry*, 204, 207; Brundage, *Grazing as Management*, 66.

Immersion Levels

It is possible to observe other changes within the cattle crossing scene that can be related to the A.R.I.D. hypothesis. Of those depictions of cattle crossing before the time of Niuserra, most depict the animal immersed above the shoulder, with only one depiction displaying parts of the animal below the body.[1112] From the time of Niuserra onwards, cattle crossing scenes begin to depict the lower part of the animal in more detail,[1113] revealing most of the animal and often the knees.[1114] These include the tombs of Nefer and Kahay,[1115] Ptahshepses,[1116] Niankh-khnum and Khnumhotep,[1117] Ty,[1118] Za-ib,[1119] Irukaptah/Khenu,[1120] Iynefert,[1121] Akhethotep,[1122] Nimaetre,[1123] Mera,[1124] Niankhnesut,[1125] Hemre/Isi[1126] and Bawi.[1127] That may mean that the water is so shallow, that in real life you would see the cattle's legs, and therefore the artists have shown them. A survey of the amount of the animal covered by the water was performed upon these depictions. Boundaries were marked at the neck and shoulders ('fully immersed'), the belly and the knees (see Table 32: Crossing cattle immersion levels: pre- and post Niuserra).

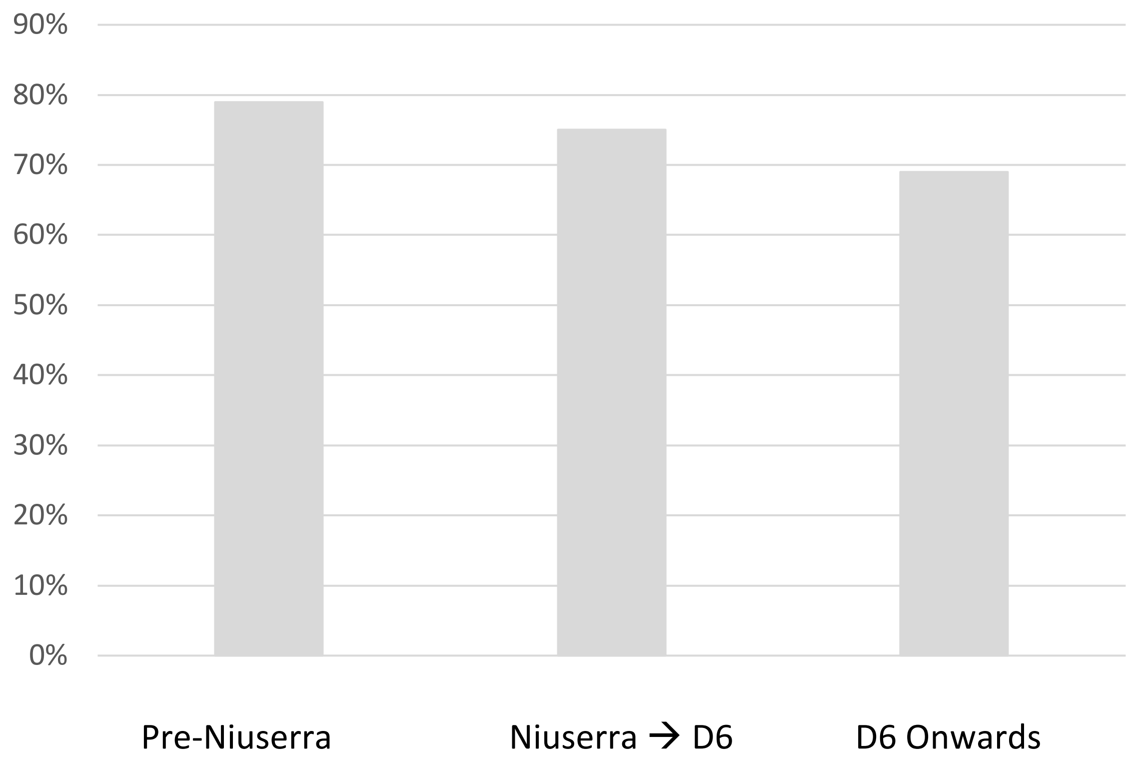
Table 32: Crossing cattle immersion levels: pre- and post Niuserra

Fully immersed	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
proportion of all cattle crossing scenes	79%	75%	69%

1112 See Harpur, *Khnumhotep*, fig.8.
1113 Harpur, *Decoration*, 195.
1114 Lashien, *Kahai*, 30.
1115 Moussa & Altenmüller, *Nefer and Ka-hay*, pls. 1, 5; Lashien, *Kahai*, pls. 9b, 13d.
1116 Vachala, *Ptahshepses,* 96–97, A815 (1102), C173 (1189).
1117 Moussa & Altenmüller, *Nianchchnum und Chnumhotep,* Taf. 76–77.
1118 Steindorf, *Ty*, pls. 112, 118: in plate 118, the water is so shallow that you can see the outline of the legs.
1119 Roth, *Palace Attendants*, pls. 73a–b, 74a, 181, 182.
1120 McFarlane, *Irukaptah*, pls. 16, 41, 46.
1121 Schürmann, *Ii-nefret*, Abb. 7 [a, b], 21.
1122 Davies, *Ptahhetep & Akhethetep* II, pl. 14.
1123 Hassan, *Gîza* II, fig. 236.
1124 Borchardt, *Cat. Caire* II, Bl. 109.
1125 MMA, *Egyptian Art*, 468–471.
1126 Davies, *Deir el-Gebrâwi* II, pl. 20.
1127 Kanawati, *El-Hawawish* VII, fig. 18.

From the time of Niuserra onwards, it is increasingly common for a larger proportion of the animal to be on show above the waterline (see Figure 48: Crossing cattle immersion levels: proportion change over time). When the animal is depicted deeply immersed, it is sometimes accompanied by an indication that it is entering the deeper part of the river – for example, in the tomb of Iteti/Shedu,[1128] and that of Senedjemib Inti, where the cattle are accompanied by men in boats.[1129] Increasing visibility of the lower part of the animal suggests secondary channels becoming shallower. Also, the more regular transfers between the many secondary channels, as proposed, would give the artist greater opportunities to witness the animals moving between channels. However, it should not be assumed that the water level was so low that cattle could cross the Nile itself, despite this being suggested in commentary on the tomb of Hetepherakhti, where the caption reads "…*crossing the Nile*…".[1130]

Figure 48: Crossing cattle immersion levels: proportion change over time

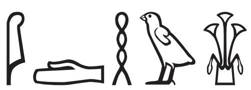
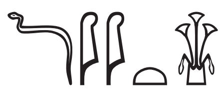


1128 Kanawati & McFarlane, *Deshasha*, 50–51, pls. 14, 46.
1129 Brovarski, *Senedjemib* I, 42, pl. 18, figs. 29–30 (Scene 2).
1130 Mohr, *Hetep-her-akhti*, 63.

A number of depictions display the animal with just the leg below the knee covered – for example, in the tombs of Ptahshepses,[1131] Niankh-khnum and Khnumhotep,[1132] Za-ib,[1133] Akhethotep[1134] and Iynefert.[1135] All these examples date to the latter half of the Fifth Dynasty and beyond. Some may suggest that these depictions represent cattle as they are leaving the ford, but those depictions portraying an animal with a sloping back give the impression of climbing out onto the land more effectively; it seems these 'knee-deep' scenes represent entering and leaving shallow water. Tombs depicting cattle actively climbing out of the marshlands include Senedjemib Mehi,[1136] Ptahhotep II/Thefi,[1137] Kaemnefert II,[1138] Akhmerutnesut,[1139] Ibi[1140] and Djau/Shemai.[1141] These tombs all date from the time of Niuserra and beyond. This could indicate that an increasingly shallower river inspired representations of animals with less of their bodies immersed.

Swamps, Marshes and Channels

In the mid-Fifth Dynasty tombs of Niankh-khnum and Khnumhotep and Akhethotep, the cattle are specifically described as coming out of the 'swamp',[1142] as opposed to the 'marshlands' referred to in many other tombs. The ancient Egyptians had different words for each,[1143] so would be expected to use them appropriately, so the use of swamp must have particular significance.

Swamp	Papyrus marsh	Papyrus thicket
		

[1131] Vachala, *Ptahshepses*, 96–97, A815 (1102), 98–99, C173 (1189).
[1132] Moussa & Altenmüller, *Nianchchnum und Chnumhotep*, 155–156, Taf. 76–77.
[1133] Roth, *Palace Attendants,* 111, pls. 73a–b, 74a, 181, 182.
[1134] Davies, *Ptahhetep & Akhethetep* II, 15, pl. 14.
[1135] Schürmann, *Ii-nefret*, 33, Abb. 7 [a, b], 21.
[1136] Brovarski, *Senedjemib* I, pl. 107, 110–111, figs. 96–98, 104–105.
[1137] Davies, *Ptahhetep & Akhethetep* I, 9, pls. 3, 21, 23.
[1138] Hassan, *Gîza* II, 126, fig. 140.
[1139] Smith, *HESPOK*, 347–348, fig. 229.
[1140] Davies, *Deir el-Gebrâwi* I, 4, pls. 5–6.
[1141] Davies, *Deir el-Gebrâwi* II, 6, pl. 5; Kanawati, *Deir el-Gebrâwi* III, 30, n.160.
[1142] Moussa & Altenmüller, *Nianchchnum und Chnumhotep* ,155–156, Taf. 76–77; Ziegler, *Akhethetep*, 81, 133–134, 154, fig. 37.
[1143] Gardner, *Grammar*, 481.

The word for swamp appears specifically related to the delta, where water flows less powerfully, whereas the word for papyrus marshes and papyrus thickets are significantly different. Some of the river trails may have been improved through human activity: for example, the quote "*the channel has been prepared for the cattle*"[1144] in the tomb of Senedjemib Inti suggests that existing pathways were improved upon rather than new ones constructed (see Figure 49: Cattle channel caption: Tomb of Senedjemib Inti). The phrase or something similar is used in the Senedjemib complex at least three times.[1145]

Figure 49: Cattle channel caption: tomb of Senedjemib Inti

Figure 49 removed due to copyright restrictions

Figs. 104–5 = Scene 2. Brovarski, Edward. The Senedjemib Complex, Part 1: The Mastabas of Senedjemib Inti (G 2370), Khnumenti (G 2374), and Senedjemib Mehi (G 2378). Giza Mastabas 7. Boston, Museum of Fine Arts, 2003.

"*The channel has been prepared for the cattle*"

Source: Brovarski, *Senedjemib* I, figs. 104–5 = Scene 2.

1144 Brovarski, *Senedjemib* I, 137, pls. 110–111, figs. 104–5.
1145 Brovarski, *Senedjemib* I, 38, 134–137.

Also relevant to the A.R.I.D. hypothesis is the identification of canals or pathways within the marshlands, such as in the tomb of Akhmerutnesut.[1146] Some of these 'channels' appear to be a part of the geographical arrangement at that time. While not overwhelming in statistical terms, the fact that scenes suggesting lower-than-normal levels of water all appeared during and after the reign of Niuserra does seem noteworthy. With the significant increase in representations of cattle crossing between marshland feeding sites, it seems feasible that the local people were taking advantage of the burgeoning floral resources on offer.

The potential for semi-permanent pathways between sources of fodder may have led to unexpected fortunate side effects. The pathways also become a channel for fish to traverse, forming a potential site for the laying of traps. These short-lived pathways would have provided easier access to the river's edge at which to lay larger traps or from which to launch boats. The constant use of the pathways along the edges of the river would have pressed down the sedimentary layers, leading to less disturbance of the river floor, making the water less cloudy, which would have made it easier for fish to be seen. Those smaller channels that formed fish pathways needed smaller nets and traps to lay within them, perhaps occasioning the increase in the tomb scene representations of small nets observed at the same time as the increase in fording scenes. This permits speculation that some form of rudimentary aquaculture may have been practised during this time.

Travelling North to the Delta

With the deposition or more sediment in the delta, it is expected that the delta would have grown during this time. While the Delta has been recognised as a desirable location for the grazing of cattle,[1147] the idea that ALL cattle travelled to the Delta to graze, however, deserves to be challenged.[1148] Travelling to marshlands to provide fodder for cattle seems a sensible response to the problem of ensuring adequate nutrition. However, it is a long way from Elephantine, for example, to the 'Estate of the Cattle', Kom el-Hisn, in the north.[1149]

[1146] Smith, *HESPOK*, 347, 348, fig. 229.
[1147] Klebs, *Die Reliefs*, 60, suggest large herds of cattle in the delta.
[1148] This possibility arose in discussion during a session of supervision, July 11, 2013, with Dr Linda Evans, Macquarie University.
[1149] Approximately 920km of walking, according to https://www.distancecalculator.net/ (Nov. 11, 2017).

Cattle can travel at speeds that vary from less than three kilometres per hour[1150] up to a breath-taking four kilometres per hour.[1151] However, this drops to about one kilometre per hour while grazing.[1152] Having to walk around marshy areas, cultivated lands and settlements would have added to this distance substantially. Allowing twelve kilometres per day,[1153] cattle from Elephantine would take at least eighty days to complete the almost one thousand–kilometre trip.

Is this journey feasible? The logistics seem more than problematic. Did each nome send its cattle north to the Delta at the same time? Did they depart at a set time, presumably following the river's rise? What did the subsequent herds eat if they are following preceding herds? How did the communities along the river cope with successive herds of foraging cattle? How long did they stay in the Delta and what did they eat upon their return? While resting rates would have been lower than what is considered acceptable nowadays,[1154] and mortality rates higher,[1155] there must have been some layover days for those accompanying the cattle to repair and recover. Perhaps the phrase 'travelling north to the marshlands'[1156] did not necessarily mean the Delta for all cattle, but for those from the Memphite region alone. There are areas of marshland identified as extant in Old Kingdom times before one reaches the Delta: the Fayum and, in Middle Egypt, areas near modern day el-Minya and Assyut.[1157] Cattle travelling from Upper Egypt would have had to travel north to reach any of these sites. In the tomb of Nesutpuneter in Giza, the cattle crossing scene is accompanied by text stating the cattle are being '"guided to the south".[1158] It seems feasible that Minya or Assyut could be one of those southern locations. The tomb of Sopedhotep at Saqqara, describes cattle as… "*Proceeding out of the Lower Egyptian marsh towards the chief of this herdsman….*"[1159]

1150 DairyNZ, https://www.dairynz.co.nz/media/214237/Understanding-cow-movement.pdf (Nov. 11, 2017).
1151 Di Marco & Aello, *Energy Expenditure*, 105–110.
1152 Di Marco & Aello, *Cattle Walking*, https://journals.uair.arizona.edu/index.php/jrm/article/viewFile/9272/8884 (Nov. 11, 2017).
1153 This is 140% of the average speed recorded in a recent cattle drive in Australia, involving 18,000 head moving 1,500km in 180 days: http://www.abc.net.au/local/stories/2013/08/07/3819912.htm (Nov. 9, 2017), and twice that of the examples quoted by McLean, *British Columbia Cattle Industry*, 132–133, but about the same as the example quoted in Wagoner, *Arizona Cattle Industry*, 89.
1154 Miranda-de la Lama et al., *Livestock Transport*, 10–11.
1155 Svenson & Morrow-Tesch, *Cattle Transport*, 103; Miranda-de la Lama et al., *Livestock Transport*, 1–2.
1156 Roth, *Palace Attendants*,130, pls. 89, 185; Kanawati & Abder-Raziq, *Iynefert & Ihy*, 46, pls. 16 [b] both quote from tombs in this region.
1157 Köln, *Project A5*, Picture 6.
1158 Smith, *HESPOK*, 191; Junker, *Gîza* III, 51.
1159 Borchardt, *Cat Caire II*, 16, 18, 165.

Foraging Impacts

Another consideration of increased cattle population along the river's edges would be the changes to localised food webs as a result of their feeding behaviours. The grazing impact of herbivores on local plants is an important factor.[1160] Overgrazing of one component in a habitat may lead to a spread of others, increasing biodiversity.[1161] While grazing sometimes encourages such benefits as secondary regrowth, however, overgrazing leads to more significant negative impacts from which recovery becomes more difficult.[1162] Foraging in a region has some beneficial side effects, with cattle grazing and goat browsing[1163] found to limit unwanted plant spread.[1164] In modern-day times, cattle are brought in to feed upon crops that have failed, or been damaged by either pests or too little or too much water.[1165] Lack of access to water hinders agricultural success, now as always. Similar pragmatic decisions must have been made in the past; flood damage would have spoiled crops as readily as it does today.

Waste products add to the fertility of the region, and some seeds deposited in a small pile of dung experience greater germination rates than those deposited without their very own compost pile.[1166] Some grasses, however, are cooked by the high temperatures of the decomposing manure.[1167] Papyrus is not mentioned as a plant that uses animal dung as a vector for germination, but the seed has been observed as being spread by waterfowl.[1168] Cattle dung is not reported as a transmission for *Phragmites*, *Typhae* or the *Nymphaea*, either. Perhaps this relationship is one that needs to be tested. The presence of dung in the water adds to further chemical changes in the local habitat,[1169] and the decomposition of dung in the water is another factor in reducing its oxygen content.[1170]

1160 Turner, *Grazing Effects*, 54–60.

1161 Frank et al., *Grazing History*, 1–3; Brundage, *Grazing as Management*, 43–47.

1162 Fernandez et al., *Degradation & Recovery*, 297–323; Tal, *Grazing Regulations*, 455; Ash, *North Australia Food Supply*, 19; Steward et al., *River Runs Dry*, 207.

1163 Brundage's thesis, *Grazing as Management*, for example, tests the role of goats in the spread of *Phragmites*. While this work was not carried out in Egypt, the results have universal application, however, since the plant species is the same; so, her results have some merit as do the conclusions she has reached.

1164 Silliman et al., *Livestock as Control Agents*, 6–9.

1165 Ash, North *Australia Food Supply*, 18.

1166 Milotić & Hoffman, *Dung & Competition*, 774; Brundage, *Grazing as Management*, 49.

1167 Milotić & Hoffmann, *Reduced Germination Success*, 1045.

1168 CABI, '*Cyperus papyrus'*, https://www.cabi.org/isc/datasheet/17503 (Nov. 16, 2017).

1169 Frank et al., *Grazing History*, 2; Brundage, *Grazing as Management*, 53.

1170 Brundage, *Grazing as Management*, 4–8.

9.3 – Small Cattle: Goats

Our understanding of the evolutionary story of Egyptian goats is not fully complete,[1171] though the narrative of domestication has been outlined, as has a survey of the artistic representations of these animals for corroboration of the morphological changes with those noted in archaeological findings.[1172] Notwithstanding they have very little recognition in the iconographic record, goats were among the earliest, if not actually the first, species to be domesticated as livestock in the Middle East,[1173] providing many useful materials.[1174] It is difficult to imagine domesticating larger animals without first having some experience at controlling the smaller versions.[1175] This verification is incomplete because the overall genetic relationships among breeds have not been fully evaluated, leaving an unclear grasp of the progression of the different breeds.[1176]

Goats performed a sizeable role in the economy of ancient Egypt,[1177] especially for those inhabitants of the poorer-quality pasturelands on the margin of the Nile valley and in vulnerable ecosystems and resource-poor environments.[1178] Despite being less efficient than cattle at converting food to meat, and producing more offal per kilogram,[1179] goats are thought to have been the most significant source of red meat in the diet of the majority of the non-elite ancient Egyptians.[1180] The proportion of attestations depicting goats is quite consistent throughout the early and middle Old Kingdom,[1181] only changing during the 6th Dynasty (see Table 33: The narrative of the goat: proportions pre- and post-Niuserra).

1171 Riemer, *Risks & Resources*, Fig. 5.15, depicts a most logical pathway.

1172 Boessneck, *Die Haustiere in Altägypten*.

1173 Vermeersch, et al., *Sodmein Cave*, 486–487; Zeuner, *Domesticated Animals*, 138–139; Gautier, *Domesticated Fauna*, 304; Clutton-Brock, *Domestic Animals*, 68–69. Hatziminaoglou & Boyazoglu, *Ancient Goats*, 123–124, suggest ~8000BCE.

1174 Hatziminaoglou & Boyazoglu, *Ancient Goats*, 126–128; Iñiguez, *Goats in Dry Environments*, 147. See also Hauschteck, *Goats in Houses,* 59–70 (though the evidence presented comes from after the Old Kingdom, it is difficult to imagine peasant practices changing significantly).

1175 Brass, Domestication Reassessment, 107;

1176 Kim et al., *Genomic Signatures*, 255–256, 263.

1177 Gade, Goats, 531; Wenke, Egyptian Civilisation Evolution, 292.

1178 Iñiguez, *Goats in Dry Environments*, 137; Gade, *Goats*, 532, 534; Hatziminaoglou & Boyazoglu, *Ancient Goats*, 126.

1179 McDowell & Woodward, *Goat Production*, 387–91; Brass, *Domestication Reassessment*, 104; Shirai, *First Farmer-Herders*, 312.

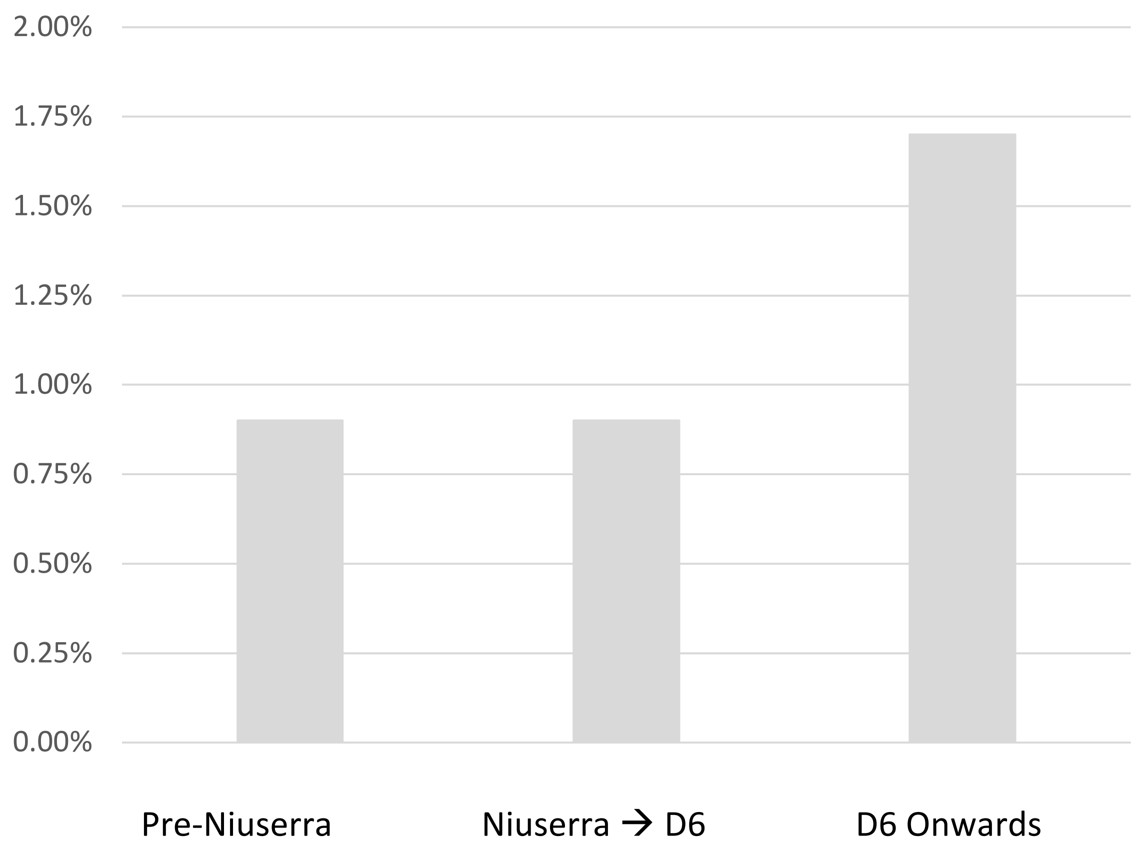
1180 Morenó García, *Production alimentaire*, 73–90; Morenó García, *Village*, 4; Gautier, *Domesticated Fauna*, 304. Contra Swinton, *Resources,* 102, 113.

1181 Swinton, *Resources,* 110–111, tracing the historical development of depiction in mortuary situations.

Table 33: The narrative of the goat: proportions pre- and post-Niuserra			
Goats	Date		
	Pre-Niuserra	Niuserra → D6	D6 Onwards
Proportion of overall attestations	0.9%	0.9%	1.7%

While it seems likely that cattle figured more predominantly in tomb decorations due to their never-ending important role in elite ritual,[1182] the changes in abundance of goat representations suggest a relative importance almost as significant (see Figure 50: The narrative of the goat: proportion change over time).

Figure 50: The narrative of the goat: proportion change over time



From the Sixth Dynasty onwards, the absolute number of representations almost doubles; more than half of the attestations depicting goats in trees over the time frame under

[1182] Eyre, Cannibal Hymns, 191; Warden, Old Kingdom Economy, 57.

investigation date to the Sixth Dynasty and beyond.[1183] By the end of the Sixth Dynasty, goats had become a significant feature of the animal procession in the provincial tombs,[1184] and were an integral part of the basic food supply by the Middle Kingdom.[1185] Certainly, by the end of the Old Kingdom, the emphasis had changed from husbandry of the individual animal to the acquisition of larger herds.[1186]

There may have been some areas of conflict between goats and other means of sustenance: because cereal cultivation is more productive per unit area, it would be expected that agriculture would take priority.[1187] Therefore, animal grazing would be expected to occur within regions less conducive to cultivation, such as the Delta, or along the wetland margins of the floodplain,[1188] as well as in the fields after the harvest,[1189] where the animals would add the nutrient load of their manure to the soil.

Goats in trees: an Indicator of Environmental Deterioration?

Goats have long been used as 'proof' that an environment is in ecological decline. It is important to recognise the potential for damage by goats when added to poor-quality land.[1190] Once sheep and/or cattle have denuded a landscape, goats are often introduced to eat the trees and remaining scrubby material[1191] (see Figures 51 and 52: Goats in trees). Goats in trees may represent the ultimate last resort in environmental management, for there is very little likelihood of recovery once the trees have been removed from their habitat. From this time onwards, the environment struggles to recover.[1192] The iconography depicting goats in or around trees is first attested in the mid-Fifth Dynasty,[1193] becoming a predominant scene type in the provincial tombs prepared after the time of Niuserra, with more than half of the attested scenes found in provincial tombs and all but two produced before the time of Niuserra.

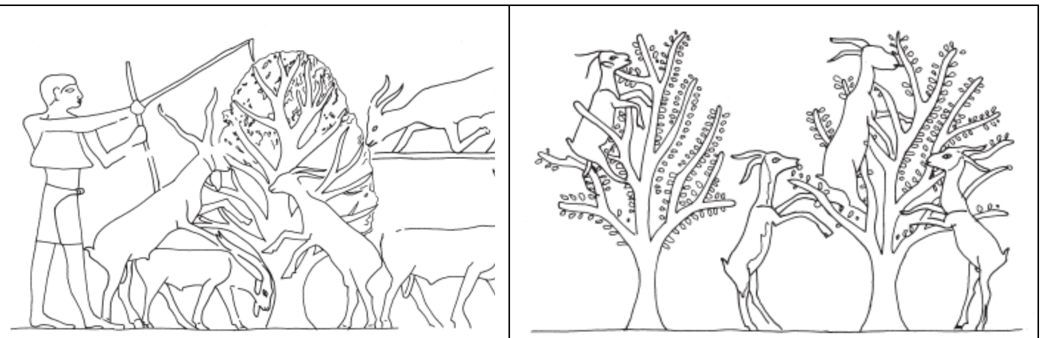
1183 Ninety percent of the scenes date to the time of Niuserra onwards.
1184 Swinton, *Resources,* 113; Clarke, *Upper Egypt Overseer*, 127.
1185 Hauschteck, *Goats in Elephantine*, 59–70.
1186 Swinton, *Resources*, 111.
1187 Swinton, *Resources,* 100; Hassan, *Riverine Civilization*, 51–55.
1188 Redding, Animal Use Patterns, 15; Redding, Pig vs. Sheep/Goats, 171–178.
1189 Hassan, *Riverine Civilization*, 56; Redding, *Animal Use Patterns*, 99–107.
1190 Iñiguez, *Goats in Dry Environments*, 143; Macias, *Degradación de los Suelos*, 3–18.
1191 Silanikove, *Adaptation in Goats*, 184–185; Mellado, *Dietary Selection by Goats*, 331–333.
1192 See, for example: Evans, *Animal Behaviour*, 191; Mellado, *Dietary Selection by Goats*, 331; Shaker et al., *Salt Tolerant Fodder*, 66–68.
1193 Harpur, *Decoration*, 105.

Figure 51: Goats in trees

Figure 51 removed due to copyright restrictions

Huffington Post, http://i.huffpost.com/gadgets/slideshows/349084/slide_349084_3726705 (Aug. 3, 2017).

Figure 52: Goats and trees



Akhmerutnesut [1194] | Ka-hay[1195]

Scenes depicting goats rearing up on their hind legs to eat leaves from (presumably, living) trees may perhaps be seen as an indicator of drought; all such scenes date from the time of Niuserra and beyond.[1196]

1194 For example, the tomb of Akhmerutnesut, Smith, *HESPOK*, fig. 239. See also *HESPOK*, 49b and Lashien, *Kahai*, pls. 6a, 6c, 28, 30, among many others.

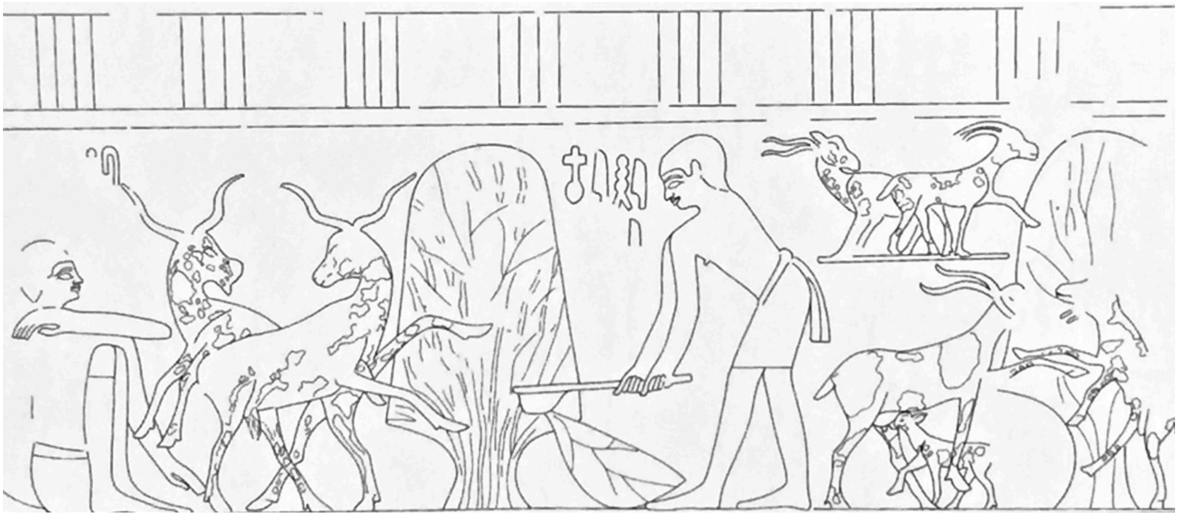
1195 Moussa & Altenmüller; *Nefer & Ka-hay*, pl. 18.

1196 For example:- Iteti: Petrie, *Deshasheh*, pl. 15, updated by Kanawati & McFarlane, pl. 46; Ibi: Davies, *Deir el-Gebrâwi* I, pl. 11, updated by Kanawati, *Deir el-Gebrawi* II, pl. 52; Pepyankh the Middle: Blackman, *Meir* IV, pl. 14, updated by Kanawati, *Meir* I, pl. 84; and Pepyankh the Black: Blackman & Apted, *Meir* V, pl. 32, updated by Kanawati & Evans, *Meir* II, pl. 84.

Goats AND trees

At el-Hawawish,[1197] el-Hagarsa[1198] and el-Khoka,[1199] many tombs depict goats rearing up to eat (see Figure 53: Goats and trees). Not all images represent goats looking for sustenance in trees; some depict goats enjoying fresh fruit, the seeds of which are then deposited with their own pile of dung, ready for re-growth. It is important to remember that art is to be interpreted from the perspective of the producer, and not the viewer.[1200] Some of the scenes[1201] may represent goats eating the leaves of trees that have been purposefully felled[1202] for their consumption, suggesting a need to broaden the resources available to the goats.[1203]

Figure 53: Goats and trees



Some of the feeding goats appear to be reclining; for example, in the tomb of Khunes at Zawyet el-Maiyetin, the uppermost register shows goats on their haunches,[1204] lying down to browse, something difficult to do halfway up a tree, suggesting that the artist is attempting to render depth and distance rather than height, a concept discussed at length by Evans.[1205]

[1197] See Kanawati, *El-Hawawish* I, fig. 15 for the tomb of Theti-iker; and *El-Hawawish* VII, fig. 3 [c] for the tomb of Hesimin, and fig. 30 for the tomb of Gehasha/Nebi.

[1198] See Kanawati, *El-Hagarsa* III, pls. 22–23 for the tomb of Wahi and pls. 37, 40 for the tomb of Mery-aa.

[1199] For the tomb of Ihy, see Saleh, *OK Theban Tombs*, pl. 18.

[1200] Evans, *Animal Behaviour*, 8 (n. 24).

[1201] For example, in the tomb of Nebkauhor: Hassan & Iskander, *Neb-Kaw-Her*, figs. 12–13. For commentary, see Klebs, *Tiefendimension in Zeichnung des Alten Reiches*, 24.

[1202] Evans, *Animal Behaviour*, 41.

[1203] Swinton, *Resources,* 107.

[1204] Lepsius, *Denkmäler*, II, B.IV, Bl. 108. See also Hassan & Iskander, *Neb-Kaw-Her*, figs. 12–13.

[1205] Evans, *Animal Behaviour*, 8, 48, 192–193, with browsing especially commented upon, 90–92.

Notably, some of the scenes depicting goats feeding in trees are nearby those depicting the felling of trees and boatbuilding. As agriculture's role in supplying food and resources dwindled, the need to exploit the river in different ways grew. In the nearby tomb of Niankhpepy, goats are depicted in (more likely, on) a (felled) tree beside images of workmen cutting down trees and above scenes of workers removing branches.[1206]. Presumably, the tree has been felled to begin the process of making a boat to do so.[1207] Feeding the unnecessary branches to the goats seems an eminently pragmatic use of resources[1208]

Goat Attestations and A River In Drought

Goat scenes may indicate a response to fluctuating ecological conditions, for a number of reasons. A decline in excess water would have resulted in a decline in excess grain, normally fed to sheep. Goats, in particular, are well adapted to take advantage of changing environmental situations with their wider feeding range.[1209] Goats are a good option for a region experiencing ecological stress, due to their ability to reproduce rapidly in fertile times,[1210] with goats displaying a greater proclivity for producing twins compared to sheep.[1211] Also, there is less competition for food between goats and cattle, compared to sheep versus cattle,[1212] allowing the herder to best utilise the local habitat. However, the adaptation of goats to the prevailing harsh conditions, with respect to the feeding responses of goats to that of sheep, cattle and other animals, has not been studied as deeply as has that of other grazing animals.[1213] Breed–parasite interactions, for example, which could limit ecosystem exploitation capabilities, are little known.[1214] As increasingly sophisticated techniques to correctly distinguish between goats and sheep are utilised,[1215] a clearer

---

1206 Harpur, *Decoration,* 110. Note however, reservations described in Evans, *Animal Behaviour*, 90–91, n.26.

1207 Harpur, *Decoration*, 110. Note, however, some of the reservations described in Evans, *Animal Behaviour*, 90–91, n.26.

1208 Lashien, *Kahai*, pls. 28, 30, 34; Evans, *Animal Behaviour*, 91. Note that Schäfer, *Principles*, 253–255, is not fully convinced. Evans, *Animal Behaviour*, 91, suggestion seems a valid explanation.

1209 Gade, *Goats*, 531–532. For their ability to tolerate salt better than sheep, see Shaker, *Salt Tolerant Goats*, 66–77.

1210 McGregor, *Goat Notes*, 81–83.

1211 Evans, *Animal Behaviour*, 172–173; Swinton, *Resources,* 102.

1212 Redding, *Animal Use Patterns*, 102; fig. 3.

1213 Kay, *Responses to Drought,* 683–694; Kim et al., *Arid Environment Adaptations*, 255–264. See also, for comparison, an outline of responses and adaptations to an ideal feeding situation in Bryant et al, *Nutritive Content*, 410–414.

1214 Silanikove, *Adaptation in Goats*, 182–183.

1215 Copley et al, *Foraging & Foddering*, 1274, combines the archaeological evidence of sheep/goat remains into one group whereas Payne, *Morphological Distinctions*, 139–142, identifies the differences.

understanding of the relationship between these two species will develop. A more detailed study investigating the relationship between the zoology of the ancient species to the reported archaeology and the artistic representations may be in order.[1216] For example, in. the tomb of Hetepi, at Abusir, using enhanced techniques, goats constitute as much as 20% of remains.[1217] Whether the artists were aware of it or not, goat husbandry, according to the pictorial evidence, had become a significant part of the culture at the end of the Old Kingdom, so much so that goats fighting, in imitation, perhaps to scenes of bull fighting, entered the artistic repertoire.[1218]

1216 See Evans, *Animal Behaviour*, 19, recommending Porter, *Cretan Wild Goat*, 295–315, as an excellent exemplar of this approach and a suitable scaffold for similar studies.

1217 see Bárta et al., *Hetepi*, 159, 179, Table 3.2.

1218 Evans, *Animal Behaviour*, 142, identifying two tomb scenes and fig. 9-19, showing the scene from the tomb of Nebkauhor (from Hassan & Iskander, *Neb-Kaw-Her*, pl. 19 [c]).

9.4 – But … Where Are the Pigs?

While it has been attempted here to explain changes in the distribution and abundance of decorations in terms of changing environmental circumstances, the elephant in the room is the lack of porcine representations. As noted, there are significant amounts of iconographic evidence relating to large and small cattle,[1219] but it has been difficult to fully understand the role of the pig in ancient Egypt.[1220] The explanation of 'taboo' against eating pork does not hold based on the archaeological evidence:[1221] and, with increasing refinements of technology, pigs' presence is being more readily identified.[1222] Notwithstanding the claim that pigs were not a part of the funerary cycle,[1223] pig bones have been found in many different offering contexts in recently uncovered tombs at Abusir.[1224] Despite this, they are noticeably rare in the cultural context of Old Kingdom tomb decoration.[1225] The example in Kagemni's tomb at Saqqara is undoubtedly a dog,[1226] despite some scholars re-drawing the image to show hooves in place of paws,[1227] presumably correcting the artist's original 'mistake'! What pig representations there are, mostly depict naturally occurring wild boars.[1228]

Pigs and Early Egypt

The date of the first appearance of domestic swine in Egypt is debatable. Although it is difficult to assess archaeologically whether early remains came from hunted or domestic animals, skeletal remains of wild pigs are marginally smaller, but more robust, than those belonging to truly domesticated pigs.[1229] Changes thought to be the result of the

---

1219 Keimer, *Remarques sur le porc*, 147–156; commenting about cattle!
1220 Evans, *Pig Overboard*, 153–158.
1221 Evans, *Pig Overboard*, 159; Faust, *Pigs in Space*, 279–280; Blench, *Pigs in Africa*, 358–359; Amills et al, *Domestic Pigs,* 76–77; Hecker, *Pork Consumption*, table 1.
1222 Hecker, *Pork Consumption*, 61–64.
1223 Hecker, *Pork Consumption*, 59.
1224 For example, the tombs of Ankhires: Duliková, *Ankhires at Abusir*, 27–30; Iiti, and Hetepi: Bárta et al, *Hetepi*, 77, 80, 159–161, 169–71, 179, Table 3.2.; and tombs AS34–35, 50–53 and 57.
1225 Blench, *Pigs in Africa*, 357.
1226 Harpur, *Decoration*, 276; Harpur & Scremin, *Kagemni*, fig. 7; Miles, *Enigmatic Scenes*, 71–88.
1227 Evans, *Animal Behaviour*, 107–108.
1228 For example, Keimer, *Le Sanglier*, 26–33; Manlius & Gautier, *Sanglier en Egypte*, 573–574.
1229 Brewer et al., *Domestic Plants & Animals*, 94–95.

domestication process include decrease in size and the loss of hair and pigmentation. This corresponded with a decrease in brain size,[1230] perhaps making domestication easier.[1231] During the late Palaeolithic and Epipalaeolithic in Egypt, the people of Helwan ate pork;[1232] pig bones were also recovered from these times at sites in the Fayum.[1233] Pig bones have been recovered from most Lower Egyptian Predynastic sites,[1234] where it seems that pig was the main source of domestic animal protein,[1235] probably reflecting the advantage of a damper habitat.[1236] The evidence is less precise for Upper Egypt, though the presence of swine at Hierakonpolis is confirmed.[1237] Early settlers at Merimde, for example, consumed such quantities of pork[1238] that some archaeologists concluded that pork consumption was a characteristic of early Delta culture.[1239] The large number of bones recovered and their relative frequency compared to sheep/goat and cattle bones, ranging from the first to third most abundant animal, strongly suggests that they were kept animals.[1240] Despite this, it appears that pigs lost their relative importance. Brewer suggests a cultural preference for less pork as well as an environmental one;[1241] as cultivation rates increased, pig populations declined. Most likely, pig raising flourished where cultivation did not.[1242]

Pigs and Old Kingdom Society

With its omnivorous habits,[1243] it is not difficult to get a pig accustomed to whatever food is available in village settlements. Feeding and sleeping are the two activities that dominate a pig's life.[1244] Ruminants will feed for a short time, ruminate, perhaps sleep for a while and then feed again; pigs will feed continuously for many hours and then sleep for many hours.

1230 Zeder, *Animal Domestication*, 167.
1231 Price, *Domestication & Behavior,* 89, noting also a higher stress threshold.
1232 Köhler, *Of Pots and Myths*, 175.
1233 Note that the animals recovered from the Fayum, however, are thought to be of wild stock.
1234 Brewer & Wenke, *Mendes*, 191–197.
1235 Brewer et al., *Domestic Plants & Animals*, 96, table 7.1.
1236 Köhler, *Of Pots and Myths*, 175, reporting on the conclusion of an as-yet-unpublished thesis by M. Abd El-Karem, completed at the University of Vienna in 2013, entitled '*Die Nutzung tierischer Ressourcen während des 5. und 4. Jahrtausends v. Chr. in Ägypten: ein archäofaunistischer Beitrag zur Entstehung und Entwicklung von Versorgungsstrategien und Handelsbeziehungen*,'
1237 McArdle, *Hierakonpolis Fauna*, 116–121.
1238 Brewer et al., *Domestic Plants & Animals*, 97.
1239 Redding, *Animal Use Patterns*, 106; Wenke et al., *Kom el-Hisn*, 5–34; Brewer et al., *Domestic Plants & Animals*, 96, table 7.1; Hecker, *Pork Consumption,* 62.
1240 Wenke et al., *Kom el-Hsin*, 18–21.
1241 Brewer et al., *Domestic Plants & Animals*, 95, table 7.1.
1242 Redding, *Animal Use Patterns*, 103.
1243 Edwards, *Pigs*, 253.
1244 Edwards, *Pigs*, 253.

This means that in captivity they do not require food during the night and their sleeping and feeding programs can be easily accommodated to that of humans.[1245] In addition, even wild pigs have social tendencies, where the basic unit being the family makes them suitable for domestication.[1246] They are relatively long-lived and have a rapid reproduction cycle,[1247] able to produce two litters a year. Pigs mature quickly, producing harvestable protein more rapidly than sheep and goats.[1248]

The physical stature of the pig, its preferred habitat, and its innately stubborn personality (some may say: pig-headedness, even) make it an unlikely selection for herding over great distances.[1249] It is difficult to visualize nomadic or semi-sedentary peoples being accompanied by pigs as we know them:[1250] pigs seeming more suitable to settled, agricultural societies. Because pigs are beneficial to village farmers and less so to more mobile groups,[1251] one would not expect to find domestic pigs until such agriculture-based communities developed. It seems unlikely, therefore, that the pig was domesticated before the establishment of permanent settlements, yet the presence of domesticated pigs in the Middle East has been verified for the last eight to ten thousand years, with some parts of ancient Turkey, at Hallan Cemi, for example, providing evidence suggesting that pig herding had developed well before the adoption of agriculture,[1252] making it the oldest known domesticated creature apart from the dog.[1253] Perhaps, their ability to scavenge among human refuse[1254] led to, at first, 'accidental' domestication, which might explain why domestication occurred simultaneously at multiple locations.[1255]

Redding has shown that pigs were an important resource,[1256] primarily in rural areas, and therefore out of sight of those artists decorating the tomb. This may perhaps explain the persistent erroneous belief that pigs played a minimal role in the provision of protein. The

---

[1245] Edwards, *Pigs*, 254–255.
[1246] Edwards, *Pigs*, 254; Gades, *Hogs*, 536–537.
[1247] Williamson & Payne, *Animal Husbandry*, 552–554.
[1248] Redding, *Animal Use Patterns*, 104.
[1249] Edwards, *Pigs*, 253; Brewer et al, *Domestic Plants & Animals*, 94.
[1250] Fang et al., *Domesticated Coat Colours*, 4–5.
[1251] Edwards, *Pigs*, 254–255.
[1252] Gades, *Hogs*, 537.
[1253] Fang et al., *Domesticated Coat Colours,* 4–5, suggesting domestication over more than 10,000 years. See also Blench, *Pigs in Africa*, 357; Amills et al, *Domestic Pigs,* 73–74.
[1254] Zeder, *Animal Domestication*, 173.
[1255] Larson et al., *Pig Domestication Multiplicity*, 1616–1621.
[1256] Redding, *Pyramids & Protein* (Mar. 20, 2017).

primary role of the pig was as a source of meat and fat for the community, complementing that provided by cattle, sheep and goats, and further complementing sheep/goats/cattle by eating what those animals did not.[1257] As well, pigs' foraging behaviour would have helped turn the soil, producing favourable conditions for cultivation. Their adaptability allows them to freely range and root in the village or to live in a confined space. Their versatility offers a unique advantage over other domesticates, particularly in densely populated areas, yet the question remains … why are there so few depictions of this valuable resource?[1258]

Pigs and A River In Drought

As the river weakened and cultivation production diminished, the flexible eating habits of pigs, like goats, should have ensured them a key role in the food resource base. This doesn't seem to be evidenced in the decoration programme. While a taboo has been discounted, it has been suggested that the absence of pigs in the elite tomb decoration programme may be explained as an example of elitist snobbery.[1259]

Pigs would be expected to survive handily foraging on the edge of newly flourishing papyrus and *Phragmites* plants. Despite their potential to survive readily, the extra distances pigs needed to travel while foraging may have meant that they were less suitable at this time than goats and cattle.[1260] Perhaps the competition with cattle for the same feed sources may have led to a disinclination of the society to take advantage of pigs. Also, since pigs enjoy a similar diet to humans,[1261] possibly starting out as competitors,[1262] maybe it is reasonable to suggest that, as food resources declined, so, too, did their relative importance.

As fish, fowl and cattle took advantage of changing environmental conditions and foraged in the flourishing flora, pigs may have become less desirable as sources of food. Perhaps, due to an increasing need for mobility in times of less reliable water supply, pig herds were too cumbersome at this time in Egyptian history. Waterfowl and fish were not domesticated, so needed no care, and cattle could forage for themselves.

1257 Redding, *Animal Use Patterns*, 103–104, fig. 3; Brewer et al., *Domestic Plants & Animals*, 95.
1258 Moreno Garcia, *J'ai rempli les pâturages*, 251–254, asks the same question.
1259 Evans, Pig Overboard, 159; Rossel, Food for the Dead, 198–202; Rossel, Tale of the Bones; Redding, Pyramids & Protein.
1260 Bárta et al., *Hetepi*, 159.
1261 Miller, *Hogs & Hygiene*, 125; Gade, *Hogs*, 537.
1262 Porada, *Chronologies*, 280; Redding, *Role of the Pig*, 22–23.

9.5 – Increasing Reliance on the 'Mobile' Economy?

As mentioned earlier, it has been suggested that the marshlands could be expected to have responded differently to the floodplains A.R.I.D. times.[1263] A weaker river would have changed habitats, leading to circumstances where reeds and papyrus grew more widely, and were more readily available to be easily cropped by cattle. If the produce of cultivation was declining, then perhaps the local population relied more on resources 'on the hoof'.

The Rise of the 'Cattle Barons'

Landscape research points to several micro-regions within the Nile Valley; some of these appeared to be more conducive to the successful rearing of cattle.[1264] Some authors have suggested influence from the west and south. Since the first examples of Saharan dairying, for instance, are recorded at this time,[1265] Midant-Reynes suggests a strong influence from Saharan culture.[1266] Recent research by Brass has shown that the idea of an independent emergence of cattle domestication from the south also seems unlikely, with the Euphrates the most likely inspiration for domestication.[1267] Before domestication of cattle could develop, it seems more likely that domestication of smaller animals occurred.[1268] The time for selective breeding to decrease the size of the wild cattle to a more manageable size may be a reason for the delay is domesticating cattle, as opposed to the caprines. The increasing proportion of cattle bones, in comparison to other ungulates like sheep and goats, as well as pigs' remains, suggest that cattle were becoming an increasingly significant part of the resource mixture.[1269] Evidence from the industrial site of Wadi Zabayda suggests that the food provided to the workers was organised in a very controlled manner, with bone fragments suggesting entire self-replicating herds onsite, not groups delivered at regular intervals.[1270]

[1263] In a drought the land cannot 'steal' nutrients from the river; see Rzóska, *Nile Swamps*, 2.
[1264] Manning & Timpson, *Saharan Holocene Demographics*, 28–35; Moreno García, *Recent Developments*, 231; Brass, *Cattle Domestication Reassessment*, 105.
[1265] Dunne et al., *Green Saharan Dairying,* 390–394.
[1266] Midant-Reynes, *Prehistory*, 148, 164.
[1267] Brass, *Cattle Domestication Reassessment*, 109.
[1268] Brass, *Cattle Domestication Reassessment*, 107.
[1269] For example, Dulíková, *Ankhires at Abusir*, 27.
[1270] Willems et al., *Wadi Zabayda*, 318.

A greater understanding of the role pastoralism plays in protecting an environment is developing.[1271] The ability of cattle to rapidly recycle nutrients may have provided added material, in the form of fertiliser, to areas of cultivation.[1272] In some parts of Africa the environment relied so much upon the nutrients released by cattle that some herbaceous plants evolved to take advantage of these offerings,[1273] so it is possible that the same response could have developed in the regions alongside the river. In some areas, perhaps the importance of cattle was such that it precluded the exploitation of another resource, such as fishing. In order to minimise the contamination of livestock water supply by waste from the cleaning and preparation of fish, some herders in northern Sudan at this time appeared to actively chose *not* to exploit local fish stocks,[1274] perhaps responding to an understanding of the need to minimise biological pollution in order to maintain the ecological balance.

In southern Africa, cattle are regarded as 'portable wealth' as an adaptation to unreliable water supply.[1275] Some of the early cattle cults developed as a social response to environmental changes in the Holocene, with an increasing emphasis on portable wealth, or a "walking larder",[1276] and this same thinking may have established itself among land holders in Upper Egypt as a comparable response to a similar situation .[1277] The fact that societies practising pastoralism persisted in arid regions for so long demonstrates an inherent flexibility in traditional African pastoralist strategies that enables them to make the most efficient use of an increasingly fragile environment.[1278] The rise of local chieftainships in Upper Egypt during this time[1279] may have been aided by a declining reliance on food distributed from the capital and the increasing independence that mobile wealth delivered.[1280]

1271 Homewood & Rodgers, *Pastoralism & Conservation*; Notenbaert et al., *Pastoralism & Biodiversity*; Niamir-Fuller, *Legitimization of Transhumance*; Hart*, Plant Biodiversity*; Neely et al., *Drylands Pastoral Systems.*

1272 McNaughton, *Grazers Nutrient Cycling*, 1798–1800.

1273 Stebbins, *Grass Herbivore Coevolution*, 75–86; Kuper & Kröpelin, *Saharan Holocene*, 803–807.

1274 Linseele & Zerboni, *Done with Fish,* 237.

1275 Brierly et al., *Green Saharan Pastoralism*, 2–7; Wengrow, *Cattle Cults*, 91–104.

1276 Clutton-Brock, *The Walking Larder*, 115–118.

1277 di Lernia, *Cattle Cults*, 50–62; Jelinek, *Pastoralism & Social Stratification*, 41–44; di Lernia et al., *African Cattle Complex*, 25–26.

1278 Brierly et al., *Green Saharan Pastoralism*, 6–7; Brass, *Cattle Cult Origins*, 101; Kay, *Responses to Drought*, 683–694.

1279 Seidylmayer, *FIP*, 108–136.

1280 Wright, *Human Holocene Termination*, 5–8, discussing 'livestock economies.' See also Makarewicz, *Pastoralist Manifesto*, 159–174.

Move your Ass: Donkeys and Their Increasing Role in Society

Despite being domesticated relatively early in Egyptian history, donkeys' representation upon tomb walls appeared much later.[1281] While it is difficult to distinguish, archaeologically, between wild asses and early domesticated donkeys,[1282] domesticated donkeys seemed to have become significant features of Early Dynastic long-distance trade.[1283] The donkey was a relatively insignificant subject in Old Kingdom tomb scenes,[1284] but donkey meat had begun to be left as offerings in some Dynasty Five tombs.[1285] Representation of donkeys in tomb scenes increased from the middle of the Old Kingdom onwards,[1286] at the same time that organised way-stations for donkey caravans were being introduced through the desert.[1287] Harkhuf reported to King Merenre to have returned from one of his expeditions with 300 asses full of exotic goods.[1288] Donkeys were important to the economy in many ways other than simple agricultural.[1289]

Evans mentions that, by the time of the Middle Kingdom, donkeys were often depicted performing actions that were usually performed by sheep in the Old Kingdom; for example, treading in the seed.[1290] Perhaps the need for such large numbers of these hardy animals may have led to the development of donkey breeding programmes at this time.[1291] The physiological features of the donkey made it suitable for long-distance hauling. Donkeys are hardy animals and well adapted to working in arid environments.[1292] Their dietary preferences lie towards the consumption of plants that did not flourish alongside the banks

---

1281 For a simple overview, see Brewer et al., *Domestic Plants & Animals*, 98–100. For more detailed recent updates, see; Gifford-Gonzalez & Hanotte, *Domesticating Animals in Africa*, 13–14; Rossel et al., *Donkey Domestication*, 3715; Peters et al., *Animal Domestication*, 96–124; von den Driesch, *Buto im Nildelta*, 23–39; Kimura et al., *Donkey Ancestry*, 50–57.

1282 Rossel et al., *Donkey Domestication*, 3716–3717.

1283 Arnold et al., *Early Animal Trade*, 2, 8; Rossel et al., *Donkey Domestication*, 3718–3719; Hassan, *Food Metals & Towns*, 551–569; Förster, *Abu Ballas Trail*, 2; Osborn & Osbornová, *The Mammals*, 132–136.

1284 Power, Donkey Drawing Deconstruction, 131–151.

1285 For example, Dulikova, *Ankhires at Abusir*, 30. See also reports in Bárta et al., *Hetepi*, 77, 80, 159–171, 179-181, 334–335, 345–349, 368, identifying donkey bones as burial offerings in a number of Abusir tombs form the 5th and 6th Dynasties.

1286 Evans, *Animal Behaviour*, 63; Lashien, *Donkeys in Egyptian Art* (in preparation). Based upon a paper entitled 'The Donkey in Egyptian Art of the Old and Middle Kingdoms' presented at the Old Kingdom Art and Archaeology – 7th Conference, Milan, July 2017.

1287 Förster, *Abu Ballas Trail*, 3–5; Yilmaz et al., *Domesticated Donkey*, 339–352.

1288 Lichtheim, *Literature* I, 23–27.

1289 Swinton, *Resources*, 122–123.

1290 Dr L. Evans, Macquarie University, *pers. comm.*

1291 Brewer et al., *Domestic Plants & Animals*, 100.

1292 Arnold et al., *Early Animal Trade*, 5; Rossel et al., *Donkey Domestication*, 3715; Förster, *Abu Ballas Trail*, 4–6; Dill, *Life, Heat & Altitude*, 104–109.

of the river,[1293] meaning they did not become a source of competition to the cattle and other large herbivores.[1294] This also meant that donkeys were able to travel long distances away from the river, enabling the development of overland trade networks.[1295]

The apparent rise in the significance of donkeys in tomb scenes can be readily interpreted by the A.R.I.D hypothesis. If the river developed increasing blockages, then this must have required an increasing frequency of unpacking and re-packing of the vessels plying their trade along the river.[1296] Perhaps it had become more efficient to adopt donkey caravans to bypass these blockages. It may also help explain why the Abu Ballas Trail seems to have lost its importance after Dynasty Eight:[1297] perhaps a more freely flowing river meant long-distance trails as described by Förster may have become less necessary.

1293 Evans, *Animal Behaviour*, 85; Vogel et al., *Grasses in the Deserts*, 258–265; Bailey et al., *Bedouin Plant Utilization*, 145–162.

1294 Yilmaz et al., *Domesticated Donkey,* table 2.

1295 Rossel et al., *Donkey Domestication*, 3715. While not technically within the period of investigation, the tomb of Ankhtify contains a good representation of a donkey train; see Vandier, *Mo῾alla,* figs. 44, 48, pl. 36.

1296 Marshall, *Donkey Domestication*, 371–407.

1297 Förster, *Abu Ballas Trail*, 9.

Summation: Chapter Nine

An Emerging Status of Cattle and Goats and Donkeys?

The major points extracted from this chapter include:

- ⇒ A rapid growth in reed and papyrus would have resulted in an increase of feed available for cattle.
- ⇒ The rapid growth in cattle herd size coincides with the timeframe suggested in this investigation for an increase in plant growth on the riverbank.
- ⇒ The increasing depictions of cattle crossing river channels suggest a regular moving the herds from one fresh source of nutrition to another.
- ⇒ Despite the many advantages of pigs as a food source, their relative immobility may have led to their decline in relative importance during A.R.I.D. times.
- ⇒ On the contrary, goats, with their ability to subsist well on marginal lands may be the reason why depiction of these animals increased in significant proportion over the time frame of this investigation.
- ⇒ Goat representation changed from depictions in small groups to large herds over this time, suggesting their role in society changed.
- ⇒ Similarly, donkey representations increased, and archaeological evidence suggests they had become a more significant part of the society.

Cattle became an increasingly important feature of society at this time. With the goat often identified as a 'marker' species in regions experiencing ecological stress, perhaps it is not surprising, therefore, that the goat first appeared in significant numbers in the tomb decoration programme at this time. Goats have a wide and varied diet and rarely compete for food with sheep and cattle, making them a good supplementary option in an environment that is experiencing limited availability of resources. Pigs may have been too difficult to organise in times of more necessary mobility, with fish and waterfowl perhaps providing an easier source of alternative protein. Donkeys, with their ability to carry significant mass, and an ability to survive harsher environments, became another important factor of the society newly adapting to changing ecological conditions.

CHAPTER TEN

THE DESERT AND A RIVER IN DROUGHT

10.0 – INTRODUCTION

According to the artistic record, desert-based mammals had become an increasingly important aspect of the offering ritual by the end of the Old Kingdom. In light of the unfolding narrative of the A.R.I.D. hypothesis, it appears significant that the desert hunt motif was to re-establish itself as a significant element of tomb scenes around the time of Niuserra. Even though some religious connotations are possible, associating the desert with chaos and casting the desert hunt as a symbolic representation of victory over anarchy, with the cult of Re missing in response to a changing environment; the explanation for this change could be more prosaic: one of a reinvigorated artistic expression of a religious concept or outlook. Instead of viewing the surge in desert scenes as a reaction to metaphysical influences, it may be that a more physical influence led to these decorative changes, or a combination of these factors.

In this chapter, the depictions of the desert hunt will be re-examined in light of a possible decline in Nile levels. An influx of desert-sourced protein is explained as a consequence of a diminishing resource base. With a decreasing grain surplus, the requisite calories needed to come from another source.

10.1 – The Desert Hunt

During the time frame under investigation, it has been noted that a number of new artistic themes arose, including those themes related to the desert hunt itself.[1298] The desert hunt motif re-enters the lexicon around the time of Niuserra, with an increasing proportion of such scenes attested from the late Fifth Dynasty into the First Intermediate Period (see Table 34: Desert hunt scenes: pre- and post Niuserra).

Table 34: Desert hunt scenes: pre- and post Niuserra			
Desert hunt scenes	Date		
	Pre-Niuserra	Niuserra →D6	D6 Onwards
Proportion of All Scenes	2.6%	1.7%	2.4%

The pre-Niuserra proportion of desert scenes at 2.6% may seem substantial, but most of these attestations can be accounted for in tombs of the early Fourth Dynasty. At this time, a greater proportion of decorated tombs were owned by members of the royal family, which perhaps points to a metaphysical role for the desert scene. Despite the high proportion of scenes attested to the time before Niuserra, what the simple figures conceal, however, is the astonishing absence of scenes dating from the time of Khafra (IV.4) to Shepseskara (V.5). However, in simple numerical terms, the absolute number is very low. Compared to the late Fourth, early Fifth Dynasty the absolute number and relative proportion increased significantly from the time of Niuserra onwards. Judging from the changes in tomb decoration patterns already identified in this investigation, it would seem that a drive towards the acquisition, exploitation and regulation of food resources, especially fishing and pastureland resources, also witnessed an increase in those scenes with the desert as its primary theme. It is likely that the re-adoption of the desert hunt scene is a manifestation of the same motivation'

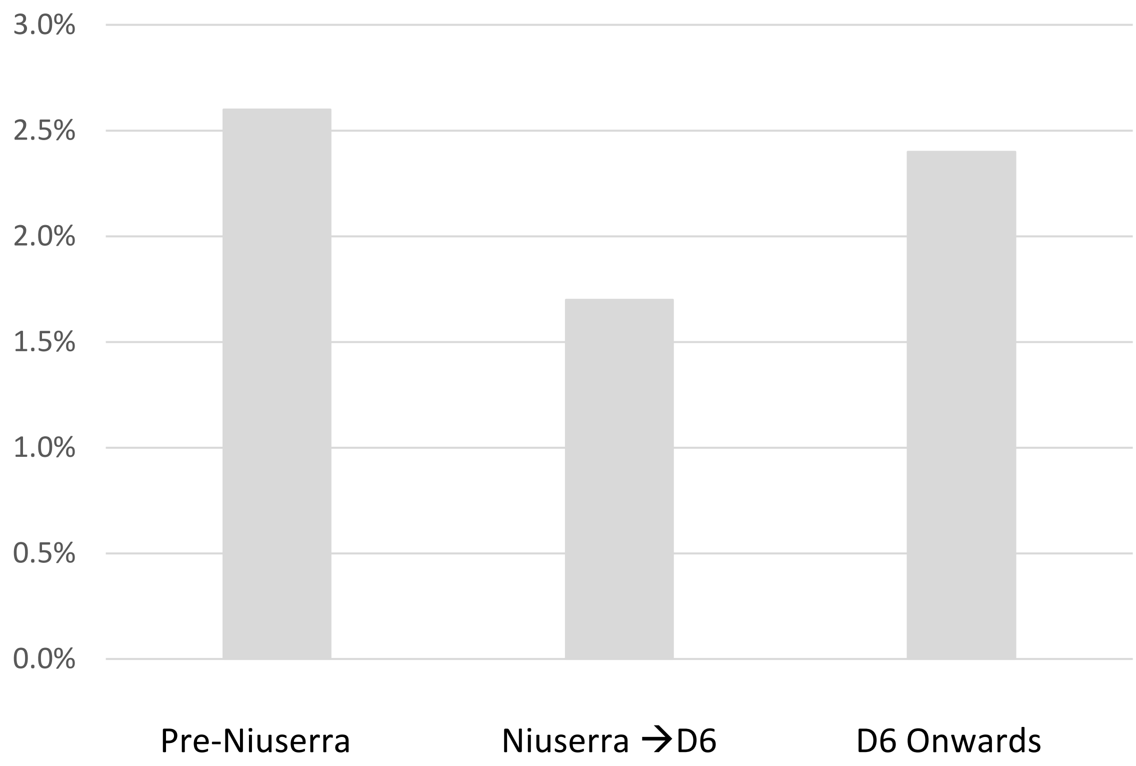
As noted previously, during a riverine 'drought', a 'blossoming' of plant life would be expected within the river,[1299] and as the drought extended in duration, increasing aridity

---

1298 Espinel, *Desert Hunters Iconography*, 88–90.
1299 See Chapter Four.

would draw the desert closer to the river. Both circumstances might prompt a closer interaction between river and desert organisms. Knowing that tomb depictions of various resources changed over the time frame under investigation,[1300] it may be possible to identify hints that the artists were sufficiently aware of their surroundings to notice changes within it. If the 'drought' led to increasing desertification, then it should be possible to identify a reflected trend in those scenes with themes related to the desert hunt and its associated activities (see Figure 54: Desert hunt scenes: proportion change over time). Animals of the desert were drawn so precisely that individual species can be identified, and different variants of the same species recognisable.[1301] In provincial scenes depicting the presentation of cattle and other large creatures, desert animals become a regular part of the display, suggesting an increasingly important role for them in the food chain.[1302]

Figure 54: Desert hunt scenes: proportion change over time



1300 Swinton, *Resources*, 27.

1301 See Evans, *Animal Behaviours*, in comparing different species' characteristics based on the artistic rendition.

1302 Thompson, *El-Hawawish*, 57, 61–64, 224, in comparing Memphite and provincial depiction styles, comments on the formal poses and nature of the display during cattle presentation scenes, while contrasting the informal and 'laid-back' style of representation of the cattle count scene itself – a representation of the day-to-day life the cattle represented?

10.2 – The Desert Hunt as a Tomb Scene Theme

There are many different interpretations of the desert hunt scene: depictions of sport, the reality of hunting or the religious symbolism of a moral victory over the forces of chaos.[1303] While religious symbolism became increasingly important, with some suggestion of the Pyramid Texts having begun to influence the decoration programmes within tombs,[1304] it may be that the addition of these decorative elements was in reaction to metaphysical or symbolic influences. However, it is possible that a more physical influence led to these decorative changes as the increasingly realistic representation of the process suggests that this activity had a more pragmatic function, over time.

Scene Development

The evolution of the desert hunt motif can be traced from Predynastic times.[1305] On the Hunter's Palette (pre-dynastic Naqada III), for example, numerous desert animals are depicted fleeing a group of hunters.[1306] Hierakonpolis Tomb 100[1307] depicts a desert hunt with archers, and most of the animals corralled within an enclosure.[1308] In one section of the Hunter's Palette, a wounded lion appears transfixed by arrows loosed presumably by the many men around the edges of the scene.[1309] Given the symbolic role of the lion in Egyptian art, this representation may be more than just descriptive.[1310] In scenes found upon the mortuary temple of Sahura at Abusir, the king is depicted firing arrows into desert animals in an enclosure, like the decoration in Hierakonpolis Tomb 100.[1311] He is aided by hunting dogs, as well as attended by figures with lassos and sticks.[1312] The impression is one of a dominant and powerful monarch.

1303 Säve-Soderbergh, *Hippopotamus Hunting*; Hendrickx, *Order over Chaos*, 723–749; Swinton, *Resources,* 245; Montet, *Les reliques*, 76.
1304 For example, see Vischak, *Ankhmahor & Agency*, and Allen, *Reading a Pyramid*. Contra Hays, *Unreading the Pyramid Texts*; Burn, *Pyramid Texts.*
1305 For an excellent overview, see Strandberg, *Gazelle*, 57–71.
1306 Fragments BM 20790 and BM 20792; and Louvre E 11254.
1307 Adams, *Early Egypt*, 1.
1308 See Quibell, *Hierakonpolis*, pl. 26, for an early impression of an enclosure. Animals were driven into the small, defined area to be more easily 'hunted'.
1309 Hence the alternate name of 'the Lion Hunt Palette'.
1310 See commentary and analysis discussing the symbolism of the scene's composition in Strandberg, *Gazelle*, 39–40.
1311 Strandberg, *Gazelle*, 55, n. 43.
1312 Borchardt, *Sahure*, pl. 17.

Strandberg has noted the similarity of this decoration to those desert hunt scenes depicted in the Chamber of Seasons in Niuserra's Sun Temple at Abu Ghurob.[1313] In contrast, while hunting dogs are also present, here the king is not shown in an active role and no animals appear to be shot by arrows. An interesting addition to the iconography in this sun temple are mating and birthing scenes,[1314] implying fertility and further emphasising the regenerative cycles within nature. One interpretation suggests that at Abu Ghurob, the emphasis is on a glorification of harvest, as opposed to that at Abusir, which seems to be a "veneration of slaughter."[1315]

Non-Royal Depictions of the Desert Hunt: Dynasty 4

Early in Dynasty 4, beginning with the reign of Snefru, individuals other than the king had begun to adopt images of the desert hunt upon their tomb walls. Harpur identifies the tombs of Nefermaat,[1316] Itet[1317] and Rahotep[1318] at Maidum, and the tomb of Methen[1319] at Saqqara, as the earliest private individuals containing this scene type in a non-royal context.[1320] Despite being members of the royal family, they were not a part of the ruling section of the royal family. The scenes found in these four early Dynasty 4 tombs contain a similarity of design. While all depict dogs hunting, it is only the tomb of *Itet* that depicts images of hunters returning,[1321] as well as being the only tomb from this era that depicts a major figure holding the leashes of hunting dogs.[1322] Interestingly, Itet is the wife of Nefermaat and it is worth wondering why her husband did not depict these scenes in his own tomb, especially considering that his also contains images of desert-related hunting with dogs.[1323] Since no other tombs from this era contained the depiction of major figures actively hunting, it is conceivable the royal prerogative of depicting only the king hunting was still being observed.

1313 Von Bissing, *Trois Saisons*, pls. 11, 21, 33.
1314 Von Bissing, *Trois Saisons*, pls. XI a.; Smith, *Interconnections*, fig. 178; Edel & Wenig, *Königs Ne-user-Re,* pl. 14.
1315 Strandberg, *Gazelle*, 53, suggests Sahura's desert hunt scene is more powerful and evocative.
1316 Petrie, *Medum*, 25, pl. xvii [left].
1317 Harpur, *Maidum*, 77–91, 201–202, figs 80, 88, pls 11, 37.
1318 Petrie, *Medum*, 23, 37, pl. ix [lower].
1319 Smith, *HESPOK*, 151–152, fig. 60.
1320 Harpur, *Decoration*, 82.
1321 Harpur, *Maidum*, 77, 79, fig. 80, pls. 11–12.
1322 Harpur, *Maidum*, 89–90, 94, 201–202, fig. 88, pl. 37.
1323 Harpur, *Maidum*, 61–62, 72–73, 183–184, fig. 74, pl. 5. See also Klebs, *Reliefs des Alten Reiches*, 68.

The only type of decoration found in the tombs of Methen and the later tomb of Minkaef[1324] at Giza are desert hunt scenes, depicting hunting dogs and their prey, suggesting that this particular type of decoration must have had an especial significance, at least to those two persons. The Giza tomb of Minkaef, at who lived under King Djedefra, is thought to contain as its only scene that of a hunter in the desert: this implies that this singular aspect was most significant to the tomb owner. Afterwards, a considerable chronological gap exists before the next examples of tombs featuring desert hunt scenes appear. No desert hunt scenes are recorded in the Fifth Dynasty until the reign of Niuserra.

Non-Royal Depictions of the Desert Hunt: Dynasties 5 → 6

After a long hiatus from the early Fourth Dynasty, desert hunt scenes made a significant re-appearance around the time of Niuserra (V.6), the theme re-emerging in the tombs of Ptahshepses at Abusir,[1325] and Ramaka at Saqqara,[1326] both dating to Niuserra's reign. After having not been attested in the previous eight reigns, depictions of the desert hunt occurred during the reign of every king from Niuserra's administration to the end of the Old Kingdom. Thereafter, though the scene composition varied, the desert hunt scene appears regularly in elite tombs up until the Middle Kingdom and beyond.[1327]

From the distribution of the data, it appears that the reign of Niuserra was a significant time with respect to a change in the proportion of desert hunt representations. Many new scene types within the desert hunt theme appear in the iconographic record at this time (for an overview of this progression through the Old Kingdom, (see Table 35: Desert hunt scene variants (OEE Scene-details Database): Dynasties 4–6). The dates, as always represent the Dynasty and the king. Note that lions are not represented in desert hunt scenes of elite tombs until the reign of Niuserra: by this time, the lion motif was no longer restricted to the royal prerogative.[1328]

1324 Smith, HESPOK, 167, 170, fig. 65.
1325 Vachala, *Ptahshepses*, 120–121.
1326 Hayes, *Scepter of Egypt*, 98–99, fig. 56.
1327 Harpur, *Decoration*, 82, and Swinton, *Resources*, 27–50, tables 2–4. For the most recent summary of tombs containing desert hunt scenes so far, see Espinel, *Desert Hunt Iconography*.
1328 Garnot, *Le lion*, 75–91. See especially, Evans, *Animals*, 9–10, 113–114, for commentary on the symbolism of leonine representations. For the symbolism associated with the depiction of the lion in the tomb, see Evans & Woods, *Twins*, 64–66.

Table 35: Desert hunt scene variants (OEE Scene-details Database): D4→6

Scene Details - desert related	Date																					
	IV. 1	IV. 2	IV. 3	IV. 4	IV. 5	IV. 6	V. 1	V. 2	V. 3	V. 4	V. 5	V. 6	V. 7	V. 8	V. 9	VI. 1	VI. 2	VI. 3	VI. 4	VI. 5	VI. 6	VI. 7
2.1.1. Major figure holding leashes attached to dogs depicted in sub-registers	1																					
2.1.2. Hunter in the desert		1	1									4		1	4	3	1		3	1	3	2
2.1.3. Dogs hunting in the desert	4											4		2	6	3	1		3	1	3	2
2.1.4. Puppy accompanying a hunter															1				1			
2.1.5. Wild ox in the desert	1											2			4	1	1		1	1	1	1
2.1.6. Lion in the desert												1	1	1	5	2	1	1	1		1	
2.1.7. Leopard in the desert	1											1			2	1				1		
2.1.8. Jungle cat in the desert												1			1							
2.1.9. Caracal in the desert															1							
2.1.10. Wild ass in the desert															1					1		
2.1.11. Deer in the desert	1														1	1	1					
2.1.12. Oryx in the desert	1											2			5	3	1	1	1	1	3	1
2.1.13. Roan antelope in the desert	1															1			1			
2.1.14. Ibex in the desert	2											4	1		3	3	1			1	1	
2.1.15. Barbary goat in the desert												1			1					1		
2.1.16. Addax in the desert												1		1	2	1						
2.1.17. Hartebeest in the desert	1											2		1	3	2	1	1	1	1		
2.1.18. Gazelle in the desert (Dorcas gazelle)	3											4	1	1	6	3	1	1	3		1	1
2.1.19. Gazelle in the desert (Soemmering's gazelle)	1											1			1	1	1					
2.1.20. Gazelle in the desert (Isabella gazelle)												1										
2.1.21. Hyena in the desert												2			3		1			1		
2.1.22. Jackal in the desert															1		1					
2.1.23. Fox in the desert	2											3			2				1			
2.1.24. Hare in the desert	3											3	1		1	1				1		
2.1.25. Ichneumon in the desert															1							
2.1.26. Jerboa in the desert	1											1			2							
2.1.27. Ratel in the desert	1														1							
2.1.28. Weasel in the desert	1											1			1							
2.1.29. Rat in the desert	1														1							
2.1.30. Porcupine in the desert												1										
2.1.31. Hedgehog in the desert	1											3		1	3	3	1	1	1	1	1	
2.1.32. Ostrich in the desert															1							
2.1.33. Guinea fowl in the desert															1							
2.1.34. Young antelope, usually crouching in a sub-register, all species												4		1	4	3	1		1			
2.1.35. Animals with fatty appendages, or 'wattles', all species															1				1			
2.1.36. Mating animals, all species												1			3				1			
2.1.38. Animals suckling young, all species												2			2							
2.1.39. Animals defecating, all species													1		2	1						
2.1.40. Net barrier enclosing desert animals												1	1	1	2	2	1					
2.1.41. Wavy desert baseline	2											4		2	4	3	1		2	1	3	1
2.1.42. Sand grains or pebbles defined on the desert floor	1														1				1		2	
2.1.43. Foliage, mainly shrubs and succulent plants, growing in the desert												3	1	2	4	3	1		1	1		
2.2. Hunters returning from the desert with game	1											1	1		3	1	1	1	1	1		
TOTAL	31	1	1	0	0	0	0	0	0	0	0	59	8	14	91	42	18	6	25	15	19	8

By the early Middle Kingdom, for example, in the tomb of Khnumhotep II, representations of felines appear in a way to suggest that the tomb is highlighting his power, with the individual emphasising his prerogative to use this motif. Khnumhotep II's biography[1329] suggests that his governorship was not appointed but perhaps inherited – a 'fiefdom', perhaps.[1330]

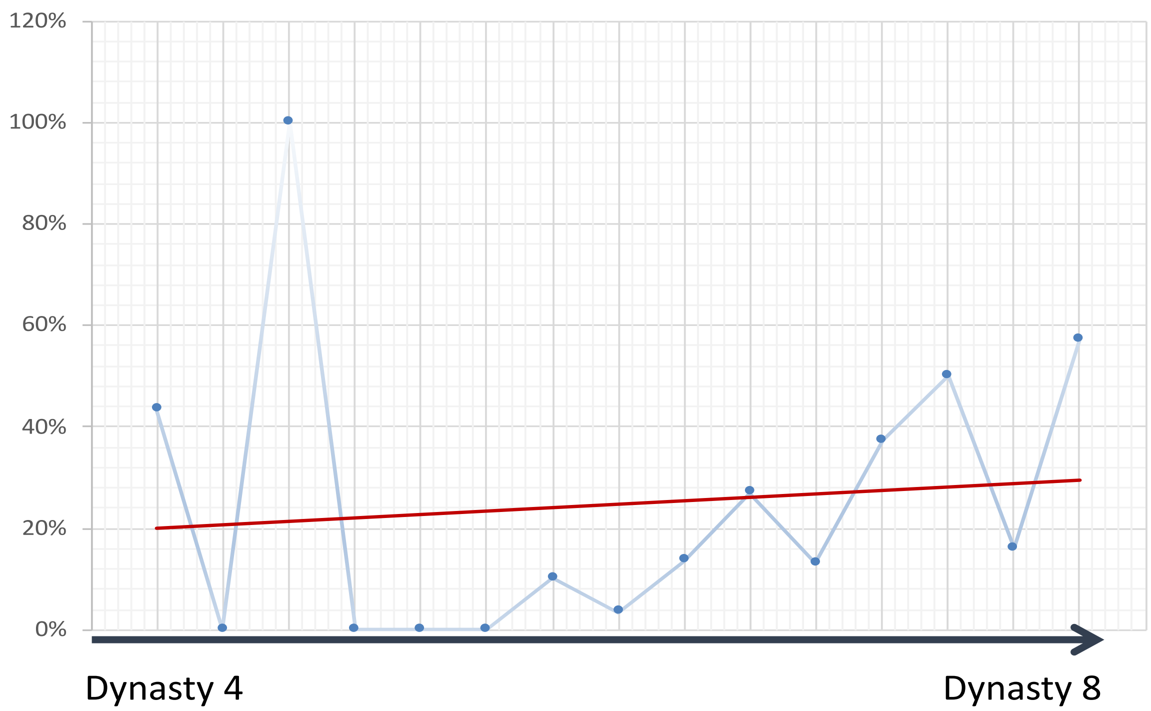
[1329] Newberry, *Beni Hassan* 1, 56–67. A new translation is offered in Kanawati & Evans, *Beni Hassan* 1.
[1330] Indeed, could the King have selected another? See Kanawati & Woods, *Beni Hassan*, 34–35.

10.3 – Changing Decoration Variants

While the wavy desert baseline is a feature common throughout the entire era in question, none of the Dynasty 4 tombs depicted desert foliage. However, over the time frame under investigation, the components making up the desert hunt scene type displayed changes.[1331] By the time of the Old Kingdom, the desert hunt motif had been well developed.

Increasing Complexity of Desert Hunt Scenes

Figure 55: Component elements of desert hunt scene



While the proportion of desert hunt scenes did not increase over the time frame of the investigation as perhaps would be expected from the A.R.I.D. hypothesis, the variety of scene types burgeoned, as did the amount of detail within the individual desert hunt scenes themselves.[1332] The number of 'scenic-elements' appears to have increased. In tombs

[1331] Kanawati, *Tomb & Beyond*, 9697.

[1332] My thanks to Miroslav Bárta (personal conversation, July 2014) who suggested conducting a more detailed analysis of the increasing complexity within desert hunt scenes.

containing a desert hunt scene, the number of different 'scene-elements' within each desert hunt scene was identified. The average quantity of components was plotted over time and presented in a scattergram (see Figure 55: Component elements of desert hunt scene), to see the relative increase in scene elements within individual images. Each point represents the proportion of desert scenic elements for each king and the red line represents the average tendency. The data suggests a slight increase in the number of components that made up the individual desert hunt scenes (rising from 20% to 30% according to the trendline). This factor is interesting when added to the other factors that have been identified in this investigation. As the land was slowly dry, the desert came closer to the river and the society interacted more with the desert environment.

Desert Hunters

The desert hunt scene type chronicles a more significant change, however, with an increased proportion of the scenes' features focusing upon hunters returning with game. An earlier emphasis upon the hunt itself and what it represented had shifted to an increasing highlight on the rewards of the hunt (see Table 36: Desert scenes: Depictions of hunters – Pre- and post Niuserra).

Table 36: Desert scenes: Depictions of hunters – pre-and post Niuserra

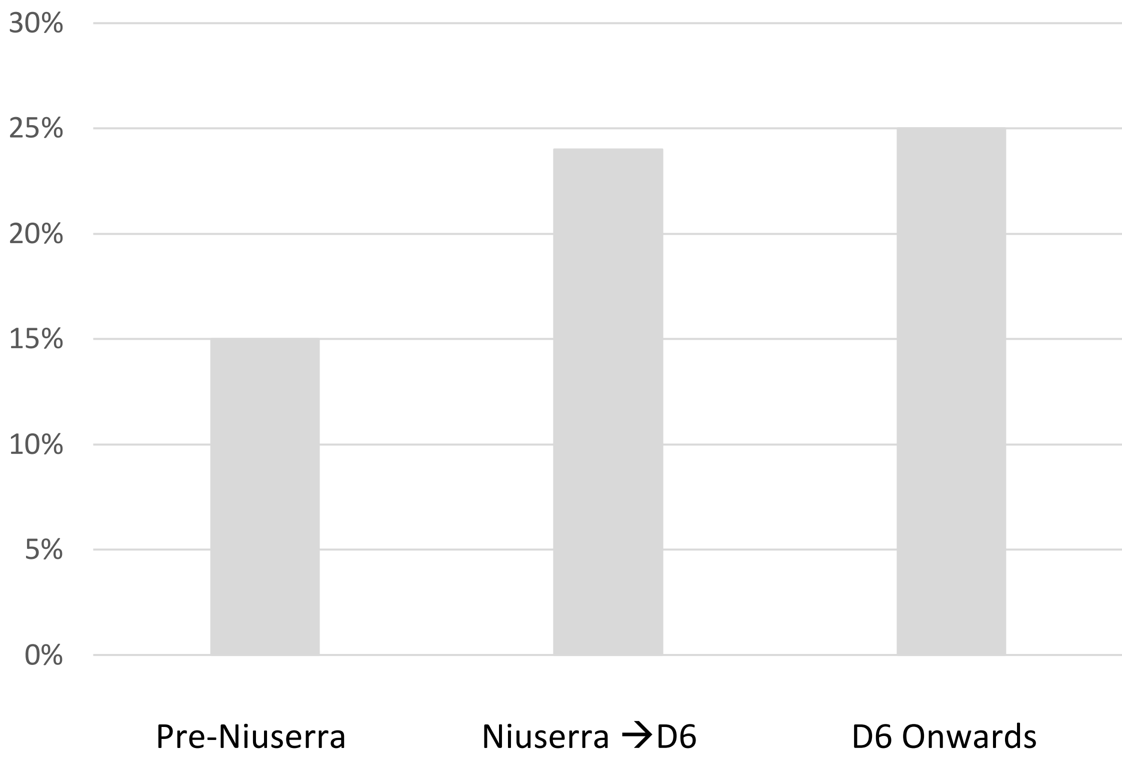
Desert hunters	Date		
	Pre-Niuserra	Niuserra →D6	D6 Onwards
Proportion of all scenes	2.6%	1.7%	2.4%
Theme = Desert Scene	2.2%	1.3%	1.8%
Theme = Hunters	0.4%	0.4 %	0.6%
Proportion = Hunters in Desert Scenes	15%	24%	25%

Early desert hunting scenes have been interpreted as representing the status of an individual, inferring dominance, power and control.[1333] Later Old Kingdom hunting scenes depict more

[1333] Hassan, in *Followers of Horus*, 316; Kemp, *Anatomy*, 81.

of the prey and convey a sense of a process more 'mass-produced' and 'industrialised' and less ritualistic. The changes in proportion of decorative elements depicting hunters is significant (see Figure 56: Desert scenes: Proportion of hunter depictions change over time), where it seems that the hunt is once again a demonstration of the power of the individual.

Figure 56: Desert scenes: Proportion of hunter depictions change over time.



The Hunter as Archer

Bow-armed hunters appear for the first time in a non-royal context during the Sixth Dynasty.[1334] In the tomb of Khunes at Zawyet el-Maiyetin, craftsmen are depicted constructing a bow.[1335] The context appears to be non-military, so might be related to hunting. The tombs of Ibi at Deir el-Gebrawi,[1336] Idu/Seneni at el-Qasr wa-'l-Saiyad[1337] and Meru at Naga ed-Deir[1338] all depict hunters as archers.

1334 Thompson, *El-Hawawish*, 63; Hoffmeier, *Hunting Desert Game*, 8–13; Espinel, *Desert Hunter Iconography*, 91. Bow-armed hunters appear in the royal funerary temple of Sahura – see Borchardt, *Sahure* II, pl. 17.

1335 LD II, Band IV, Bl. 108.

1336 Kanawati, *Deir el-Gebrawi,* II, 44–45, pls. 52, 71b.

1337 Säve-Söderbergh, *Hamra Dom*, pl. 10.

1338 Peck*, Naga ed-Dêr*, 99, pls. 7, 10, 12.

Among the earliest representations of non-royal archers in the Old Kingdom, however, who is the oldest may still be under debate.[1339] The tomb of Khunes at Qubbet el-Hawa depicts an archer in the left background of the combined fishing and fowling scene.[1340] Despite the growing ranks of archers in tomb scenes, no Old Kingdom tomb owner depicted himself in such an active role in the desert hunt.[1341]

By the end of the Old Kingdom, bow and arrows had become status symbols,[1342] becoming more frequently represented in funerary decorations and equipment during the First Intermediate Period and into the early Middle Kingdom.[1343] The tomb of Ankhtify at Mo'alla is another that contains a desert hunt scene. In this tomb a significant figure in the hunt is depicted as an archer, of whom the detail of the head is missing, however, Vandier does not identify the archer as Ankhtify.[1344] If the person represented is indeed Ankhtify, then it is a unique representation of a non-royal individual representing himself as an archer in a desert hunt before the Middle Kingdom.[1345] The large-scale tomb owner with bow and arrow who flanks the hunting scenes in private tombs is preserved in Middle Kingdom contexts, however. Perhaps we are seeing a developing self-perception of one who no longer sees himself as governing on behalf of the King but is rather himself acting in a king-like manner.[1346]

As the importance of acquiring resources increased, so did a more pragmatic approach to the collection of food, as archers began to be depicted hunting. There appears to be an increasing tendency to represent hunters with markers suggesting Nubian ethnicity.[1347] While Nubians have been identified as mercenaries,[1348] perhaps a supplementary role as hunters can also be considered.[1349]

1339 Kanawati & McFarlane, *Akhmim* I, n.108.
1340 de Morgan, *Catalogue*, 159.
1341 Perhaps Pepynakht/Hekaib at Qubbet el-Hawa: see Decker & Herb, *Bildatlas zum Sport*, 313–314, pl. 142.
1342 Fischer, Nubian Mercenaries, 44–80; Fischer, First Intermediate Archer, 50–52; Fischer, Egyptian Studies, 84–85.
1343 Seidlmayer, *Gräberfelder aus dem Übergang*, 194; Grajetzki, *Burial Customs*, 37; Zitman, *Assiut*, 195.
1344 Vandier, *Mo'alla*, 93–95, figs. 29, 45–46.
1345 Nearby is the tomb of Sebekhetep, containing an incomplete hunting scene, also featuring archers; see Vandier, *Mo'alla*, 271–274, fig. 81, pl. 42.
1346 Kanawati & Woods, *Beni Hassan*, 31–33.
1347 Pemler, *Looking for Nubians*, 443–449, with many references.
1348 Edel, *Qubbet el-Hawa* 3, fig. 7; Edel, *Qubbet el-Hawa* 4, pl. 74.
1349 Espinel, Desert Hunter Iconography, 100.

In a study with a similar approach to the current one, Espinel has plotted the change in abundance of hunting tools depicted in tomb scenes, producing results where the object in the scene, the 'tool' or 'weapon', is identified and recorded.[1350] He has traced the change in type of weapon and contrasts its aim to either the 'hunt' or the 'capture' of the animal.[1351] The theme of hunter depicted in the desert is present in almost two-thirds of tombs dating to Dynasty 5 and more than three-quarters of tombs dating to Dynasty 6.[1352]

Increasing artistic prioritization of depicting the desert hunt?

With regard to the region beyond the river, the desert floor was depicted in the form of a wavy line, perhaps to represent the disorder of the desert environs. Skilled artists could identify singular characteristics in their surrounding environment.[1353] Some tomb owners chose as their only form of decoration desert-related themes within their tombs: the examples of Methen and Minkaef have been identified previously as examples of tombs where the ONLY decoration depicted was a representation of the desert hunt.[1354] Suggesting that, to at least those two named individuals, this particular type of tomb scene must have had an especial significance. Note, however, that only one Dynasty 6 tomb, that of Nehwet-desher-Meri at Akhmim, seems to have depicted no other scene than the desert hunt.[1355]

Boessneck identified the representations of various desert animals over dynastic history and, from this, calculated their apparent importance, identifying the relative importance of these animals at the end of the Old Kingdom.[1356] The relative importance of the desert hunt may be measured in the comparative abundance of the animals within the scenes. Some desert animals appear to be more significant than others.[1357] Otherwise, why would Nimaetre, for example, take the time to have an ostrich or a caracal so carefully rendered?[1358]

1350 Espinel, Desert Hunters Iconography, tables 1–3.
1351 Espinel, Desert Hunters Iconography, 91–94.
1352 Depicted in ~ 60% of Dynasty 5 tombs and ~80% of Dynasty 6 tombs, see Espinel, *Desert Hunters Iconography*, tables 1–3.
1353 Kanawati & Woods, *Artists*, 71–72.
1354 Smith, *HESPOK*, 151–152, fig. 60 and 167, 170, fig. 65, respectively. Note however, that the preservation of some scenes may limit the use of absolutes.
1355 Kanawati, *Akhmim* VIII, 12, pls. 2a, 8a, fig. 3b.
1356 Boessneck, *Die Tierwelt*, 36.
1357 Herb & Förster, *Desert to Town*, 26–27.
1358 Roth, *Palace Attendants*, 132–3, pls. 95–97, pl. 189.

10.4 – Desert Resources and A River In Drought

As a consequence of a weakened river, the poor inundation would have resulted in the diminishment of the width of the valuable settled farming land between river and desert. This would have brought desert animals into increasing contact with the sedentary population bedside the river. Resources from the desert and desert trade increased during the time frame under investigation.[1359] The increasing representation of salted fish as a trade good with mobile communities based away from the river suggests that this communication was mutually beneficent.

By the opening years of the Predynastic the land had already begun to dry out.[1360] The increasing hyper-aridity made the hunting of larger game easier as these animals became increasingly dependent on the water and plant resources of the river.[1361] Considering it is thought that Egypt was experiencing a severe drought in the closing stages of the Old Kingdom, it would be expected that tomb decoration scenes depicting the desert hunt and related activities should have increased in abundance. While this was not the case, it is true that the complexity and amount of detail depicted within desert hunt scenes increased markedly over this time frame.[1362]

Hunting or Domestication in a time of a Changing Climate?

Significant also is the change from representations depicting sport to those using barriers or traps, serving to indicate a more 'industrialised' process in the 'harvesting' of desert produce. Swinton suggests a greater value was placed on desert animals in the funerary parade, identifying their attendants as of higher status, indicating these animals were becoming increasingly prized.[1363] Whether the Egyptians domesticated the desert animals, or whether these animals had simply become more accustomed to human contact due to the forced interaction caused by the thinner ecotone and were therefore easier to capture, is an

---

1359 Negus, *Great African Drought*, 320–321.
1360 See Chapter One.
1361 Herb & Förster, *Desert to Town*, 19.
1362 Moreno Garcia, *Paturages de vaches tachetes*, 241–242; Swinton, *Resources*, 244–245; Herb & Förster, *Desert to Town*, 33–34; Linseele & van Neer, *Archaeology of Exploitation*, 70–72; Pantalacci & Lesur-Gebremariam, *Wild Animals Downtown*, 253–256.
1363 Swinton, *Resources*, 248.

interesting investigation. The size of the stockades built to contain them suggests domestication was not very successful. Swinton considered an organised breeding program for desert ungulates, but suggests the scenes identified are more related to a process of 'taming' the animal.[1364] However, Herb and Förster and Linseele and van Neer believe that herds were kept on a more permanent basis.[1365] It appears that the desert animals had become habituated to humans and their cattle. Gazelles are very common in the archaeological record and are renowned as being easy to domesticate, especially if the young are collected early.[1366]

In their commentary on this work, Herb and Förster summarised the various archaeological and epigraphic evidence to develop a "*hierarchy of importance*" of large animals, identifying that cattle were the most significant large mammal, followed by the oryx, the ibex and then the gazelle.[1367] Perhaps the term 'desert hunt' is inappropriate. It may seem more accurate to identify the desert sequences as the gathering and keeping of desert animals before their utilisation:[1368] a form of desert husbandry, perhaps. Only in one tomb is the 'slaughtering of desert cattle' scene found outside the cult chapel. In the tomb of Mehu (Saqqara, Dynasty Six), two such scenes are found in the antechamber to the cult chapel.[1369] However, the chapel also contains a further three separate scenes of the slaughtering of desert cattle,[1370] so the tomb of Mehu is not completely deviant.

A Deepening Dependence on the Desert

During the Great Wet Phase of the Terminal Pleistocene, about 11,000 BP, it seems that humans had ready access to game,[1371] with environmental conditions so favourable that there would have been little impetus to change their lifestyle. Aridification of the environment may have led to increasing attempts at domestication of desert animals.

1364 Swinton, *Resources*, 246–247.
1365 Herb & Förster, *Desert to Town*, 22; Linseele & van Neer, *Archaeology of Exploitation*, 47.
1366 Pöllath, *Prehistoric Game Bag*, 79; Manlius, *Historical Biogeography,* 114–115, fig. 1; Linseele & Van Neer, *Archaeology of Exploitation*, 53, 70–71.
1367 Herb & Förster, *Desert to Town*, 27–33, fig. 14.
1368 Herb & Förster, *Desert to Town*, 17–19.
1369 Altenmüller, *Mehu*, 156–162, fig. 12, pl. 48–51.
1370 Altenmüller, *Mehu*, 193–198, fig. 19, pl. 72–74.
1371 Muzzolini, *Saharan Food Economy*, 228.

Desert animals are better adapted to irregular feed and variable-quality drinking water.[1372] Perhaps the rapid increase in the representations of goats may be another indicator of the need to endure (stomach?) food grown in less desirable environments.[1373] With an ability to follow the feed, animals that could forage as they moved may have become more viable in the increasing aridity at the end of the Old Kingdom.[1374] Their increased exploitation may explain their increasing abundance in the archaeological record.[1375] Mobile wealth may have been a strategy adopted at this time. It seems that cattle and desert mammals were kept in the same type of enclosure, suggesting that they were treated in a similar manner.[1376]

Whatever the outcome of these attempts, desert animals became an increasingly important component of the resource mix. The epigraphic and archaeological evidence suggests that the exploitation of desert mammals increased over the Fifth Dynasty, through the Sixth Dynasty and into the Middle Kingdom.[1377] The procession scenes depicted at Abusir where cattle are accompanied by desert animals indicate an increasing habituation of the desert animals to cattle and their human handlers.[1378]

1372 Brass, *Cattle Cult Origins,* 104; Kay, *Responses to Drought,* 683–694.
1373 Shaker, *Salt Tolerant Goats*, 66–77.
1374 On livestock economies, see Wright, *Human Holocene Termination*, 5–8.
1375 Linseele & Van Neer, *Archaeology of Exploitation*, 47–78; Pollath, *Prehistoric Gamebag*, 79–108.
1376 Herb & Förster, *Desert to Town*, 22; Linseele & Van Neer, *Archaeology of Exploitation*, 47.
1377 Boessneck, *Die Tierwelt*, 35; Herb & Förster, *Desert to Town*, 32; Linselele & Van Neer, *Archaeology of Exploitation*, 47.
1378 For example, Vymazalová & Arias Kytnarová, *Sheretnebty*, 41; Dulikova, *Ankhires at Abusir*, 11.

SUMMATION: CHAPTER TEN

Developing aridity increases the necessity to use desert resources

⇒ Not as many scenes depicting desert animals are attested as would be expected for a time of 'drought'.

⇒ All tombs dated to the Sixth Dynasty that depict desert scenes also depict marshland scenes.

⇒ The variety and diversity of subjects within the desert hunt scene increased as did the richness and complexity of the compositions; suggesting a different attitude to the desert hunt.

⇒ The emphasis appeared less focussed upon individual prowess and more on the success of the 'harvest'.

⇒ Scenes depicting the intermingling of desert animals and 'regular' cattle, both big and small, suggest an overlapping of the marginal lands.

⇒ Desert animals appear to have become habituated to humans and became increasingly portrayed in the procession scenes produced at the end of this period.

⇒ As the river failed to deliver excess water, the width of the arable zone would have shrunk, bringing desert animals into increasing contact with the more sedentary population living bedside the river.

If the Sixth Dynasty was a time of worsening famine, then it would be expected that more tombs at this time would have included a desert hunt scene. Even though, by this time, the average size of tombs was declining, many tomb owners thought it important enough to include these decorations to the exclusion of others. The increasing relative importance of the desert hunt to tomb owners is evidenced by an increasing complexity of desert hunt composition. Desert animals would have found themselves in more direct competition with the cattle, sheep and goats of the settled population. Their gradually more permanent presence, so close to the riverbank and its attendant margins, and their increasing familiarity with humans and their herds, would have made their capture easier.

Part D

Discussion and Conclusions

Chapter Eleven

Art Imitating Life? Niuserra to the First Intermediate Period

11.0 – Introduction

The following are the principles guiding the methodology used here to develop the concept of 'A River In Drought' (A.R.I.D.):

1. *The first principle, based on the ecological sciences, was to suggest possible variations to the Nile and its associated biology that may have occurred as a result of a weakened river.*
2. *The accompanying principle was to determine potential cultural changes as identified in tomb scenes, that may have arisen as a consequence of the Nile experiencing 'drought'.*

During (A.R.I.D.) times, a low inundation would have resulted in less nutrients being deposited onto the land; those nutrients normally lost from the river remaining within it. When the river retained more nutrients, it would have developed ecological characteristics that were different to those from the normal situation, and as such would have exhibited environmental features different to those customarily demonstrated.

It was expected that these changes should have impacted upon the visual culture produced at that time. The distribution and abundance of tomb scene types produced over A.R.I.D. times were investigated to identify if any changes to the repertoire of tomb scenes occurred. The resultant variations were studied in order to investigate the potential of an environmental influence being detected in the artwork.

A number of associations between the environmental changes occurring at the end of the Old Kingdom and variations in the decorative programmes produced in tombs at that time have been noted. While it is difficult, however, to progress to the next level of certainty and claim that this thesis has provided historical evidence of a significant correlation between the two factors: environmental and cultural - as evidenced by the tomb scenes, with so very many coincidences being presented, then taken as a whole, some form of connexion appears highly likely.

To further this study, it became important, therefore, to relate the environmental situation in which these tomb owners found themselves to the wider historical, social and economic context of this era. In this chapter, the inferences outlined by the A.R.I.D. hypothesis will be investigated in the broader context of ancient Egypt at this time.

11.1 – Reign of Niuserra: A Re-Alignment?

The reforms undertaken during the reign of Niuserra have been associated with the goal of strengthening royal power and re-establishing the authority of the king in the face of growing dominance of officials and their families.[1379] In order to minimise the excessive accumulation of power and wealth, different families were given particular activities in which to become 'specialists', theoretically making it difficult to broaden their powerbases within the administration.[1380] These changes heralded the further introduction of social and administrative change,[1381] with the reforms (in theory, at least) remaining in place until the king could no longer project his power, that is, into the First Intermediate Period.[1382] Some of these administrative reforms may have been designed to wean the society off relying on a regular inundation. The rapid growth in importance of the Dakhleh Oasis may indicate one such strategy.[1383] Since the Oasis' water supply was less reliant on an annual flood, the increasing colonisation and cultivation of the oases be seen as another strategy to compensate for an unreliable riverine water supply and ensure a more dependable food supply.

As well as administrative reforms, social change occurred with some evidence suggesting that individuals seemed to have had a greater say in the design and organisation of their own tombs.[1384] The furnishing of decorated burial chambers from the late Fifth Dynasty and into the Sixth Dynasty may be an indication of a greater desire for a more secure resting place, one that would be better protected underground.[1385] These changes may be indicators of elite individuals becoming less confident of their funerary homes lasting for eternity.[1386] This may have been an indicator of changes in the religious and administrative arrangements of the time.

1379 Bárta & Duliková, *Divine & Terrestrial*, 46–47.

1380 Krečji, *Ptahshepses*, 358–360; Moreno García, *Trade & Power*, 97.

1381 Bárta & Duliková, *Divine & Terrestrial*, 32–37; Krečji, *Nyuserra revisited*, 513, outlining some of the deep changes in society; Morris, *Art of Not Collapsing*, 75–78, suggests another interpretation and explains, to his mind why these reforms were needed.

1382 Morenó García, *Trade & Power*, 100.

1383 Morris, *Art of Not Collapsing*, 81–82.

1384 Bárta, *Architectural Innovation*, 106, 114; Jánosi, *Houses of Eternity*, 34–36.

1385 Kanawati, *Decorated Burial Chambers*, 57–63. For a detailed inventory of decorated burial chambers, see Dawood, K., 2005. *Animate Decoration and Burial Chambers of Private Tombs during the Old Kingdom. New Evidence from the Tomb of Kairer at Saqqara.* Publications de la Maison de l'Orient et de la Méditerranée, 40: 1, 107–127.

1386 Bárta, *Filling the Chambers*, 10.

11.2 – TOMB DECORATIONS IN PRE-A.R.I.D. CEMETERIES

A number of cemetery sites rose to prominence before the end of the Fifth Dynasty and, therefore, theoretically before the impact of climate change was making its influence noticeable in the tomb scenes. Many tombs in these areas dating from before the time of Niuserra display a different decorative programme to that produced after this time.[1387] A comparison of the different patterns of tomb decoration within these cemeteries provides a contrast between themes relevant to the tomb occupants at those earlier times and those whose later tomb owners experienced times of ecological hardship.

Pre-Niuserra Cemeteries: Tehna and El-Hammamiya.

The number of provincial cemeteries with tombs dating prior to the mid-Fifth Dynasty is limited, making comparison about the tomb scenes difficult. Both the cemeteries at Tehna and El-Hammamiya contain tombs dated to the time before Niuserra. This was period when, according to the artistic analysis presented earlier in this study (see Chapter 5), environmental factors had yet to have had an influence of the types of scenes that were depicted on tomb walls. If the changing riverine environment was, as yet, NOT an influence, then this may explain the lack of depictions of fishermen using small nets and these individuals displaying techniques more suited to a crowded riverbank before the tome of Niuserra.

The Old Kingdom cemetery at Tehna, in Middle Egypt, was initially described by George Willoughby Fraser, who excavated some burials, recorded the most prominent wall-scenes and published them in 1893, providing a brief description of all the then-known tombs.[1388] The cemetery is currently being re-examined by an expedition from the Australian Centre for Egyptology, based at Macquarie University, Sydney, Australia.[1389]_This work is ongoing and has led to an increase in the total number of tombs recognised at this site.[1390]

1387 Krejči, *Ptahshepses*, 258–259.
1388 Fraser, *Early Tombs*.
1389 Thompson, *Tehna* I.
1390 Including a late Fourth/early Fifth Dynasty tomb not reported by Fraser, see Lefebvre & Moret, 'Tehnèh', 30–38, and an additional tomb discovered by the Australian excavators in 2011, tentatively dated to the Fifth Dynasty.

The tombs in the cemetery are among the earliest burials of provincial officials in the Old Kingdom, dating from the end of the Fourth Dynasty and into the beginning of the Fifth. They include an exceptional administrative document outlining the distribution of temple income to family members.[1391] While the tomb of Nikaiankh I at Tehna contains, perhaps uniquely an inscription of a royal endowment from Menkaure (IV.5) for land,[1392] for a temple dedicated to Hathor, no other scenes depict any major acts of cultivation. The significance of this scene is that it was prepared before the apparent environmental changes that are under investigation and suggests cultivation as the pre-eminent resource. They do not depict scenes associated with the acquisition and exploitation of marshland resources, and so follow the pattern proposed earlier. Due to the early date, none of the tombs at Tehna contains the fishing scenes that became more prevalent with the 'drought'.[1393] This is even more noteworthy considering the site of the necropolis has ready access to the river.[1394] The bulls portrayed in the tomb scenes display no signs of the aggression on show in the later tombs at Meir and El-Hawawish.[1395]

Decorations prepared at the Fifth Dynasty necropolis of El-Hammamiya display features more similar to those at Tehna than to those prepared in the nearer cemetery of El-Hawawish,[1396] which is dated later: to the second half of the Fifth and the Sixth Dynasties. Similar to those scenes at Tehna, the bulls depicted in the El-Hammamiya tombs of Kaikhent (A2) and Kaikhent (A3) appear quite docile and more passive than those depicted at El-Hawawish.[1397] Interestingly, the tomb of Rehetep, dating closer to the time of Niuserra,[1398] contains a number of scenes suggesting that environmental stimuli may have begun to have had an influence on the composition of its decorations. This appears to be the earliest example of a provincial tomb where scenes depicting the agricultural cycle have been added to the artistic sequence.[1399]

1391 Thompson, *Tehna Report*, 1–2.
1392 Thompson, *Tehna* I, 45–48, pls. 22–23, 56–57, updating the description in Fraser, *Early Tombs*, 126–127 and the translation in Strudwick, *Texts*, 216–218.
1393 Thompson, *Tehna* I; neither the tombs of Nikaiankh I, 30–48, Kaihep, 86–88, or Nikaiankh II, 66–76 depict scenes related to river resources.
1394 Personal observation. See also Thompson, *Tehna* I, pl. 2a.
1395 Thompson, *Tehna* I, pl. 14a, shows a scene from tomb 13, dating to the reign of Userkaf or later, of a docile bull comes
1396 Thompson, *Tehna* I, 15–17, noting similarities in form and function of the tomb design and artworks.
1397 El-Khouli & Kanawati, *El-Hammamiya*, pls. 44–45 and 68, respectively.
1398 El-Khouli & Kanawati, *El-Hammamiya*, 16.
1399 El-Khouli & Kanawati, *El-Hammamiya*, pl. 73a (middle register).

Note, however, that some Memphite officials had begun to prepare their tombs in the provincial capital to which they had been assigned. Perhaps this an example of the transferral of artistic influence from the capital arriving with the entourage of the nobleman assigned.[1400] It also includes scenes of the cutting down of trees, though no goats are included.[1401] While El-Khouli and Kanawati recognise the scene as incomplete,[1402] they offer no suggestions as to what may be missing, although Harpur proposes that goats would have been present.[1403] Judging by the similarity of this scene to those at Zawyet el-Maiyetin,[1404] El-Hawawish[1405] and El-Hagarsa,[1406] this seems the most likely interpretation. This addition of scenes depicting the agriculture cycle and goats in or near trees to the artistic repertoire at El-Hammamiya is consistent with the broader pattern identified in Chapter Five of this exposition: that the new iconography may be part of a developing pictorial narrative influenced by environmental change.

1400 Swinton, *Dating Tombs*, 171

1401 El-Khouli & Kanawati, *El-Hammamiya*, pl. 73a (bottom register).

1402 El-Khouli & Kanawati, *El-Hammamiya*, 74, pl. 73a. If this is the case, then this is also the earliest representation of this theme or scene type in a provincial tomb.

1403 From her analysis, Harpur has apparently decided it most likely does depict this theme since she has included it in the OEE Scene-details Database.

1404 Lepsius, *Denkmäler*, B.II, Bl.II, Abt. 108, for the tomb of Khunes; B.II, Bl.II, Abt. 111b for the tomb of Niankhpepy.

1405 See Kanawati, *El-Hawawish* I, fig. 15 for the scene in the tomb of Theti-iker; Kanawati, *El-Hawawish* VII, fig. 30, for the scene in the tomb of Gehesa/Nebi; and Kanawati, *El-Hawawish* I, fig. 15 for the tomb of Hesimin.

1406 See Kanawati, *El-Hagarsa* III, pls. 22–23 for the scene in the tomb of Wahi and pls. 37, 40 in the tomb of Mery-aa.

11.3 – Ra Setting… Osiris Rising in A.R.I.D. times?

The suggestion that the ancient Egyptians displayed a "*latent horror of death or extinction*"[1407] may explain why so much effort was put into ensuring a successful afterlife. The linkages of art to society's beliefs, especially with regard to its ideas of a continued existence in the afterlife, allows for a simple understanding of their apprehensions.[1408] Concerns relating to an individual's religious beliefs may be identified upon tomb walls, as can concerns about the maintenance of one's good name: and other evidence of spiritual life and desires can be found in the tombs produced by the elite of the period.[1409]

Due to Egypt's geographical features, it is no wonder that the religion of ancient Egypt reserved a special place for the role of the sun.[1410] While the gods Ra, Ptah, Amun and Osiris appear to have been universal throughout the country,[1411] the negative effects of the increasing aridity in the latter half of the Old Kingdom may have led to a decline in the relative importance of Ra, and an apparent increase in the veneration of Osiris, when compared to earlier times. The political machinations of the priests of Ra, for example, in influencing the enthronement of Userkaf as king[1412] and providing legitimacy for his succession may have built up a resentment to their power.[1413] The great wealth they accumulated[1414] may have been another factor that led to a resistance to their active influence in the administration of the country.[1415] Sun temples were no longer constructed after the time of Djedkare, and Menkauhor, for example, did not assume a 'Ra' name.[1416]

1407 Iverson & Shibata, *Canon & Proportions,* 6.
1408 Malek, *Egyptian Art,* 20–21*;* Shirai, *Ideal & Reality*, 325–333, suggests that planning for one's funeral seemed to be something that all the elite began as soon as possible. Siebels, *Agricultural Series*, 55, identifies the representations of this sequence as it relates to preparation for a successful afterlife.
1409 Smith & Simpson, *Art & Architecture,* 104; Robins, *Egyptian Art,* 102; Kanawati, *Tomb & Beyond*, 112–122.
1410 Kahi, *Ra is my Lord*, 1.
1411 David, *Religion & Magic*, 57.
1412 Whether he married the daughter of the Priest of Ra or Userkaf himself was a Ra priest is open for debate: see Verner & Zemina, *Forgotten Pharaohs,* 102, 118; Goedicke, *Abusir–Saqqara–Giza*, 405—406; Malek, *Old Kingdom*, 98; David & David, *Biographical Dictionary*, 164; Verner, *Pyramids,* 263.
1413 David, *Religion & Magic*, 79; Gallardo, *Séquito de Horus,* 21–22.
1414 Dunard & Zivie-Cochie, *Gods & Men,* 85–86; Jacquet-Gordon, *Domains*, 106–108, fig. F; Janák et al., *Sun Temples*, 441–442, suggests at least 24 domains.
1415 David, *Religion & Magic*, 111–112.
1416 Kanawati, *Conspiracies*, 3. Note that neither did Userkaf, despite the identity of his father-in-law.

It may be possible to ascribe an environmental influence behind a religious re-alignment from Ra to Osiris.[1417] As the arid conditions continued, the accuracy of representations of particular birds associated with specific aspects of spirituality declined. By the end of the Old Kingdom, for example, the notion of the *ba* had entered the sphere of the private funerary ritual and mortuary cult,[1418] but over this period, representations of the *ba* bird (and the *akh* bird) became less accurate, a consequence of the original birds becoming no longer regular visitors to Egypt.[1419] Janák in identifying changing artistic representations of these birds has shown the succession from depictions to real-life examples to representations of birds that appear to be no longer drawn from life,[1420] linking this decline in artistic skill to the gradual disappearance of some bird species from the region; as due to a changing climate. Presumably their migration routes had changed in response to a changing environment, so they were unavailable to be drawn from real life.

Osiris in the Ascendant?

Osiris is the king under whom the blessed dead hope to spend eternity.[1421] Osiris is an old god, found in early Egyptian religious thought where he is more closely identified with the Delta than with locales further south and identified exclusively in private burials, not royal ones.[1422] His first funerary representation appeared in a relatively insignificant manner in the reign of Djedkare, but he became more established in the later Sixth Dynasty.[1423] Once his name began to appear in the tombs of high officials,[1424] it became very common, appearing in almost every private tomb from late Dynasty V onwards.[1425] Eventually this deity assumed the role of the judge of the dead, indicating that he achieved an increasingly prominent role among the pantheon of the gods.[1426]

1417 See Janák, *Extinction of Gods*.
1418 Altenmüller, *Sein Ba*, 1–15.
1419 Janák, *Extinction of Gods,* 125–129.
1420 Janák, *Early Ba Attestations*, 143–153; Janák, *Spotting the Akh*, 17–31.
1421 Andrews, *Book of the Dead*, 11–12.
1422 Griffiths, *Origins of Osiris,* 236–237; Shalomi-Hen, *Dawn of Osiris*, 460.
1423 Bárta, *Journey to the West*, 187; Mojsov, *Death & Afterlife,* 33.
1424 Hassan, *Gîza* II, fig. 228.
1425 Shalomi-Hen, *Writing of Gods*, 133–136; Mojsov, *Death & Afterlife*, 29.
1426 David, *Religion & Magic,* 95.

Osiris was originally identified as an exclusively Sixth Dynasty phenomenon[1427] but there evidence indicating his worship beginning in the mid-Fifth Dynasty[1428] – during the time frame of this study, or even earlier?[1429] An increase in the importance of the cult of Osiris paralleled the decline in the construction of sun temples.[1430] New, extravagant underground chambers that were added to tombs over this time frame may have linked the subterranean landscape to the domain of Osiris, as seen for example in the tomb of Kaiemankh at Giza.[1431] It may be possible to attribute his 'ascendancy' in part to the potential environmental changes outlined in this investigation. The 'earthiness' of Osiris may be directly linked to the river, growth and fertility: a physical manifestation of a new, perhaps more pragmatic approach to worship, with people preferring the "*concrete humanity of Osiris over the abstract distance of Re.*"[1432]

As well as the god of the dead, Osiris was the underworld identity who granted all life, including the sprouting of vegetation and the fertile flooding of the Nile River.[1433] The linkage of Osiris to the mud of the inundation[1434] may also explain why some representations of him give him a green skin colour, the colour of the green growth of life, similar to that of a fecund river. 'Osiris burials,' where Nile silt in beer jars was placed alongside the body,[1435] have been identified in a number of recently excavated tombs at Abusir.[1436] The layer of mud above the body is not the result of natural activity but has been shown to have been purposefully placed.[1437] Since silt/mud is black and fertile, it contains within it the stuff of life,[1438] these burials are possibly a response to the search for life and fertility in a drought. Once again, there exists a potential link between the timing of Osirian influence and a river burgeoning as a consequence of a weaker flood.

1427 Shalomi-Hen, *The Dawn of Osiris*, 461. See, more recently, Dulíková, *Transformation*, 46–54.
1428 Griffiths, *Origins of Osiris*, 44, 61–68; Bárta, *Architectural Innovation*, 120.
1429 Bolshakov, *Fourth Dynasty Osiris*? 65–80.
1430 Kanawati, *Government Reform*, 15.
1431 David, *Religion & Magic,* 135; Mojsov, *Death & Afterlife*, 30.
1432 Shalomi-Hen, *Dawn of Osiris*, 466.
1433 Wallis Budge, *Osiris & Resurrection*, 32.
1434 Mojsov, *Death & Afterlife*, 33.
1435 Bárta, *Qar*, 61.
1436 Dulikova, *Ankhires at Abusir*, 16, 30; Bárta et al., *Neferinpu*, 211; Bárta, *Shepseskafankh*, 25. See also Dulíková, *Nyuserre Transformation*, 56, with fig. 7, identifying an offering formula invoking Osiris.
1437 Bárta, *Shepseskafankh*, 25.
1438 Bárta, *Journey to the West*, 211.

A Moral Re-alignment at the End of the Old Kingdom?

An apparent breakdown of order characterised the last years of the Old Kingdom, with the central government appearing to become more feeble and less proactive. Perhaps, due to this earthly disruption and to guarantee acceptance into the after-life, there developed an increasing emphasis upon the need to live according to a strict moral code.[1439] An increase in expressions of 'charity' became evident among the tomb wall scenes at the end of the Old Kingdom.[1440] By the time of the Eighth Dynasty**,** for example, Merer had recorded the following in his tomb at Denderah, *"...I gave bread to the hungry, clothing to the naked and protected the poor...*"[1441] So, if it had become commonplace by Dynasty Eight, it appears feasible that the tradition had begun earlier.

Gee suggests that an increase in personal charity developed in response to an increasing distrust in the government,[1442] or perhaps a recognition of its inability to provide for its population. Perhaps the modest monuments produced by the kings during the latter stages of the Old Kingdom were not indicators of decreasing wealth but evidence of further efforts to minimise discontent[1443] and to present a more humble attitude. Niuserra and Djedkara may or may not have had roles in disseminating this new religious understanding but, nevertheless, the struggles for authority[1444] resulted in a shift in religious observances at about the same time as ecological change resulted in a shift in the variety of resources available for distribution among the population.

1439 Andrews, *Book of the Dead*, 12; David, *Religion & Magic*, 83; Kahl, *Ra is my Lord*, 51–60.
1440 Gee, *Old Kingdom Collapse*? 67–70.
1441 Petrie, et al., *Dendereh*, pl. 8; Franke, *Arme und Geringe im Alten Reich,* 104–120.
1442 Gee, *Old Kingdom Collapse*? 69–70.
1443 Morris, *Art of Not Collapsing*, 75–76.
1444 Gallardo, *Séquito de Horus,* 45–46; Bárta & Duliková, *Divine & Terrestrial*, 41–43.

11.4 – The Ascent of the Marshland Economy

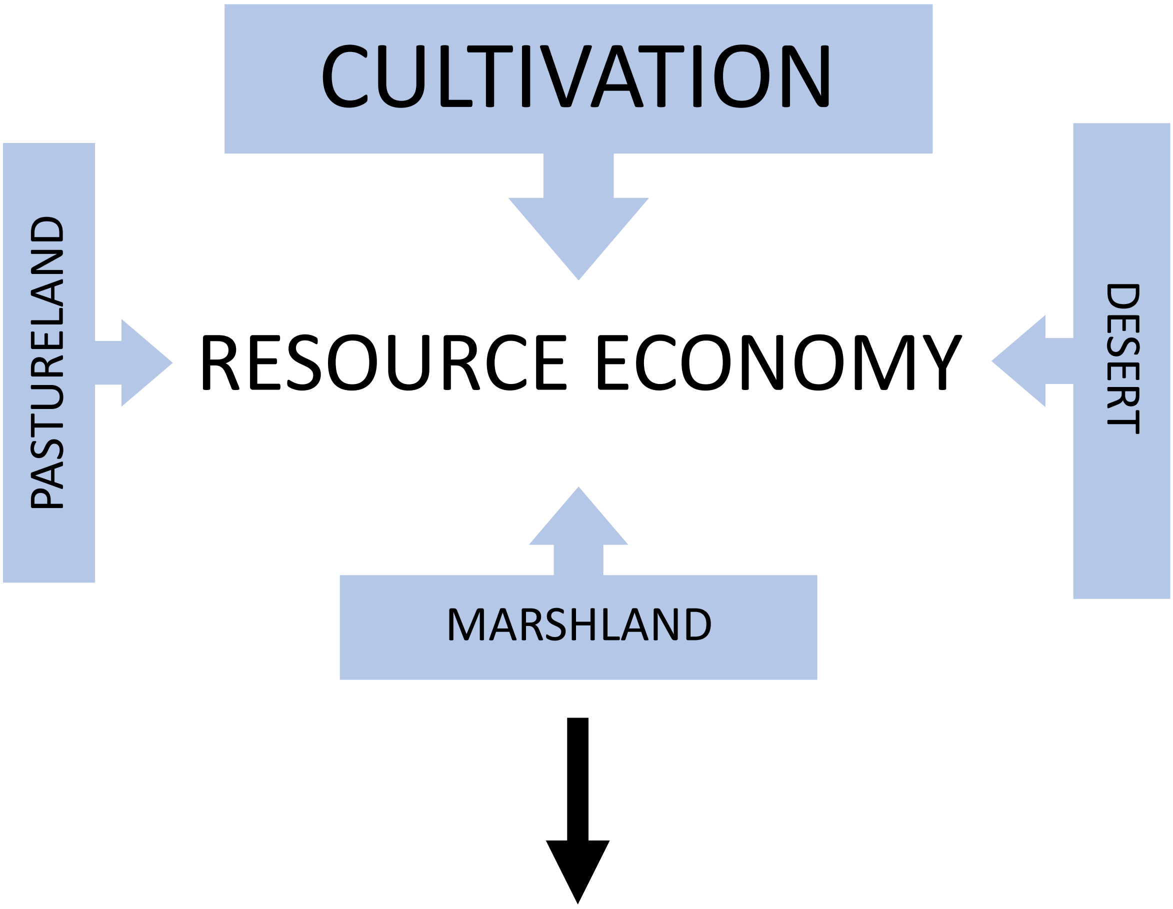
It has already been noted that the period under investigation witnessed a significant increase in the abundance of tomb scenes displaying representations of fishing and its associated techniques and technologies. This suggests that the river came into greater focus in the Egyptians' acquisition and exploitation of food resources, as has been suggested by the A.R.I.D. hypothesis. Many of these activities took place in areas that, with regard to agricultural purposes, Morenó García labels as "marginal".[1445] These activities, based on living in the marshes and behaving as pastoralists herding goats instead of cattle, and perhaps swine, could more readily have supported alternative, more independent lifestyles, a likely response to an increasingly unreliable river. This appears to have had already occurred in the Levant, where some populations appeared to have decided to 'absent themselves' from the cycle of cultivation and its political responsibilities.[1446] In some areas, such as the delta and along the desert margins, the collapse of central authority and its associated redistribution system, stimulated a return to more mobile lifestyles, based on the exploitation of a greater variety of resources that were more readily available in a local context.[1447]

Resources Change in Response to a Changing Environment

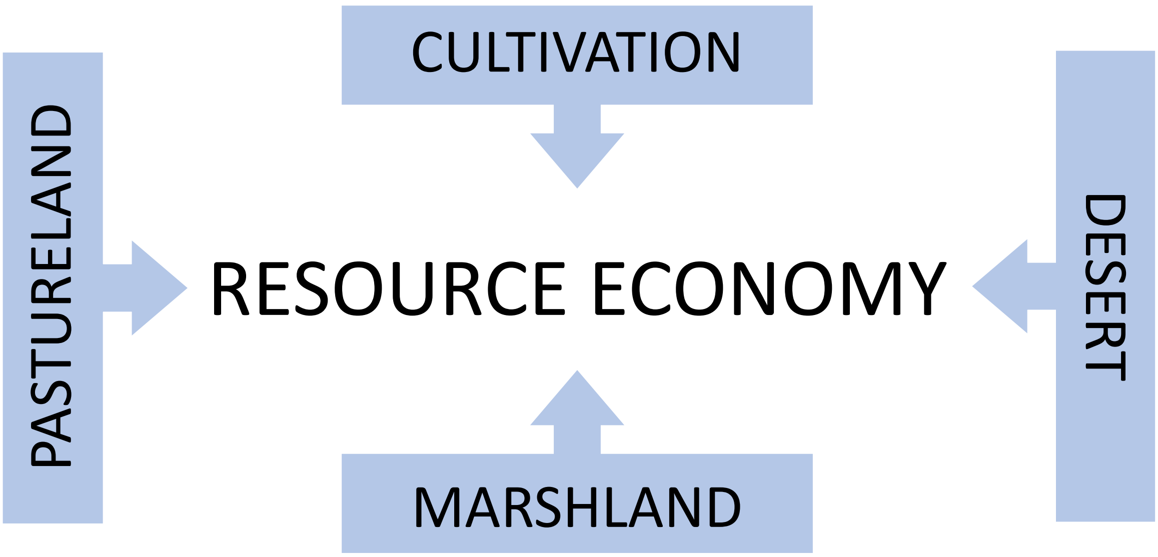
The economy of the Old Kingdom was a delicate balance between those resources obtained from cultivation, cattle, the river and the desert.[1448] As a consequence of regular flooding, cultivation was the primary resource base, with a successful agricultural outcome and its attendant surplus reliant on an inundation large enough to provide a wide fertile floodplain. This state of equilibrium was not static but existed in a constant state of flux, which passively adjusted itself according to circumstance. In the normal situation, resources were accessed from the river, its edges, and the desert, but primarily from the results of cultivation. If the river did not break its banks, then the overall yield from cultivation would have declined. Since the river had become more unreliable, then it may have become necessary to look for other food resources to supplement the regular diet.

1445 Morenó García, *Trade & Power*, 93.
1446 Greenberg, *No Collapse: Transmutation*, 48–50.
1447 Morenó García, *Limits of Pharaonic Administration*, 88–101.
1448 Herb & Forster, *Desert to Town*, 19; Linseele & Zerboni, *Done with Fish,* 235.

Normal Situation – Annual Inundation



A.R.I.D. Times



In times of a river in drought, the ability for cultivation to remain the major source of resources was hampered by the lack of inundation: consequently, the other sources of nutrition became relatively more important. Transformations to the tomb decoration programmes may have been representations expressing an illustrative narrative of this change.

Dietary Changes in A.R.I.D. times: Fish, Fowl and Cattle.

As a regular agricultural surplus became less assured, it is possible that the flourishing marshland ecotone provided extra or different food resources.[1449] In northern Sudan, evidence suggests that, in times of ecological stress, at about the same time Egypt was experiencing an increase in aridity, fishing strategies had been adapted to cope with the circumstances of a changing environment.[1450]

In Chapter Seven, a similar change was predicted for ancient Egypt, as the local populations had to adapt to changing ecological conditions. Fish bone concentrations have been shown to change in archaeological sites in parallel response to changing water levels.[1451] A rapid increase in depictions of catfish during the time frame under investigation has already been noted in Chapter Seven. The increasing proportion of catfish bones in some of the excavations from Abusir indicate a changing dietary balance, as fish more suited to brackish situations became more common.[1452]

A similar rapid increase in the abundance of scenes depicting the gathering and presentation of waterfowl has been identified in this study and commented upon in Chapter Eight, and has been noted in some excavation reports.[1453] The rapid increase in abundance of attestations of cattle during the time frame of this investigation, as discussed in Chapter Nine, likewise suggests that these animals had become relatively more important to the culture.

1449 Maltby & Acreman, *Ecosystem Services*, 1341–1359.
1450 Linseele & Zerboni, *Done with Fish,* 237–238.
1451 Willems et al., *Wadi Zabayda*, 318; Linseele & Zerboni, *Done with Fish,* 237–238.
1452 Dulíková, *Ankhires at Abusir*, 27, 30; Willems et al., *Wadi Zabayda*, 318, 325.
1453 See, for example, Vymazalová & Arias Kytnarova, *Sheretnebty*, 441.

The Persistence of the Hippopotamus Hunt

The depiction of the hippopotamus hunt continued through the Old Kingdom from the time of Menkaura (IV.5) to beyond the time of Pepi II.[1454] Although the quality of the artwork and the precision of the presentation of the depictions deteriorated over time, the desire to represent this activity continued. Originally symbolic of the power of the king over the forces of chaos,[1455] depictions of the hunt continued, but with little suggestions of the royal ritual which earlier depictions evoke. Interestingly, royal images display the king actively slaying the river monster, yet in the great majority of tomb decorations depicting hippopotamus hunting scenes, the activities are performed not by an elite personage,[1456] but by minor figures tasked with protecting the noble. Of the major (non-royal) players depicting themselves as hippopotamus hunters, Khentika and Medou-nefer at Balat[1457] are shown in their Sixth Dynasty tombs in the Dahklah Oasis. They may have been far enough away not to have earned the ire of the King for assuming the royal prerogative as the killer of a hippopotamus, while Ptahhotep at El-Mahasna[1458] (Dynasty Eight) may be just outside the date range for this investigation. Comparison with other tombs constructed during the time of Pepi II, the quality of the tombs prepared for the governors indicate the increased wealth flowing to the Oasis at this time,[1459] and may also indicate a declining range of royal influence.

It is possible to relate the persistence of the hippopotamus hunt to the A.R.I.D. hypothesis presented in this study. The ancient Egyptians prized the ivory teeth of the hippopotamus, which also provided meat, fat and skin,[1460] so the continued hunting made nutritional sense. As a voracious, herbivorous, aquatic animal, the hippopotamus would have benefited from the thriving plant growth that resulted from the nutrient bloom in a shrinking Nile. Cattle

---

1454 However, Harpur, *Decoration*, 181, contends the provenance of the scene from the tomb of Debehen at Giza, see Hassan, *Gîza* IV, 175, fig. 121. The scene is found in Pepi II's time in the (D6) tomb of Hemre/Isi at Deir el-Gebrawi: Davies, *Deir el-Gebrâwi* II, pl. 20, updated in Kanawati, *Deir el-Gebrawi* I, pl. 64. For an extensive list, see Woods, *Marshes*, 2, table E: feature #66.

1455 Evans, *Animal Behaviour*, 15; Säve-Soderbergh, *Hippopotamus Hunting*, 15–19, 52–56; Hendrickx, *Hunting & Social Complexity,* 249–250.

1456 Woods, *Marshes* 2, 87–91, table A; Hamed, *Artistic Perspectives,* 11–12.

1457 Castel et al., *Khentika*, fig. 86 and Valloggia, *Medou-nefer*, pl. 41, respectively.

1458 Decker & Herb, *Bildatlas* I, pl. 199. For dating ranges, see Woods, *Marshes* 2, 67. Note that at Beni Hassan, the tomb of Khety depicts an active hippopotamus hunt. Interestingly, this tomb also depicts pigs, suggesting that these animals had now graduated to being deemed as suitable eternal companions for the tomb owners.

1459 Morris, *Art of Not Collapsing*, 78.

1460 Stünkel, *Hippopotami,* http://www.metmuseum.org/toah/hd/hipi/hd_hipi.htm (June 10, 2018).

would have taken advantage of the trails bulldozed through the marshes by the hippopotamus to reach the most succulent parts of the plant. Interestingly, hippopotamus grazing appears to enhance the variety of the riverine vegetation which make the area more attractive to other herbivores.[1461] This would have taken the hippopotamus into direct competition with the increased herds of cattle that were also thriving on a burgeoning plant growth.[1462] In areas that are also exploited by hippopotamus cattle eat more of the available food before moving on: this leaves behind areas of stripped vegetation, typically less suitable for hippopotamus foraging.[1463]

With an increase in the number of secondary channels, incidences of contact between highly territorial hippopotamus[1464] and cattle and their human handlers would have risen. The need for the Egyptians to protect cattle (and themselves)[1465] from these competitors would have intensified, indicated by a number of tomb scenes depicting the hippopotamus hunt adjacent to cattle crossing scenes.[1466] In the tomb of Hemre/Isi at Deir el-Gebrawi, for example, cattle are being protected in their crossing channel.[1467]

Scenes also place the hunt adjacent to other swampland activities, such as spearfishing[1468] or fowling,[1469] or even a pleasure cruise.[1470] All of these activities would have disturbed the hippopotamus in their natural habitat. The tomb of Shepsipumin/Kheni at el-Hawawish depicts the hunting scene on the same wall as other marsh activities, this time with dragnet haulers being protected by the hunters,[1471] In the tomb of Hemre/Isi at Deir el-Gebrawi,

---

1461 Kanga, et al, Landscape Ecol Eng (2013) 9: 47. https://doi.org/10.1007/s11355-011-0175-y (May 13, 2019), summarising the beneficial impact of hippo grazing in modern Africa.

1462 Hendrickx, *Hunting & Social Complexity*, 249; Muller, *Feindvernichtungsrituals*, 488.

1463 Perry, L. R., *Observations of Hippopotamus H. amphibius in the Little Scarcies River of Sierra Leone and Arguments for their conservation based on roles they play in riverine grasslands and nutrient loading*, 58, describes the basic grazing competition that exists between the two in modern Africa. https://digitalcommons.mtu.edu/etdr/41 (May 13, 2019).

1464 Karstad & Hudson, *Riverine Hippopotami*, 154, 157–162; Dudley, et al., *Hippopotamus Carnivory*, 192, 196; Stommel et al., *Hippopotamus Vulnerability*, 2.

1465 Evans, *Animal Behaviour*, 134.

1466 For example, Kaimnefret, in Hassan, *Giza* II, fig. 140; Schürmann, *Ii-nefret*, pl. 21; Ihy, in Kanawati, *Unis* II, pl. 54; Nimaetre, in Hassan, *Giza* II, fig. 236; Pepyankh the Black, in Kanawati & Evans, *Meir* II, pl. 90.

1467 Davies, *Deir el Gebrâwi* II, pl. 20, updated in Kanawati, *Deir el-Gebrawi* I, pl. 64.

1468 For example, Ankhmahor, in Kanawati & Hassan, *Ankhmahor*, pl. 37c; Duell, *Mereruka* I, pls. 9–13.

1469 For example, Schürmann, *Ii-nefret*, pls. 6, 21; Irukaptah, in McFarlane, *Unis* I, pls. 41, 46; Iteti, in Kanawati & McFarlane, *Deshasha*, pl. 48.

1470 For example, Wild, *Ti* II, pl. 119; Senedjemib Inti, in Brovarski, *Senedjemib* II, fig. 42. For a summary, see Woods, *Marshes* I, 216–224; table 9.1; II, pl. 103–116.

1471 Kanawati, *El-Hawawish* II, fig. 22.

cattle are being protected in their crossing channel.[1472] At Meir in the tomb of Pepyankh the Black, the hippopotamus hunt scene is adjacent to clapnetting, seine net hauling, cattle crossing and other swampland activities.[1473] On the northern wall of room 6 in the tomb of Ty at Saqqara, the papyrus stalks are well-organised, but the top half of the thicket is wild with scenes of birds in various states of agitation and travelling in many different directions, presenting a chaotic image quite appropriate since in this section, the tomb owner is supervising a hippopotamus hunt.

The other large animal that shared the river with the humans and hippopotami was the crocodile. The increased movement of cattle across the small fords and secondary channels must have captured the interest of the crocodiles.[1474] As the river shrank, the interactions between crocodiles and hippos must have become more noticeable and, coincidently or not, they entered the tomb decoration programme during the time frame under investigation.[1475] Woods, updating Harpur, suggests that the scene of crocodile and hippopotamus fighting enters the repertoire at the same time as the river appears to become a more integral part of the resource cycle.[1476] No hippopotamus hunt scene remains in the tomb of Pepyankh the Middle, but a crocodile is shown in its death throes in the jaws of a hippopotamus.[1477] The increasing quantity and variety of these hippopotamus/crocodile representations suggest that this aspect of riverine activity was an important factor in influencing the design of the tomb decorations at this time.

Back to the Past: Return to a Semi-Subsistence Existence?

With the new food arrangements, the economy appears to have become became more localised. If so, how did this more independent and semi-subsistence economy play out into larger Egyptian society at the time? New food resources would have been sought. The food sources that replaced grain would have been less storable for re-distribution, and subsequent re-distribution, so local redundancies may have developed.

1472 Davies, *Deir el Gebrâwi* II, pl. 20, updated in Kanawati, *Deir el-Gebrawi* I, pl. 64.
1473 Kanawati & Evans, *Meir* II, 48–52, pl. 90.
1474 Evans, *Animal Behaviour*, 127.
1475 Evans, *Animal Behaviour,* 14; Harpur, *Decoration*, 258, dates its introduction to the latter part of the Fifth Dynasty.
1476 Woods, *Marshes* 2, table E, feature #177, adding to those identified in Harpur, *Decoration*, 366–367. For discussion on those scenes, see Evans, *Animal Behaviour,* 144–145.
1477 Kanawati, *Meir* I, pls. 79–80.

While all this change may have been stressful for most people at the time, it may also have provided a bounty of socio-economic opportunities and greater health, at least for some localised populations. In a manner similar to earlier societies,[1478] and in association with selective herding practices, some new hunting/gathering/foraging activities were adopted in order to utilise the extra produce arising from the newly bountiful 'drought'-ridden riverine habitats.[1479] A partial return to a semi-sedentary way of life, or adoption of a "*periodic nomadism*"[1480] may have occurred in response to a slight decline in cultivation success.[1481] In a manner to the survival subsistence practices adopted by of the Mesopotamian marshland dwellers when mainstream agriculture collapsed,[1482] low intensity cultivation with many and varied resources would have made the acquisition of adequate subsistence sustenance more readily achievable.

1478 Brass, *Cattle Cult Origins*, 102.
1479 Bard, *Archaeology of Ancient Egypt*, 83–84;
1480 Brewer et al., *Domestic Plants & Animals*. 99.
1481 A similar process, perhaps, to that outlined in Daoud et al., *Adaptation & Resilience*, 209–250.
1482 http://www.clw.csiro.au/publications/consultancy/2004/Mesopotamian-marshlands-soil.pdf. (May 18th, 2019)

11.5 – TRADE, WARFARE AND FOREIGN RELATIONS

Sowada suggests that the pottery assemblages she investigated indicate that the Egypto-Levantine trade had begun to diminish during the Fourth Dynasty and was virtually non-existent by the end of the Fifth Dynasty.[1483] Since there appears to have been very little Egyptian trade with the Levant by the end of the Fifth Dynasty,[1484] it suggests that the Levantine territory had already begun to experience a decline in regional cohesion and an increasing fragmentation.[1485] As such, luxury or exotic items from Egypt were no longer needed or could no longer be afforded,[1486] or were no longer accessible. More inward-looking societies may have been less willing to receive trade envoys, they may have been less able to receive them with the same finesse and efficiency as previously, they may have been unable or reluctant to exchange luxury goods and may have had less surplus available for trade. Was it possible that the environmental challenges faced in the Levant were similar to those experienced in Egypt, and a non-sedentary mode of living was becoming more attractive with increasing power in the hands of the pastoralists?[1487] If this was the case, then it is unlikely that an excess of supplies or stores would have been available for trade with Egypt.[1488]

While ocean-going boats are attested from the reign of Sahura, fewer are attested in later periods of the Old Kingdom,[1489] perhaps suggesting less sea-borne expeditions, thereby becoming less conspicuous as subjects for tomb scenes. As anticipated by the hypothesis, a weaker river would have resulted in fewer navigable sections of the river, especially within the delta and outwards to the sea, decreasing the ability of deep-hulled vessels to negotiate an increasingly shallow and more plant-cluttered river, making these objects less common and therefore, less prominent.

1483 Sowada, *OK Eastern Mediterranean*, 11–12; Andrassey, *Ägyptens zu Vorderasien*, 130–132; Mazar, *Land of the Bible*, 141–142.
1484 de Miroschedji, *Egyptian-Canaanite Interactions*, 43–48; Mourad, *OK Siege Scenes*, 149; Sowada, *OK Eastern Mediterranean*, 251–253.
1485 Greenberg, *No Collapse, Transmutation*, 50.
1486 de Miroschedji, *Egyptian-Canaanite Interactions*, 47–48.
1487 Greenberg, *No Collapse, Transmutation*, 48–49.
1488 Kohl, *Archaeology of Trade*, 47.
1489 Bader, *Egypt & the Mediterranean*, 8. Note, however, the special relationship to Byblos; see Espinel, *OK Egypt & Byblos*, 103–119.

Fall of the Cities in the Levant

The destruction layers excavated in many Levantine cities suggest regional unrest.[1490] Höflmayer suggests that the fall of the first city-states of the Levant happened about 2300 BCE,[1491] which may be earlier than the dates suggested for the climatic events that may have brought about the decline of the Old Kingdom. In Part A, it was mentioned that the areas northeast of Egypt experienced a collapse of organised society at almost the same time as the Levant's southern neighbours.[1492] It is difficult to accept the proposition that Egyptian military activity, prompted literally by hunger, was involved directly in the fall of the first cities in the Levant, although Egyptian forces' increased activity in the latter half of the Old Kingdom, from the reign of Niuserra, including a most likely campaign by Djedkara,[1493] may well have helped speed up the decline.

Trade or Conquest?

This is a widely discussed issue in relation to Egypt and Levantine interactions.[1494] The way out of Egypt, known in the New kingdom as the 'Way of Horus' followed pathways known from much earlier ways.[1495] Porous borders, arising out of a diminished royal power, would have enabled mobile populations and traders to act in a more enterprising manner.[1496] It may be that Egypt was no longer the dominant power in the Nile Valley with Nubian Chiefs and Caravan leaders becoming more locally preeminent.[1497] Perhaps the reason for the decline of the Abu Ballas Trail at the end of the Sixth Dynasty suggests that this area had become difficult to police, with its re-establishment occurring in the early Middle Kingdom.[1498] More and more trade was being taken out of government control and usurped by adventurous individuals, and these actions may have encouraged the kings as attempts to minimise the increasing acquisition by individual Egyptians of more direct control over these areas of trade.[1499] Those individuals from Elephantine who dealt with the Nubians also appear to

---

1490 Mourad, *Siege Scenes*, 149, summarising Bronze Age destruction in the region.
1491 Höflmayer, *Dating Catastrophes*, 118–125.
1492 Höflmayer, *Dating Catastrophes*, 132.
1493 Mourad, *OK Siege Scenes*, 149; Anđelković, *Hegemony for Beginners,* 789–808.
1494 Czarnowicz, et al., *Trade or Conquest*? 113; 122.Jirásková, *Egypt & Syria-Palestine*, 539–568.
1495 Förster, *Abu Ballas Trail*, 3, fig. 7; Hoffmeier & Moshier, *Highway out of Egypt*, 485–486; Stewart et al, *Tracing Ancient Tracks*, 197–221.
1496 Moreno García, *Trade & Power*, 93.
1497 Morris, *Art of Not Collapsing*, 78–79; Snape, *Of Life and Death*, 111.
1498 Förster, *Abu Ballas Trail*, 9.
1499 Anđelković, *Hegemony for Beginners*, 789–808.

have dealt with Punt.[1500] Harkhuf, for example, mentions several caravans led by land and river to Nubia, the inscription of Khnumhotep in the tomb of Khui of Elephantine also suggests visits to Byblos and Punt; while another official from Elephantine, Ankhti, was killed by Asiatics, which indicates a location somewhere in the Eastern Delta, with Morenó García suggesting Ayn Sukhna.[1501] The destruction at Mendes dated to the end of the Old Kingdom,[1502] may be an indication of attacks from foreign powers ("…*the east abounds with bowmen*…")[1503] or may be indications of the need for a violent re-affirmation of direct control by the central government.[1504] A number of the injuries observed could have been caused by the attempted warding off of blows,[1505] suggesting a violent end for the individual.

With the reduction in centralised authority in the region, it is more likely that the resources that were available would have been less well protected and, consequently, more vulnerable.[1506] As one society deteriorated, others seem to take advantage of that situation. In the "*dawn of internationalism,*"[1507] perhaps as a part of the attempted consolidation of power, a more aggressive policy was adopted towards neighbouring states.[1508] In attempting to invigorate the culture from within, perhaps an attempt was made to identify a threat from without. Similar to the Early Dynastic government's aggressive stance towards Nubia[1509] and the Delta regions during that period,[1510] it is possible that an offensive strategy may have been adopted by the rulers at the latter stages of the Old Kingdom. It may be that Egyptian forces moved into the southern areas of the Levant to take advantage of the climate-induced disorder that was developing at this time, perhaps mimicking strategies that were applied further south.[1511]

1500 Müller-Wollermann, *End of the Old Kingdom*, 4; Moreno García, *Trade & Power*, 96–97.
1501 Moreno García, *Trade & Power*, 93.
1502 Adams, *Mendes Stratification,* 90–94.
1503 Lichtheim, *Literature I*, 103–104; Jansen-Winkeln, *Alten Reiches Untergangun*, 302–303; see also commentary from Förster, *Abu Ballas Trail*, 6–7.
1504 Snape*, Of Life and Death*, 113–114; Adams, *Mendes Stratification*, 91–92.
1505 Mant, *Mendes Palaeopathology*, 11–14.
1506 Greenberg, *No Collapse, Transmutation*, 36; Mumford, *Tell Ras Budran*, 43–46; Hoffman & Cohen, *Chronological Conundrums*, 3.
1507 Hoofman & Cohen, *Chronological Conundrums*, 4.
1508 Seidlmayer, *OK Elephantine*, 112–114.
1509 See Bietak, *Nubia in Review*, 385–391.
1510 Mortensen, *Settlement Pattern Change*, 29.
1511 Smith*, Egyptian Imperialism*, 77–102.

The title 'Overseer of Troops', is noted as occurring with increased frequency at this time.[1512] As Egyptian government control became more direct, tomb decorations began to include military themes,[1513] starting from the mid-Fifth Dynasty, in some tombs of Inti,[1514] at Deshasha, and Kaiemheset,[1515] at Saqqara, with depictions of cities being besieged with the opponents are identified as Asiatics.[1516] It appears that these two individuals were involved in and were commemorating the same campaign,[1517] which Sowada has suggested was one directed by Niuserra against populations to the northeast of the delta.[1518]

Perhaps this behaviour indicates a dynamic similar to that played out by those earlier rulers with the military escalades against the north east undertaken by Weni from Abydos[1519], in the time of Pepy I, designed to take advantage of the ongoing disruption. Whether the opponents were city-states or smaller entities recovering from previous disorders is unclear. The many campaigns of Harkhuf and Pepynacht-Heqaib, from Aswan,[1520] for example, may have been protracted campaigns against a few opponents or examples of numerous minor campaigns against a number of smaller disparate entities?

This Levantine disorder is unlikely to have arisen as a consequence of Egyptian foreign policy, for it followed a time when many cities in the region had completed a period of fortification.[1521] It is important to consider the timing of the emergence of siege scenes within elite tombs, and what they represent.[1522] Perhaps the siege scenes depicted in the tombs of Inti and Kaiemheset are of a forcible collection of 'tribute' that was no longer a regular part of the relationship between the two regions.

1512 Moreno Garcia, *Sociopolitical Transformation*, 5.

1513 See Mourad, *OK Siege Scenes*, 135, for an identification of likely representations of military activity during this era.

1514 Strudwick, *OK Administration*, 150–151, Kanawati et al., *Saqqara* I, 7–8; Kanawati & McFarlane, *Deshasha,* 19. McFarlane's dating of Niuserra/Djedkare, see *Mastabas at Saqqara*, 19–23, seems the most accurate, according to Mourad, *OK Siege Scenes*, 135

1515 McFarlane, *Mastabas at Saqqara*, 15. See also El-Khadragy, *Soldiers Tomb*, 147–149 and Fischer, *Army Scribe*, 233–272.

1516 Mourad, *OK Siege Scenes*, 135–144.

1517 Mourad, *OK Siege Scenes*, 145.

1518 Sowada, *Egyptian Levantine Synchronisation*, 55–56.

1519 Strudwick, *Texts*, 354–357; Richards, *Weni,* 75–102.

1520 Strudwick, *Texts*, 328–335.

1521 Mourad, *OK Siege Scenes*, 149; Callaway, *Et-Tell*, 292–293. See also di Miroschedji, *Unis' Asiatic Campaign*, 273.

1522 Mourad, *OK Siege Scenes*, 148–149.

The changing military architecture may suggest that fortifications became more necessary as urban populations built to protect themselves from worsening socio-political conditions.[1523] The walls of these urban centres experiencing attack appear to be represented differently, with that depicted in the tomb of Kaiemheset, dating to the time of Niuserra, appearing a more primitive design than that depicted in the tomb of Inti, dated to the reign of Djedkara.[1524] The latter scenes depict more substantial walls, more suitable to withstand a determined enemy: these are artistic representations, and their military effectiveness have been commented upon by Mourad and de Miroschedji as more substantial than those of the earlier depictions.[1525] This may indicate an increasing effectiveness in defensive capabilities of small urban areas. Perhaps the difference in the military architecture represents one group of Asiatics had occupied an Egyptian fortified settlement and was in the process of being expelled. In order to distinguish between the context of the representations, these differences deserve a more detailed investigation by experts in the military architecture of the time.

It is important to remember that armour was quite rudimentary at the time, with the technological advancements of Middle Kingdom military equipment a little way off, so simple arrows would have made quite effective weapons,[1526] as the primary tactics for most of these societies was archery.[1527] Even by the Middle Kingdom, armoured individuals were very scarce, and the weapons relied on were mostly effective against un-armoured opponents.[1528] While the decorations in the tomb of Khunes at Zawyet el-Maiyetin display the making of bows and arrows,[1529] the most significant weapon for the Egyptian military at this time,[1530] those decorations adjacent are related to the acquisition of food and resources, so could presumably be representing their use in hunting.

1523 See Burke, *Evolution of Warfare*, 64–65; Sowada, *OK Eastern Mediterranean*, 12; de Miroschedji, *Yarmuth*, 6–7.

1524 Kanawati & McFarlane, *Deshasha*, 17–19.

1525 For detailed analysis of the different types of military architecture represented in those tombs, see, Mourad, *OK Siege Scenes* and de Miroschedji, *Uni's Asiatic Campaigns.*

1526 Faulkner, *Military Organization,* 32–47. For commentary on the relative overall (in)effectiveness of Egyptian archery equipment see Miller et al., *Ancient Near Eastern Archery*, 179, fig. 1.

1527 Miller et al., *Ancient Near Eastern Archery*, 180–187. For commentary, see Moreno Garcia, *OK Warfare*, 6–7, pointing out the irregular nature of warfare at this time.

1528 Dean, *Dynastic Warfare*, 19–23, 63–72; Fields et al., *Pharaoh's Soldiers,* 13–21; Moreno Garcia, *War in the Old Kingdom*, 31–35.

1529 Lepsius, *Denkmäler*, B.IV, Bl.II, Abl. 108.

1530 See the rudimentary finds described in El-Khadragy, *Asyut Soldier's Tomb*, 147–164. See also Partridge, *Fighting Pharaohs*, 21–28, despite their relatively poor effectiveness – see Miller et al., *Ancient Archery,* 181.

Foreign Relationships in A.R.I.D. Times

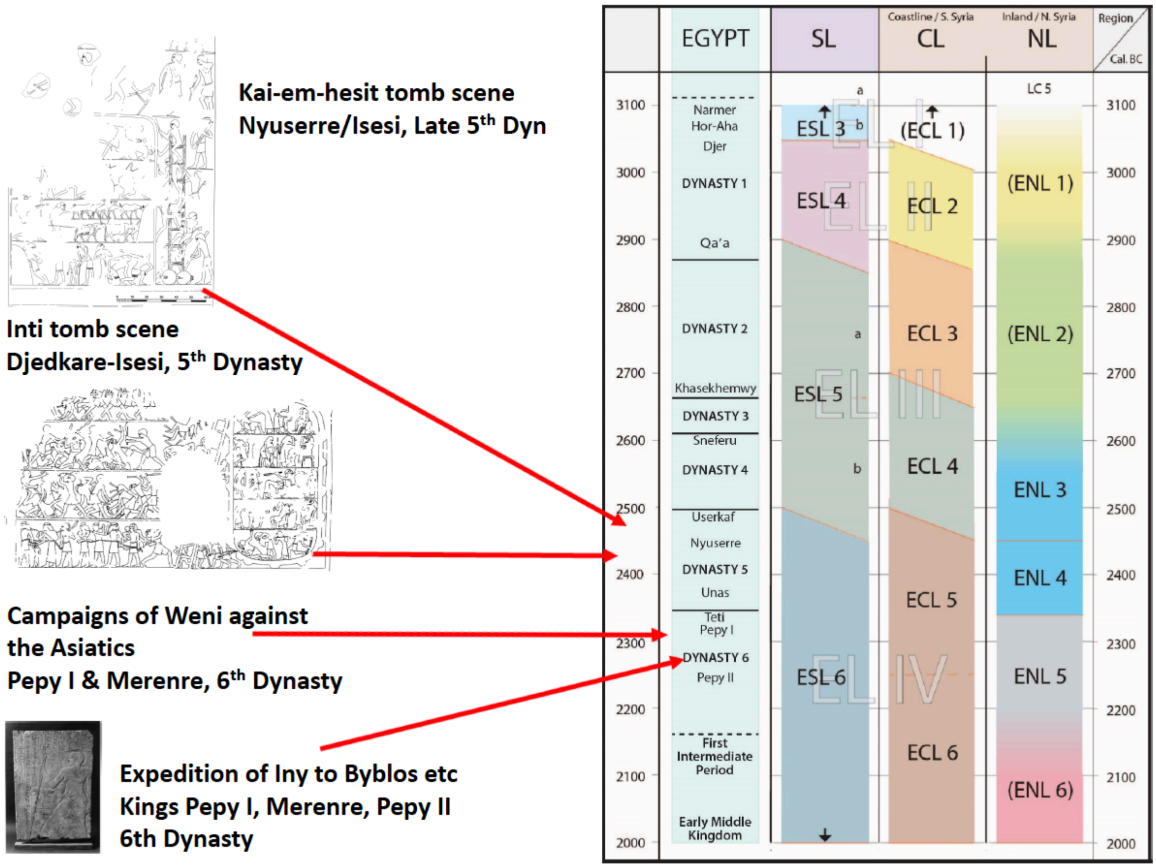
While the central government may have been losing control over the peripheries,[1531] beyond the eastern Delta, the oases and into the Sudan, the Delta itself was controlled differently to the rest of the country, being managed directly from the capital.[1532] As a result of declining trade, by sponsoring their own expeditions to acquire resources directly, the kings may have been attempting to balance the decline in Egypt's own tax revenues brought about by diminishing yields from the centres of agriculture.[1533] Was this a drawn-out campaign or one that developed spontaneously to take advantage of weakening control within the city states of the southern Levant? A lack of evidence of this occurring in the latter stages may suggest that their attempts at minimising the influence that powerful individuals may have been building were unsuccessful.

[1531] Morris, *Art of Not Collapsing*, 78–79; Snape, *Of Life and Death*, 111.
[1532] Müller-Wollermann, *End of the Old Kingdom*, 4; Moreno García, *Trade & Power*, 96–97.
[1533] Redford, *OK Egypt & Western Asia*, table 1; Sowada, *OK Eastern Mediterranean*, 251–253.

11.6 – Chronological Re-Appraisals?

Refinements of the dating of contiguous civilisations has led to modifications of their chronologies. The work published by ARCANE (Associated Regional Chronologies for the Ancient Near East and the Eastern Mediterranean)[1534] may indicate that a slightly different chronology for ancient Egypt is more likely[1535] (see Figure 57: Egypt and the southern Levant in the Early Bronze Age: latest dating correlation).

Figure 57: Egypt and the southern Levant in the Early Bronze Age: latest dating correlation.



Sowada, K, Perspectives on Egypt in the Southern Levant in Light of the High Early Bronze Age Chronology.' (Used, with permission, article currently in press).

The table represents a recent effort to consolidate current chronological understanding into a more reliable correlation in order to better understand the international inter-relationships within the region at this time. Currently, it is believed that the urban areas of the southern Levant had already begun to decline BEFORE experiencing those Egyptian campaigns that

[1534] http://www.arcane.uni-tuebingen.de/index.html
[1535] Sowada, *Egyptian Levantine Synchronisation*, 55–56, fig. 1.

were directed against them. These areas were hit by the same 'drought' as Egypt but did not have the luxury of extra resources from a river fecund with nutrients and blooming with resources. This means that the very many military interventions of Weni and Iny in the Sixth Dynasty against the southern Levant may not have been directed against a few powerful city-states requiring extended campaigns, but against a multiplicity of numerous smaller states, states already weakened, perhaps by those campaigns memorialised by Kaiemheset and Inti, or perhaps undermined by the environmental deterioration described earlier.

Changes to the Tomb Decoration Programme

Earlier in this study, the reign of Pepy I was identified as the most likely era for the impact of the '4200BP event' (referring to the climate change event that began approximately 4,200 [Years] Before [the] Present). Very few artistic changes have been attributed to this era, most of the significant changes to themes of tomb decoration appear to have occurred during the second half of the Fifth Dynasty. The major changes appear to be related to themes whose focus was upon food and marshland-based resources. The variances in the distribution and abundance of tomb decorations in the early reign of Pepy I suggest only minor cultural shift compared to those changes in the tomb decoration programme observed from the reign of Niuserra onwards. With the new suggested dates for the region, the likelihood of the reign of Niuserra more closely coinciding with the onset of the 4200BP climate event increases. Judging by the numerous variations in the tomb decoration programme, the reign of Niuserra appears more likely to be the one where a potential threat to the stability of the society was identified. Scholarly commentary suggests that Niuserra was a vigorous and pro-active ruler whose many administrative reforms[1536] may be seen in the new light of responding to the changing environmental situation that was developing. Perhaps these different environmental conditions had begun to have a minor impact upon the society, and this concern began to be represented within the visual culture.

[1536] Panovnika, *Nyuserre Transformation*, 56; Bárta, *Punctuated Equilibrium*, 8–11.

SUMMATION: CHAPTER ELEVEN

Re-adjusting for a new 'Normality'?

The major points raised in this chapter include:

- ⇒ Administrative reforms suggest a pro-active response to a perceived environmental concern.
- ⇒ Necropolises whose use had ceased before the Sixth Dynasty display 'old-fashioned' tomb decoration programmes with few of the 'new' decoration themes.
- ⇒ Osiris, and his association with the river and the marshlands, appears to have become a more significant figure in the pantheon of the gods.
- ⇒ A wider range or resources appear to have been exploited at the end of the Old Kingdom and into the First Intermediate Period.
- ⇒ Egypt's foreign inter-relationships display an inconsistent approach, perhaps as a result of less reliable environmental circumstances, indicating shifting power vacuums.

The relative consistency of the themes displayed in the tomb decoration programme from the time of Niuserra to the end of the Old Kingdom suggests, perhaps, that a new paradigm of cultural depiction had been reached. While cultivation was still important, other activities were necessary to provide the shortfall that developed as a result of an unreliable water supply. The presence of the river, despite the land being in drought, meant that an adaptiveness within of the population enabled a societal response more flexible than previously expected. Despite the apparent development of discontinuity within the country, the intrinsic resilience of the society meant that the culture continued, though perhaps in a form less recognisable.[1537]

[1537] Butzer, *Organisms or Systems*? 8.

Chapter Twelve

The A.R.I.D. Project

Extending the Investigation

12.0 – Introduction

As the river's behaviour became less consistent and the inundation less reliable, this would have caused disruptions to its 'natural' environment, with certain flow-on consequences to be expected. The A.R.I.D. hypothesis proposed has a solid scientific base, and some supporting evidence from tomb decorations produced during the timeframe under investigation has been provided.

In this chapter, additional areas for consideration will be identified. These tangents vary across many disciplines requiring a wide variety of expertise. Despite including many tempting digressions, most were beyond the purview of this analysis and if followed would have led to this presentation never being finished. To have the technology to identify changed patterns of health in ancient populations would contribute a significant advance for the field of social history and would enable historians to further understand ancient social changes. This investigation would follow the concept and techniques that comprise the A.R.I.D. project.

12.1 – Middle Kingdom Tomb Decoration Programmes

Succession studies can be traced from a source of disruption, in both time AND distance, and this approach has been applied to tomb scenes produced over the time frame of this investigation. The potential exists for this sort of succession to be further studied beyond the timeframe of this investigation, which ends with the onset of the First Intermediate Period. The further from the time of environmental dislocation, the more likely it would be that the ecological conditions had returned to equilibrium, that is, the inundation levels should have become more regularised, land would have once again been fertile with grain surpluses occurring more regularly. As the river returned to a less erratic flow, with the annual cycle returning to one more recognisable, perhaps artistic expressions of the culture returned to styles and forms more conventional, traditional decorations more in line with those scenes produced during the Fourth and early Fifth dynasties. If this was the case, then the further away from the time of disruption, the more likely it would be to recognise a more 'conventional' pattern of tomb decoration, with the decorations produced after this time returning to a more orthodox repertoire (is this perhaps a potential origin of 'archaising'?). Good candidates for this sort of examination are those sites with burials dated from the second half of the Old Kingdom into the early Middle Kingdom. While some of these sites have been comprehensively excavated over the last one hundred years, ongoing and more sophisticated re-investigations are being undertaken, as though a new 'lens' was being applied.

Art Succession and A River In Drought

The unusual artwork produced at places like Beni Hassan has been interpreted in a socio-cultural context with regard to the increasing contact with Asiatics and their introduction into the tomb decoration repertoire.[1538] First recorded by Newberry in the late nineteenth century,[1539] re-assessment of these unique images at the necropolis of Beni Hassan was presented in 2010 as an art-based investigation into society and culture in a provincial centre.[1540]

1538 Cohen, *Uses & Abuses,* 19–20.
1539 Newberry, *Beni Hasan* I and II; Griffith, *Beni Hasan* III and Carter et al., *Beni Hasan* IV.
1540 Kanawati & Woods, *Beni Hassan Art*.

A new project, currently underway by Macquarie University, Australia, has the long-term goal of publishing all of the decorated tombs at the site.[1541] Eventually, this updated artistic analysis will enable a clearer light to be shed on the social history of this period.[1542] With the benefit of improved technology, enhanced photography techniques and more accurate dating criteria, the production of a more reliable timeline is imminent.[1543]

The necropolis of Meir was extensively surveyed by Blackman and Apted[1544] and has now undergone a re-evaluation under the auspices of Macquarie University.[1545] Tombs date from the latter half of the Old Kingdom onwards and follow an extended family over generations into the 12th Dynasty, from Ni'ankh-Pepy-kem (Pepi I), to Pepy-ankh Heni-kem and Pepy-ankh Heri-ib (Pepi II) to Senbi (Amenemhat I) to the later tombs of Ukh-hotp and . Kha'kheperre-sonb, dating to the reign of Senusret II.[1546] New artistic evidence has already arisen as a result of this re-examination; for example, some grid systems displayed in Old Kingdom tombs are actually the result of Middle Kingdom artists setting up a grid *over* the artwork in order to copy the Old Kingdom decoration.[1547]

Deir el-Bershā was the chief cemetery of the nomarch of the 15th Upper Egyptian (Hare) nome during the Middle Kingdom.[1548] The origin of Deir el Bershā has now been located in the Old Kingdom, however, with traces of activity dated to the Fifth and Sixth Dynasties.[1549] Recent archaeology suggests Old Kingdom formations also for the sites of Edfu and Dendera.[1550]

1541 Kanawati & Evans, *Beni Hassan* I and III. For a report on two Old Kingdom tombs at the site, see Lashien, *Beni Hassan* II.

1542 For example, Evans & Mourad, commenting on a newly discovered motif, apparently unique to this area; see *D-Stretch & Tomb Paintings*, 82–83.

1543 For example, the use of D-Stretch® photography at sites like Beni Hassan – see Evans & Mourad, *D-Stretch & Tomb Paintings*, 81–83.

1544 Blackman & Apted, *Meir* I; Blackman, *Meir* II, III and IV; Blackman & Apted, *Meir* V and VI.

1545 Kanawati & Evans, *Meir* I and *Meir* II.

1546 These Middle Kingdom tombs are described in Blackman, *Meir* III and V.

1547 Kanawati, *Art & Gridlines*, 483–496.

1548 Leiden University, 'The KU Leuven Dayr el-Barsha Project', https://www.universiteitleiden.nl/en/nvic/research/archaeology--egyptology/ongoing-projects/the-ku-leuven-dayr-al-barsha-project (Mar. 22, 2019).

1549 Vereecken et al., *Dayr al-Barsha Pottery*, 204; de Meyer, *Two Cemeteries, One Capital*, 42–43, fig. 1; de Meyer, *Restoring the Tombs*, 125–135; de Meyer, *Shadows of the Nomarchs*, 421–427.

1550 Moeller & Marouard, *Edfu & Dendara Development*, 33–56; Snape, *Of Life and Death*, 107, 115.

The necropolis of Gebelein, in Middle Egypt, has recently been identified as a site with almost continuous occupation over Pharaonic times,[1551] and may be added to the list of possible study sites. The current survey may uncover decorations produced across a time frame similar to the one of this investigation. Due to the small sample size, however, it may be difficult to achieve significant results from individual locations, but when added to other sites developed across a similar time frame, it may be possible to discern glimpses of a new pattern unfolding.

Once the investigations outlined above are completed, with newly refined dates and a more accurate chronology, an investigation into the evolution of tomb scene types in these areas can be undertaken allowing the progression of the decorative programme to be plotted; in a manner similar to that in Chapter Five. The plotting of the distribution and abundance of tomb scenes from a number of contemporary sites, the transitional sites, from the late Old Kingdom to the Middle Kingdom, may help the understanding of the evolution the decorative programmes in this area.

If the A.R.I.D. hypothesis is correct, then the progression displayed should exhibit a similar pattern to that uncovered in the study. If the conclusions reached in this study are valid, then we would expect to identify a 'reverse-image' of the pattern identified in this current study, with those further away from the time of low water availability depicting 'traditional' tomb decorations programmes.

Art Databases Plotting the Evolution of Artistic Themes

Unfortunately, the OEE database is no longer being updated.[1552] The prospect exists, still though, to link this repository with the database "MastaBase" that was produced by the by Leiden University[1553] and is in the process of being resurrected.[1554] In order to investigate if the evolution of the decorative programmes within tombs can be linked to external

[1551] Esmond, et al., 2017. *Report on the archaeological survey at Gebelein in the 2014, 2015 and 2016 seasons,* Polish Archaeology in the Mediterranean, 26: 1, see 239–240, 265. https://doi.org/10.5604/01.3001.0012.1783 (Aug. 12, 2019).

[1552] However, a number of books summarising updated information are on offer; see http://www.oxfordexpeditiontoegypt.com/forthcoming-books.html (Oct. 11, 2018).

[1553] The Leiden Mastaba Project was initiated in 1998 and directed by Dr. René van Walsem with the goal of developing a coherent database of iconographic data from Memphite area Old Kingdom elite tombs.

[1554] A new online version of the Leiden Mastaba Project is undergoing trial; see http://mastabase.org/test/

environmental factors, the current statistical analysis of the distribution and abundance of wall scenes using the database of the Oxford Expedition to Egypt (OEE) could be extended beyond the time frame of that particular database. Data contained in the 'MEKETREpository' for tomb decorations, for example, whose goals include the collation of First Intermediate Period and Middle Kingdom decorations,[1555] could widen the range of this information. This project is underway and, as yet, incomplete. If these databases were to be merged a decoration database over many dynasties (and avoiding artificially imposed chronological boundaries) could be developed and the understanding of the art history of the time would develop much more rapidly.

[1555] MEKETREpository, http://meketre.org/repository/

12.2 – Geoarchaeology: Messages in the Mud?

Changes to the distribution of Nilotic sediments and flora as a consequence of changing riverine flood patterns should leave corroborating evidence in the soil structures,[1556] for example, how early industry had affected local water quality.[1557] If the environment changed in the ways proposed, then the consequences would have had societal implications[1558] by impacting how the landscape was modified as the population re-organised their use of space in response to the new circumstances that were unfolding.[1559] The ACACIA [Arid Climate Adaptation & Cultural Innovation in Africa] project, for example, with its goal to link the historical process of cultural development and the emergent social dynamics to the ecological background[1560] is one such project. Of particular relevance to this study is Project A5: Environmental Situation and Change in North Eastern Africa: The Special Example of Ancient Egypt,[1561] whose final results are highly anticipated. By applying a 'landscape-integrated' approach,[1562] it was able to integrate various geological, geographical and ecological aspects to the investigation of societies in the region. This multi-faceted approach can be built upon.

Geoarchaeology

Geoarchaeology applies earth sciences to inform archaeological knowledge and thought.[1563] It is a multidisciplinary approach investigating the natural physical processes affecting archaeological sites,[1564] synthesising the information and then presenting it in a holistic manner.[1565] Over the last six thousand years, the Nile floodplain has shifted significantly,[1566] with its geomorphology and local environments displaying a variety of patterns and

---

1556 Ghilardi & Desruelles, *Geoarchaeology*, 2–3; Fuller & Lucas, *Archaeobotany*, 305.
1557 Bardají et al., *Dra Abu el-Naga Geomorphology*, 242–243.
1558 Goldberg & Macphail, *Geoarchaeology*, 225–246; Ghilardi et al., *Geoarchaeology*, 227. Bunbury et al., *Holocene Nile @ Karnak*, 358–359; Wright, *Human Holocene Termination*, 1–3; Qin, *Landscape Change*.
1559 Riemer, *Risks & Resources*, 124.
1560 http://www.uni-koeln.de/sfb389/a/a9/index.htm (May 13, 2018)
1561 http://www.uni-koeln.de/sfb389/a/a9/index.htm
1562 http://www.uni-koeln.de/sfb389/a/a9/index.htm
1563 Butzer, *Cross-Disciplinary Geoarchaeology*, 403–404.
1564 See, for example, Ghilardi et al., *Nile River Evolution*, Love, *Abusir Drill Core*, and Bardají et al., *Dra Abu el-Naga Geomorphology.*
1565 Verstraeten et al., *Nile Floodplain Transition*, 239–241; Bunbury, *Memphite Floodplain Landscape*, 61.
1566 Bunbury, *Memphite Floodplain Landscape*, 71.

characteristics[1567] unique to each stage in its geological history.[1568] The formation of sites and how geological processes changed these landforms are studied, as well as how these geological processes may have affected cemeteries, and the artefacts deposited within, many years after they were constructed.[1569] Geological evidence can be applied to the development of a number of sites over the time frame of this investigation. Finding sites with precise chronological dates, while difficult, is becoming more reliable and should allow a more accurate picture of any population shifts (forced or otherwise) during the later Old Kingdom. Edfu, for example was founded in a 'flood-safe' area of the Nile, whereas nearby Dendera was built in an area further from the river.[1570] Both of these sites developed in the late Fifth Dynasty and then grew in the Sixth Dynasty, but Dendera declined during the Middle Kingdom as a result of a greater threat from the strengthening inundations.[1571]

Some geoarchaeological assessments made in earlier times, relying on more rudimentary equipment, may have under-estimated the rate of movement of the river across the floodplain.[1572] Improved techniques and technologies can be utilised to re-examine previous commentary to further refine our understanding of this area of investigation. Bunbury's water-based perspective of the First Intermediate Period suggests that the climate had begun changing much earlier, more likely from earlier in the Old Kingdom.[1573] Significantly, the amount of marshland was much less than most scholars anticipate,[1574] a proportion that according to the A.R.I.D. hypothesis, should have increased over the time frame of this

---

1567 Butzer, *Nil*, 480–483; Zahran & Willis, *Vegetation*, 251–254; Bunbury, *Memphite Floodplain Landscape*, 75–78, figs. 5, 6.

1568 Bunbury et al., *Holocene Nile @ Karnak*, 358–359, where boreholes have provided evidence of previous environments, and 364–366, where the history is 'read' from these sediments. Similarly, see Butzer, *Urban Geoarchaeology*, 3345–3346, fig. 3, tracing the history of the Nile floodplain at Giza, and 3354–3355, fig. 11, for the geoarchaeological history of Giza; Verstraeten et al., *Nile Floodplain Transition*, 247, identifying some places where the Nile has moved in the opposite direction to that previously understood, and 252–253, summarising the different behaviours displayed by the two different banks of the river.

1569 Bardají et al., *Dra Abu el-Naga Geomorphology*, 248–249, identifying geological impacts that had consequences for the long-term stability of some areas of the cemetery.

1570 Moeller & Marouard, *Edfu & Dendera Development*, 33–53.

1571 Moeller & Marouard, *Edfu & Dendera Development*, 54–55.

1572 Butzer, *Hydraulic Egypt*, 134, (published 1975) appears to have provided estimations more conservative than current findings in Verstraeten et al., *Nile Floodplain Transition*, 244–245, (published 2017) which suggest that it has moved much faster in some areas than previously believed.

1573 Bunbury, *River Nile Development*, 52–53, fig. 1; Bunbury, *Memphite Floodplain Landscape*, 73.

1574 According to ACACIA project A5: http://www.uni-koeln.de/sfb389/a/a5/a5_picture6.htm (May 13, 2018) very little of the Nile Valley was fully developed marshland, a feature that changed after the construction fo the Aswan Dam. How the current impression of the river may be influencing scholars' thinking about the role of the river and the delta in Egyptian history would be a fascinating investigation.

investigation. Since water, or a lack of it, is a significant underlying theme of this investigation, a water-based geoarchaeological emphasis may be of value as the space that could be exploited changed in response to water availability.[1575]

Archaeobiology

Archaeobiology studies, in an archaeological context, the remains of plants and animals exploited by humans. It is a composite discipline, combining botanical and zoological knowledge with archaeological materials, as it attempts the reconstruction and interpretation of past human-animal-plant inter-relationships[1576] by studying the behavioural and ecological interactions between past peoples and the living things around them. This includes the role of pastoralism and animal husbandry in the survival of populations and sometimes includes the representation of animals in rock art and on portable materials. This allows for the reconstruction of the diet, the subsistence activities practiced, those agricultural strategies employed, the social and cultural role of food, the exploitation of wild resources, the procurement of fodder, the aspects of seasonality, and the environment in which people and their animals dwelt,[1577] including all the organic remains left in the soil after the death and decay of plants and animals.[1578]

Giuseppe Passalacqua, the leader of an excavation of tombs at Deir el-Bahri, is believed to have directed the first archaeobotanical research in Egypt by having dried plant remains analysed by a botanist.[1579] Plant macrofossils are preserved through four main modes. Firstly, plant remains can be examined; usually cereal grains, chaff, seeds and charcoal that may be 'charred' as a result of cooking.[1580] Secondly, plant remains deposited in permanently waterlogged conditions are preserved because microbial decay is limited due to a lack of oxygen.[1581] Thirdly, mineralisation of plant remains occurs, usually in latrine pits and middens, with the plant remains being replaced by the mineral calcium phosphate.[1582]

1575 Riemer, *Risks & Resources*, 123–124.
1576 Fuller & Lucas, *Archaeobotany*, 305.
1577 From The Oxford Handbook of Archaeology: *Archaeobotany*, http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199573493.001.0001/oxfordhb-9780199573493-e-30 (May 28, 2018).
1578 From The Oxford Handbook of Animal Studies: *Archaeozoology*, http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780199927142.001.0001/oxfordhb-9780199927142-e-001 (Feb. 6, 2019).
1579 Stuart, *Paleoethnobotany*, 5756. See also Abdel-Magid, *Archaeo-ethnobotanical Plant Domestication*.
1580 Märkle & Rösch, *Carbonization Effects*, 257–263; Van der Veen, *Carbonized Plant Remains*. 977–979.
1581 Kenward & Hall, *Urban Organic Archaeology,* 584–596; Jacomet, *Archaeobotany,* 497–514.
1582 Smith, *Identifying Cess-pits*, 526–543.

Finally, plant remains are preserved by desiccation in arid environments, where the absence of water limits decomposition.[1583] Since water is a significant underlying theme of this investigation, the identity of the plants growing at particular locations and dates becomes particularly salient.[1584] Analyses of core drilling samples of the Nile sediment should be able to distinguish between the relative proportions of floral organisms present at the time the sediments were laid down. With regard to the A.R.I.D. hypothesis, the recovery and identification of plant and animal remains can be used to make inferences about the ecology and culture of the site, as well as proposing plant succession.[1585]

Using the above approaches, alterations to the habitat of a region or changes in the diet of its occupants can therefore be traced by observing changes in the archaeobotanical record and comparing them to those remains from earlier times.[1586] The movements of peoples as a consequence of changing circumstances, either environmental or political, has been traced using chemical means. By investigating the faunal remains, for example, it has been possible to identify population shifts during the New Kingdom.[1587] The residue in the bones of the animals used for dairy and meat can indicate where the animal lived in the early stages of its life. Significant advances in genetics now allow for the identification of organic remains previously unidentifiable.[1588] The prospects of this technique are thought to be vast,[1589] with the ability to re-examine previous evidence using these new techniques, new levels of understanding and interpretation can be elicited. Importantly, the potential negative impact of humans on their surroundings may be clarified.[1590]

1583 Van der Veen, *Carbonized Plant Remains*. 970–977.
1584 See Ritchie, *Dakhla Pollen Spectra*, 1–6 and Ritchie, *Dakhleh Palaeobotany*, 74–80, as examples.
1585 Riehl, *Archaeobotanical Evidence*, 93–114; Cappers, *Reconstructing Agriculture*, 429–446..
1586 Fahmy, *Predynastic Plant Exploitation*, 14: 4; 287–294.
1587 See, for example, Buzon & Simonetti, *Mobility Studies,* 7.
1588 Palmer et al., *Plant Archaeogenetics*, 146–56.
1589 Fuller & Lucas, *Archaeobotany*, 310.
1590 Fernandez et al., *Degradation & Recovery*, 297–323.

12.3 – Human Archaeology: Beacons in the Bones?

Duhig's work, the goal of which was to address the question… "*do the skeletal remains of those living during the First Intermediate Period support the documentary references to societal breakdown at this time?*"[1591] found that, "*…no physical evidence for the famine assumed by Bell…*"[1592] This data, a study of more than eight hundred individuals implies that famine was less common than anticipated, suggesting that the diet would have been suitable, under ordinary situations, for the maintenance of health, with most basic food types available to the great majority of the population due to the environmental uniformity of the country.[1593]

While this is very important to the context of this investigation, very little indicators of changes to the diet were identified. According to the A.R.I.D. hypothesis, it would be expected that the diets should have changed. As the Nile weakened and papyrus and reeds flourished, the sluggish river would have changed the food web profile. Fish numbers would have increased, and bird populations altered, while cattle would have flocked to the riverbanks to feast upon the newly growing plants. Desert animals would have infringed upon this shared space. This would have impacted upon the eating habits of human populations and the consequences of these adaptations should be identifiable in the remains of their bodies and the residues of their meals. As the society adapted to changing socio-ecological conditions, corroborating osteo-archaeological evidence of changes in diet and lifestyle behaviours should be identifiable in the bodily remains of these populations.[1594] Bio-archaeological studies can now identify particular nutrients as well as more accurately defining instances of nutritional stress and high mortality.[1595]

1591 Duhig, *Eating People Here*, 1.

1592 Duhig, *Eating People Here*, 115.

1593 Duhig, *Eating People Here*, 4.

1594 Cable et al., *Global Change & Disease Control*, 1–3. Veiga, *Prevalent Pathogens*, 65. See, also, Zakrzewski, *Life Expectancy,* whose background reasoning, despite using Roman Egypt for analysis, 1–4, provides a model that can be applied to earlier times.

1595 See, for example, Zakrzewski. *Population Continuity or Change*, 501–509; Zakrzewski, *Variation in Ancient Egyptians*, 219–229; Raxter, *Egyptian Body Size*; Kumar, *Health at Hierakonpolis*. See, also, Cable et al., *Global Change & Disease Control*, fig. 1; Richards, *Mortuary Landscapes*, 169, describing changing palaeo-pathological conditions, focussing primarily on the Middle Kingdom; Winkler & Wilfling, 1966. Tell el Daba VI. *Anthropological investigations on the skeletal remains of the campaigns,* 1975–1980, focussing upon Tel el-Dab'a.

Applying these analyses to different populations over different stages of the Old Kingdom and into the Middle Kingdom should provide evidence of changes in diet as well as suggest movements of populations,[1596] movements that may be linked to relocations in response to changing environmental circumstances.

Dental health

From the very earliest times, humans have been beset by dental problems and for those living along the Nile valley in ancient times, this was no different.[1597] Fortunately the environmental conditions meant that much has been preserved, with teeth a good source of information because the tissue maintains its quality for longer than other hard remains. The diagnosis and interpretation of dental disease from ancient remains is able to provide indicators of the general health of a population as well as furnishing information about diet, oral hygiene, the environment and prevailing economic conditions. It is able to provide a record of childhood stress, useful in evaluating the general health of a population, linking poor levels of juvenile nourishment to the development of hypoplasia at later ages.[1598] As well as serving as an indicator of poor diet, poor dental health indicators can be used as 'stress markers' indicating difficult living conditions.[1599]

In Egyptian history, there is palaeo-pathological evidence of diseases such as anaemia, diabetes and tuberculosis, all of which leave scarring on the teeth.[1600] Drought and famine, and their resultant nutritional deficiencies, would also impact upon dental hygiene.[1601] The ability to identify different ethnic groups by the relative vulnerability to dental disease can enable the migration of such groups to be traced and could be used to identify migration patterns that changed in response to changing climatic conditions.

[1596] Buzon & Simonetti, *Strontium Isotope Variability*, 6–7, for example, use precise genetic markers to trace the movements of immigrants into the Nile Valley. With suitably chosen populations, this technique may be applied to population changes across the end of the Old Kingdom.

[1597] Forshaw, *Dental Health*, 421.

[1598] King et.al., *Enamel Hypoplasia*, 29–39. Lovell & Whyte, *Dental Enamel Defects*, 76, suggest that high infant mortality at age 3-4 years at certain times in ancient Mendes' history was caused by weaning stress, perhaps due to a less-than-substantial diet?

[1599] Lovell & Whyte, *Mendes Dental Defects*, 69–80; Goodman et al, *Hypoplasias Development*, 7–19; Kumar, *Health at Hierakonpolis*, 206.

[1600] Miller, *Skulls & Dentition*, 15–21.

[1601] Miller, *Skulls & Dentition*, 23–27.

Those samples preserved are usually from those people with the best means to survive, so the remains should be understood as 'atypical'. It seems, however, that all Egyptians, from the peasantry to the elite, suffered from extremely worn teeth, periodontal problems and numerous dental abscesses,[1602] with women appearing to suffer worse than men.[1603] Early Nubians and those of the Western Desert had better dental health than their Early Dynastic and Predynastic Egyptian counterparts, due most likely to a more varied diet.[1604] However, The dental health of the non-Egyptian populations gradually declined so that, by early Dynastic times, all those populations displayed similar dental health problems,[1605] presumably due to an increasing reliance on the products of cultivation.

Because of its association with biological ageing, the degree of dental wear has been recognised as a useful method of estimating the age at death of an individual.[1606] As well as wear, other dental issues that serve as helpful evidence include diseases of the enamel, tooth loss, tooth fractures and abscesses.[1607] The principal cause of periodontal disease is a bacterial irritation brought about by the accretion of plaque. The condition was known in antiquity and is traceable back to prehistory.[1608] It appears less frequently in ancient Egypt than it does currently in modern times, perhaps because the diet did not include simple carbohydrates.[1609] Enamel hypoplasia, the formation of a hard but thin enamel leading to less protected teeth,[1610] appears to have been a fairly common occurrence in many ancient Egyptians.[1611] It was thought to be an indicator of malnutrition but can also indicate major infections, diseases, or vitamin deficiencies.[1612]

1602 Triambelas, *Caries Prevalence*,192–194; Forshaw, *Dental Health*, 421.

1603 Fields et.al., *Agricultural Transition*, 43; Cramer et.al, *Paleopathologies in Mummies*, 7; Antoine & Ambers, *Scientific Analysis*, 20–30.

1604 Buzon & Bombak, *Nile Valley Dental*, 15–16 and Nikita et.al., *Saharan Dentition*, 392, discussing cultural impacts upon dentition.

1605 Thompson et.al., *Ancient Kerma Diet*, 380–385, notes some cultural difference that may affect dental health. For ethnic/genetic variances in the development of dental disease, see Lukacs and Joshi, *Ethnic Hypoplasias,* 359–377; Triambelas, *Caries Prevalence*, 182–184, fig. 8; Kanchan et al., *Enamel Hypoplasia*, 101; Gerloni et.al., *Dental Status*, 58–64; Lovell & Whyte, *Dental Enamel Defects*, 76.

1606 Forshaw, *Dental Health*, 424.

1607 Schwarz, *Dentaire dans l'Égypte Pharaonique*, 37–42; Veiga, *Health & Medicine,* 55–56; Veiga, *Prevalent Pathologies*, 74.

1608 Clement, *Caries*, 115–123. Adler, *Ancient DNA*, 205, links an increase in periodontal disease to a change in diet.

1609 Rateutschak-Pluss & Guggenheim, *Dental Plaque Accumulation*, 239–244 – though Adler, *Ancient DNA*, 203, claims there is a direct link between an increase in the amount of caries in a population to the adoption of intensive agriculture.

1610 Kanchan et al., *Enamel Hypoplasia*, 99–100.

1611 Hillson, *Diet & Dental Disease*, 147–162.

1612 Langsjoen, *Diseases of Dentition*, 393–412.

The new technique of dental microwear texture analysis (DMTA) is enabling different lifestyles to be distinguished between different types of societies.[1613] Groups that exploited their surrounds as foragers, farmers or pastoralists can now be identified. Unfortunately, the study investigated different groups from different geographical locations from around the globe.[1614] The Egyptian sites selected were used for the representation of farmers. But there were no sites selected to form comparison groups; no Egyptian site composed of foragers or pastoralists. Despite that, enough differentiation was found to exist between tooth wear patterns of the different lifestyle groups, and [1615] importantly, this technique appears to be able to distinguish between those societies that had a diverse resource base compared to those with simpler practices.[1616] This technique, therefore, could be applied to populations whose remains date to the time frame under investigation and valid inferences about potential lifestyle changes could be made.

Skeletal health

Bone samples allow for the identification of factors that may have interfered with the quality of life of the individual.[1617] Overall trends in changes to the population of the Nile valley from Predynastic to well into Classical times have been identified,[1618] with the general results echoing the dental evidence: that Nubians were generally more robust than Egyptians and Egyptian women, when adapting to a diet based on the products of cultivation, displayed the most rapid decline in stature size of all.[1619] Studies at sites of long-running occupation can trace the health of the population across its history; the changing health outcomes of the workers at Deir el-Medina, for example,[1620] can provide an overview of almost five hundred years. However, this site was occupied at a time of relative stability: ideally, sites with long-term occupation during times of environmental or economic or political stress would be most suited to investigating the validity of the hypothesis made in previous chapters of this thesis.

1613 Schmidt et al., *Dental Microwear*, 208.
1614 Schmidt et al., *Dental Microwear*, Table 1.
1615 Schmidt et al., *Dental Microwear*, 217–220, figs. 3, 4.
1616 Schmidt et al., *Dental Microwear*, 222.
1617 Fritsch et.al., *Orthopedic Diseases*, 1036–1037.
1618 Zakrzewski, *Variation in Ancient Egyptians*; more recently, Raxter, *Egyptian Body Size*.
1619 Raxter, *Egyptian Body Size*, 124–126, fig. 7; Zakrzewski, *Variation in Ancient Egyptians,* 223–224, figs 3–6.
1620 See Austin, *Deir el-Medina Health Care*.

As yet only a few detailed study have been conducted on a site with large numbers of remains from the late Old Kingdom AND from the First Intermediate Period.[1621] The site at Mendes does not seem to be demographically representative,[1622] since a broad cross-section of the population is not present, suggesting that the sample may make precise inferences invalid. The lack of large numbers of ancient Egyptian skeletons available for detailed investigation[1623] makes it difficult to clearly identify and articulate the changes that may have occurred to localised populations during the time frame under investigation. While inferences may be made from extrapolated or estimated data, actual evidence is less substantial.[1624] CT scans, for example, give great insights but still cannot allow the researcher to detect infectious diseases.[1625] As more precise dating technologies come on line, a more accurate health picture of the end of the Old Kingdom and into the First Intermediate Period will emerge.

Parasites

As environmental conditions change, the diversity of parasites well-suited to that environment changes, leading to increases in varieties better adapted to the new ecology.[1626] As the Nile weakened and the marshlands flourished, the lethargic river would have become more pestilent, developing conditions favourable to an increase in malaria and bilharzia. As such it would be expected that in A.R.I.D. times, an increase in water-borne and water-related pathogens and their vectors should have occurred.[1627] Malaria was, and still is, a disease endemic to the region,[1628] and 'marshland conditions' would have favoured its spread, evidence of which could be identified in skeletal remains, with most remains suggesting encounters with this parasite.[1629] Identifying an increase in diseases brought about by sluggish waterflow or stagnant water during the time frame under investigation would provide supportive evidence to the ideas developed in this study.

[1621] See Summer, *Excavating Mendes*, 1–2. Mant, *Mendes Palaeopathology*, presents the data from at least 33 individuals dating from across this time frame (16 OK and 17 FIP).
[1622] Mant, *Mendes Palaeopathology*, 5; Adams, *Mendes Stratification*, 90–94.
[1623] Schultz, *Paleohistopathology*, 106–109; Raxter, *Egyptian Body Size*, 174.
[1624] Raxter *Egyptian Body Size*, 174; Zakrzewski, *Variation in Ancient Egyptians,* 225–227; Zakrzewski, *Population Continuity or Change*, table 2.
[1625] Cramer et al., *Paleopathologies in Mummies*, 6.
[1626] Cable et al., *Global Change & Disease Control*, 3–6.
[1627] Veiga, *Health & Medicine*, 46–48; Veiga, *Prevalent Pathogens*, 65–66.
[1628] Kenawy, *Malaria in Ancient Egypt*, 7; Smith-Guzmán, *Nile Valley Malaria*, 11.
[1629] Brier, *Infectious Diseases*, 17–27; Nerlich et al., *Plasmodium falciparum,* 1317–1319; Bianucci et al., *Malaria in Paleopathology*, 176–80.

Unfortunately, precise dating may make this identification problematic as does the ability to actually determine WHEN the individual was infected. Predynastic evidence of parasites in human remains suggests that schistosomiasis, or bilharzia, was an infection endemic to the region,[1630] as mummies are found infected with it.[1631] Schistosomiasis, also known as snail fever and bilharzia, is a disease caused by a number of species of parasitic flatworms.[1632] Symptoms of schistosomiasis include blood in the urine, changes to urinary frequency and chronic cystitis.[1633] In some cases, it can cause genital disease in both men and women, resulting in numerous symptoms including infertility.[1634] Since many of these symptoms are associated with the genitalia, one may be tempted to ask if the circumcision scenes depicted on a number of tomb walls[1635] are 'commemorating' a treatment for this condition?

As well as the increasing likelihood of infection due to the development of agriculture and the growth of population densities,[1636] schistosomiasis, a significant environmental and occupational hazard in ancient Egypt,[1637] would be expected to flourish in the developing conditions suggested by the A.R.I.D. hypothesis. When the Aswan High Dam was first constructed, instances of schistosomiasis increased rapidly in the sluggish waters.[1638] With a greater focus on marshland activities, it would be expected that this exposure should have increased over the time frame of this investigation. Schistosomes leave evidence on the skeleton and an increased proportion of evidence in remains dating to the time frame under investigation would suggest an increased level of exposure.[1639] A similar problem exist to that identified above, the difficulty of determining when the first infection occurred, how many times was the individual infected and for how long did they experience the symptoms?

1630 David, Schistosomiasis, 133–135 ; Barakat, *Schistosomiasis in Egypt*, 425–426; Ruffer, *Bilharzia in Mummies*, 16; Farley, *Bilharzia*, 5–8.

1631 Baralat, *Schistosomiasis in Egypt*, 425–432.

1632 Colley, et al., *Human Schistosomiasis,* 2253–2264.

1633 As mentioned in Chapter Five, there is some contention that it may be representing a medical procedure due to some form of injury, see Spiegelman, *Emergency Surgery*? 91–100.

1634 Merck Manual, '*Schistosomiasis*', https://www.merckmanuals.com/professional/infectious-diseases/trematodes-flukes/schistosomiasis (Dec. 4, 2017).

1635 Kanawati & Hassan, *Ankhmahor*, 49–50, pls. 19, 55b; See also Herodotus, *Histories* 109.

1636 Veiga, *Prevalent Pathogens,* 65–66.

1637 Deelder et al., *Schistome in Mummies*, 724–725; Miller et al., *Predynastic Schistosomiasis*, 54–60.

1638 Abd-El Monsef et al., *Aswan Dam Impact,* 1877–1878, 1884.

1639 Silverman, *Anthropology & Circumcision*, 419–445. Howevere, the author is unaware of any study having been undertaken to trace the changing occurrence of this particular condition.

The regular cycle of an increase of disease as a consequence of the inundation, the 'annual pestilence,'[1640] may not have occurred as regularly in the delta with 'marsh-like' conditions existing all year around. Mendes, for example, is a site located within the Delta, which suggests that the basic parameters of 'normal' health would be different to that expected of someone living within the Nile Valley.[1641] Bilharzia is less likely in areas of flowing water, so this may explain the lack of infestation in remains from this area. In some areas, for example, Hierakonplois, burials did not display as great a preponderance of these parasites.[1642] Perhaps, in times of low flood, there were not enough puddles in which the population might immerse themselves to become (potentially) infected.[1643]

One unique species of parasitic flatworm that produces infections like bilharzia, *Schistosoma mansoni,* however, is endemic to the delta and rarely found in remains from the Nile Valley.[1644] This is another potential direction for further investigation, though the precision of its identification is problematic as it is also difficult to determine when in an individual's life did the infection occur, as well as how many time the individual was infected. Hierakonpolis form the end of the Old Kingdom burials may display evidence of *Schistosoma mansoni,* due to the increasing sluggishness of the river at this time.

With more people coming into increasing contact with cattle, it is expected that this would lead to an escalating incidence of tuberculosis,[1645] which, while not always fatal, would have led to difficulties in everyday activities.[1646] Tuberculosis is an infectious disease usually caused by a Mycobacterium that is not unique to humans.[1647] Bovine tuberculosis can jump the species barrier and can affect humans, especially those with a long exposure.[1648] Tuberculosis is identifiable in skeletal remains if it is specifically looked for.[1649] As the environment dried up, the tuberculosis bacterium would have become more susceptible to desiccation,[1650] perhaps limiting the spread expected as a consequence of increased cattle

---

1640 Contardi, *Rhythm of the Nile*, 13, 20–23, Duhig, *Eating People Here*, 16.
1641 Mant, *Mendes Palaeopathology*, 1, 19.
1642 Kumar, *Health at Hierakonpolis,* 199–200.
1643 Keita & Boyce, *Dental Hypoplasias*, 733–743.
1644 Duhig, *Eating People Here*, 16.
1645 Veiga, *Health & Medicine*, 49; Veiga, *Prevalent Pathologies*, 70–73.
1646 Cramer et al., *Paleopathologies in Mummies*, 7.
1647 '*Tuberculosis*,' https://www.who.int/en/news-room/fact-sheets/detail/tuberculosis. (May 6, 2018).
1648 Olea-Popelka, et al., *Human Tuberculosis*, 16.
1649 Zink, et al., *Tuberculosis from Mummies*, 380–391.
1650 Kumar, *Health at Hierakonpolis*, 232–233.

numbers. Anthrax, another disease carried by cattle,[1651] originated in ancient Egypt,[1652] so should be also identifiable in ancient remains, providing the correct tests are performed. Since the A.R.I.D. hypothesis suggests an increase in the cattle population at this time, then it would be expected to see an increase in the proportion of remains from this time displaying this pathology.

Anaemia

Anaemia occurs due to a dietary iron deficiency which reduces the capacity of the blood to carry oxygen, causing fatigue, pale features, shortness of breath and, in some people, heart palpitations.[1653] Children with chronic anaemia are often malnourished, increasingly prone to infections and more vulnerable to learning problems.[1654] While learning problems are not readily identifiable within the archaeological evidence, malnutrition is.[1655] Evidence of anaemia in remains is a good indicator of environmental stress due to increased rates of infection or poor food supply or periodic malnourishment.[1656] Anaemia can develop in populations where increasing population density leads to increasing rates of parasitic infection,[1657] so could also be an indicator of more people coming in to contact with one another, suggesting increasing mobility in the population.

However, it has recently become recognised that low blood iron levels can be interpreted as an adaptive response to pathogen attack, as people with anaemia are somewhat protected from developing malaria.[1658] The incidence of anaemia may not an illness per se, it may be an evolutionary survival strategy to minimise the debilitating effect of malaria. This seems relevant to this investigation as this condition is evidenced in populations living in or around marshlands,[1659] and could be a significant factor in furthering this investigation.

1651 https://www.who.int/csr/resources/publications/anthrax_web.pdf , fig. 1 (May 8, 2018)
1652 https://www.cdc.gov/anthrax/resources/history/index.html (May 8, 2018)
1653 Shiel, '*Anemia*', https://www.medicinenet.com/script/main/art.asp?articlekey=15491 (Feb. 2, 2018).
1654 Stuart-Macadam, *Porotic Hyperostosis*, 39–40.
1655 Fujita & Adachi, *Qar Palaeohealth*, 40–41.
1656 Stuart-Macadam, *Porotic Hyperostosis*, 43–45.
1657 Duhig, *Eating People Here*, 102.
1658 Walker et al., *Anemia Hypothesis Reappraisal,* 109–125; Wapler et al., *Sudanese Cranial Pathology*, 333–339.
1659 Mant, *Mendes Palaeopathology*, 16; Angel, '*Anemias, Malarias, & Marshes*', 760–763; Angel, *Porotic Hyperostosis,* 10–16.

A measurable increase in this condition around the time frame of our investigation may aid in the identification of an increase in mosquito-borne illnesses.[1660] Currently the accuracy of the above diagnosis is in dispute,[1661] so it would be necessary to undertake this investigation in conjunction with a number of different markers of a satisfactory diet.[1662] This data could be used in conjunction with investigations whose goal would be to identify bilharzia in order to identify an increase in marshland-related parasitic infections.

1660 Bianucci et al., *Malaria in Paleopathology*, 176–80.

1661 Oxenham & Cavill, *Porotic Hyperostosis Response*, 199–200, contra Rothschild, *Porotic Hyperostosis*, 417–420. McIlvaine, *Implications,* 997–1000, in a summary of the debate, points out that despite the inexact definition, anaemia is still an excellent indicator of some form of stress.

1662 For a potential role model where many interacting health markers were utilised, see Gowland & Western, *Morbidity in the Marshes*, 302–305.

12.4 – Identifying A Changing Pattern of Health?

Dental indicators from remains at Mendes suggest poor nutritional stress at the end of the Old Kingdom,[1663] while other data from the same site suggests that there was less nutritional stress early in the First Intermediate Period than at the end of the Old Kingdom.[1664] Studies have failed to identify significant changes in remains suggesting that the late Old Kingdom was a time of nutritional stress.[1665] If this was a time of drought and famine, then indicators should exist identifying significant developmental harm. A change in diet, as a consequence of adaptation to new environmental factors, may be identified if well-designed investigations are performed. Duhig noticed changes in the physical conditions of remains dating to the Archaic Period when compared to those dated to the late Old Kingdom, but these difference weren't explicitly stated, and it was recommended that these changes be further investigated.[1666]

Dietary Considerations

The diet of the ancient Egyptian was thought to consist of primarily of bread and beer,[1667] accompanied by onions and other vegetables, supplemented with some fish and fowl, and some meat.[1668] Overall it would display more vegetarian-like characteristics than not.[1669] In the Neolithic period (c. 10,000 BCE–c. 4,000 BCE) Egyptian society adapted from a hunter-gatherer to a more sedentary agricultural lifestyle dwelling in settled communities along the Nile valley. One consequence was that their diet would have changed from one rich in protein to one where carbohydrates played a predominant role.[1670] This may have had a negative impact upon the general health of the society,[1671] especially with regard to the female members of the population.[1672]

1663 Lovell & Whyte, *Mendes Dental Defects*, 69–80.
1664 Mant, *Mendes Palaeopathology,* 3–4.
1665 Lawler, *Die or Fade Away*? 7.
1666 Duhig, *Eating People Here*, 116–117.
1667 Samuel, *Ancient Egyptian Nutrition*, 579–580.
1668 Saffiro, *Dietary Habits*, 297–305.
1669 Touzeau et al., *Ancient Egyptian Diet*, 121.
1670 Wells, *Changes in Nutritional Diseases*, 1–12.
1671 Rothschild, *Shift to Maize*, 157–160.
1672 Fields et al., *Sex & Agricultural Transition*, 42–51; Williams & Hill, *Meat & Evolution*, 14–16; Watson et al., *Agriculture & Women's Health*, 92–102.

Cereals do not contain all of the necessary amino acids for a healthy diet,[1673] so, if the assumption that an increase in protein uptake may have occurred, then the result should have been a population who's biological remains displayed higher concentrations of iron. Evidence of diabetes has been found in the remains of Egyptian mummies,[1674] with papyrus Ebers describing its symptoms.[1675] This has been associated with a diet high in carbohydrates. A diet consistently high in carbohydrate loading would be healthier if it became increasingly supplemented by food foraged from the edges of the burgeoning marshlands.[1676] If the consequences of a weakened river led to an increasingly varied diet, it would be expected that cases of diabetes would have declined. As yet, no investigations tracing the change in incidence of diabetes over the time frame under investigation have occurred.

Meat, Dairy, Diet and Health Indicators

If cultivation experienced a downward trend, then the proportion of the diet that came from cereal-based energy would have declined, being replaced, as suggested by a slightly more meat-based diet. With the proposed increase in availability of fowl and fish and, to a lesser extent, meat, the skeletal remains and the teeth, and associated coprolites, should indicate if this dietary adaptation took place.[1677] Perhaps the dietary evidence from this time will suggest a reversion to a herder-forager lifestyle, not as nomadic as before but with an increased mobility.[1678]

Fish was a consistent component of the diet of the ancient Egyptian, and with an apparent increase in 'incidental aquaculture' identified in the artistic record, the proportion of fish protein in the diet should have increased. An increase in protein generally increases the overall health of an individual,[1679] although it may have been that an increase of fish protein

---

1673 Williams & Hill, *Meat & Evolution*, 12; Duhig, *Eating People Here*, 14.
1674 Forshaw, *Dental Health*, 422; Kamal, *Pharaonic Medicine*, 134.
1675 Ebbel, p.*Ebers,* 115.
1676 Williams & Hill, *Meat & Evolution*, 11.
1677 Smith, *Identifying Cess-pits*, 526–543, suggesting 'markers' to aid the locating of 'cess pits.'
1678 Copley, et al., *Foraging & Foddering,* 1273–1286; Brewer et al., *Domestic Plants & Animals*, 99, refer to the process as 'periodic nomadism'.
1679 See, for example, Houston et al., *Protein Intake*, 150–155; Shimazu et al., *Dietary Patterns & Mortality*, 600–609; Donaldson et al., *Proteins & Health*, 32–36; Lonnie et al., *Protein for Life*, 1–18; Williams & Hill, *Meat & Evolution*, 1–3, figs. 1, 2, 3. For current recommendations, see WHO, *Dietary References*, 240–241.

rather than red meat protein meant that anaemia remained a problem within the population as there is less iron in aquatic meat. With an increase of meat in the diet, humans develop a more robust body shape,[1680] so we could expect to see some similar changes in populations along the river during the time frame in question.

Interestingly, some dietary analysis suggests that less fish was consumed than expected,[1681] a result most likely related to the very few samples taken. More likely, it is due to the difficulty of identifying fish bones and the possibility that collection of this data was less prioritised in earlier studies. This conclusion seems to disagree with the apparent rise in fishing as suggested by the artistic record, and more importantly, as perceived in the empirical evidence from community spoil heaps being currently investigated at Dendera[1682] and Deir el-Bershā.[1683] With a specific investigation in mind, a greater focus on this aspect of data collection; and applying improved excavation techniques may allow for the trend to be investigated more reliably.[1684]

If cattle, both large and small, and their products were becoming an increasingly significant proportion of the diet, then long-term health consequences would be expected.[1685] High cholesterol levels have been identified in the remains of high-status individuals in ancient Egypt.[1686] If the proportion of red meat in the diet increased for the majority of the population, then archaeological evidence should show a mounting incidence of cholesterol in individuals of lesser status. In this geographical area, cattle herders later developed an increasing lactose tolerance.[1687] Perhaps this characteristic entered the Egyptian gene pool at this time; and with that particular goal in mind, it should be possible to identify its presence in remains from the time frame under investigation.

1680 Pfeiffer & Sealy, *Foragers Body Size*, 7–8.

1681 Touzeau et al., *Ancient Egyptian Diet*, 123.

1682 G. Marouard and N. Moeller, May 12, 2017, personal communication.

1683 M. de Meyer, May 12, 2017, personal communication. Note Duhig, *Eating People Here*, 9 identifies these sites as ones where the human remains dating to the time frame under investigation display very few stress markers, suggesting that a good lifestyle was available.

1684 Gregory Marouard, Nadine Moeller and Marleen de Meyer have invited me to visit their sites in order to see this development in the data from their excavations. While that visit is yet to take place, an article is in preparation.

1685 Smith, *African Herders,* 1–30, 85–90; Chan et al., *Diverged Maternal Lineages*, 12–13; Makarewicz, *Pastoralist Manifesto*, 159–174.

1686 Veiga, *Prevalent Pathologies*, 76–77.

1687 Smith, *African Herders,* 144–145.

À la Famine?

Famines were experienced in Egypt throughout its history and are not unique to the end of the Old Kingdom. Some administrators claimed to have managed the situation, promoting themselves as successful despite the dark times of drought and famine.[1688] Many scholars remain unconvinced as to the veracity of many of the claims. It is believed that these mentions of 'famine' have less to do with hunger and environmental crises and more to do with self-aggrandisement.[1689] In a similar manner, those 'famine' victims depicted in royal complexes, such as those belonging to Djoser, Sahura and Unas, can be seen as 'clichés' rather than true representations of the actuality of the event.[1690] It is difficult to accept the notion that a herder who is leading hundreds of kilograms of good food by a strap can end up 'starved'. Not all the cattle are female, so it is invalid to argue that the breeding stock is being preserved. Even if it was forbidden to eat the cattle they were guarding, it seems obvious that 'accidents' must have occurred, and, for a pragmatic people, the meat of injured animals would not have been wasted.

Skeletal analysis should be able to identify if famine was indeed a problem. Some studies have suggested that the diet changed for the worse during the First Intermediate Period,[1691] yet studies that have investigated mummy health suggest a relatively homogeneous diet across the entirety of ancient Egyptian civilisation.[1692] Duhig, in her study '"They are eating people here!" Skeletal indicators of stress in the Egyptian First Intermediate Period' found very little evidence of famine in the remains that she studied from this time frame.[1693] Evidence from Aswan identifies changes to the diet that are attributed to the First Intermediate Period,[1694] with the differences dissimilar to those identified during the Second Intermediate Period. Remains from both Intermediate periods, First and Second, contain evidence suggesting dietary modifications, but the data suggest that the sources of disruption were different: aridification in the earliest example and foreign invasion in the Second.[1695]

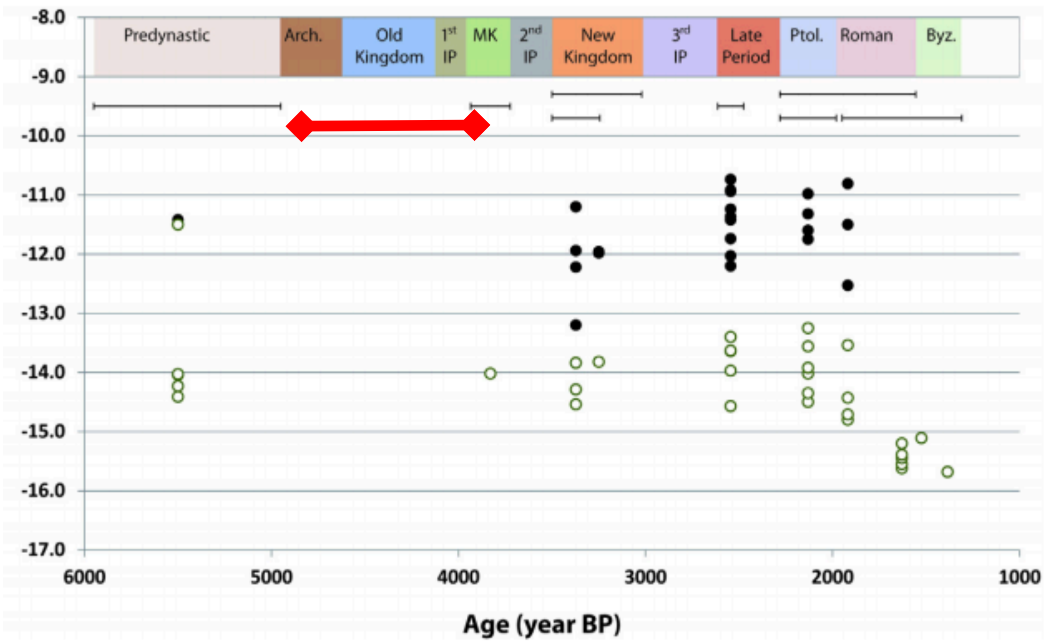
1688 The example of Ankhtify, has been discussed previously; see Vandier*, Mo'alla, i*nscriptions 1–12.
1689 Coulon, *Véracité et Rhétorique* 128–132; Coulon, *Famine*, 3.
1690 Franke, *Arme im Alten Reich*, 104–120.
1691 Kumar, *Health at Hierakonpolis*, 231–232; Zakrzewski, *Variation in Ancient Egyptians*, 219–229.
1692 Touzeau et al., *Ancient Egyptian Diet*; Adel et al., *The Horus Study*.
1693 Duhig, *Eating People Here*, 109–111, 115, claims to find very little evidence of famine in the remain that she studied from this time frame.
1694 Al-Khafif & El-Banna, *Ancient Egyptian Diet,* 1–4.
1695 Al-Khafif & El-Banna, *Ancient Egyptian Diet,* 5.

Chronological discrepancies make using samples from the period of this investigation problematic: improved dating techniques may allow samples from this time frame to be incorporated into future similar studies. However, it is important to be cautious about such statements: thousands of years of history and a few dozen mummies do not make a highly detailed analysis. While it is important to use samples from all periods of time, especially if statements are to be made about changes in diet, it is equally important to avoid leaving out huge swathes of data from important historical eras. Touzeau et al., for example, in their study of the Ancient Egyptian diet, used data from remains ranging from the Pre-Dynastic era to Byzantine Egypt.[1696] When the data is investigated more thoroughly, however, it can be noticed that it does not include samples from the time period with which we are interested (see Figure 58: Modified copy of figure 2, Touzeau et al., *Ancient Egyptian Diet*).[1697]

Figure 58: Modified copy of figure 2, Touzeau et al., *Ancient Egyptian Diet*

Note the lack of samples from late Old Kingdom to early First Intermediate Period.

(Red interval bar is the current author's addition.)



Similarly, none of the samples in the 'Horus Study'[1698] are dated to the time frame under investigation.

[1696] Touzeau et al., *Ancient Egyptian Diet*, 118, 123.
[1697] Touzeau et al., *Ancient Egyptian Diet*, fig. 2.
[1698] Adel et al., *The Horus Study*, table 1.

Case study: Djau at Deir El-Gebrawi

The scientific examination of the Dynasty VI mummy of Djau conducted by Schulz and Walker[1699] described the remains of an individual living in an era that was supposedly contending with the trauma of famine. There were no signs of major parasitic infestation. While Djau experienced two or three childhood traumas, none were able to be precisely identified as being related to malnutrition; however, the impact of diseases is exacerbated by irregular nourishment. Despite the traumas of his youth, his diet was ample enough to facilitate the obesity that resulted in osteoarthritis. The orthoses that developed were not as a consequence of poor diet.

It was suggested that Djau's diet seemed to have included less bread than expected with a larger number of calories derived from protein, though the type of protein has not been identified.[1700] Similarly, the teeth seemed 'younger' in appearance than the rest of the skeletal structure, indicating limited abrasion from bread. As tempting as it may be to insinuate such results strengthen the 'lo-carb' high-protein diet suggested by the A.R.I.D. hypothesis, it is important to recognise that Djau was among the upper echelons of society, where a more varied diet and a more refined and less coarse bread may have been more readily available. A future study may investigate Djau's teeth to identify the exact site of his youth, and his diet at various stages in his development.

Similarly, an examination of the skeleton of the '*wife of Kahai'* has suggested that she died after having reached her fifth decade and that she belonged to the "lower level of the elite."[1701] However, the internal structure of her teeth was not investigated, not through oversight but due to lack of technological ability. A more modern study would have been able to provide more precise details about these factors. Improved technology will improve the understanding of the lives of these individuals.

1699 Schultz & Walker, *Mummy of Djau*, 67–78.

1700 Forensic tests can now identify the type of protein consumed by an individual – fish versus mammalian (Dr R. Power, Macquarie University, personal communication). Funding for forensic examination of large numbers of teeth dating from the end of the Old Kingdom and into the First Intermediate Period, in order to ascertain dietary changes, will be applied for at the completion of this investigation.

1701 Schultz, *Biological Reconstruction*, 165–169.

Future explorations

Population mortality rates could be used to compare the impact of the 'drought' upon society during the time frame under investigation. The most overwhelming data with regard to palaeo-pathologies is the very high incidence of dental disorders and degeneration. Whether these disorders contributed to a weakening in overall health or merely made life less comfortable[1702] is difficult to ascertain. While disorder and diseases can be identified, it is difficult to identify the overall cause of mortalities.[1703] A disparity can develop between suggested cause of death and actual cause of death, with the actual cause of death as ascertained by CT scans sometimes disputing the cause of death that had been suggested by earlier forensic examinations.[1704]

Older studies may have been less careful with regard to the recording of the context of the finds, perhaps leading to inaccurate conclusions.[1705] While most records are related to the temple and its offerings to the king or the gods, to better understand the consequences of climate change on a population, more detailed investigation with regard to settlement archaeology and their food remains are needed.[1706] Some changes may not have been an environmental response but perhaps a social one, such as the changes to the population at Gebelein that occurred when a large body of Nubian mercenaries, with their families and different cultural needs, arrived to fight for Ankhtify.[1707]

1702 Cramer et al., *Paleopathologies in Mummies*, 6.
1703 Forshaw, *Dental Health*, 421.
1704 Cramer et al., *Paleopathologies in Mummies*, 6.
1705 Stevenson, *Archaeology at the Museum*, 7–8; Cramer et al., *Paleopathologies in Mummies*, 7.
1706 Morenó Garciá, *Microhistory*, 12, pointing out the need for more information about the 'commoners'.
1707 Ejsmond, *Nubians of Gebelein,* 11.

12.5 – NETWORK ANALYSES

In his study of late Old Kingdom inheritance practices, Kanawati noted: "*Whether the practice of nepotism was wide-spread throughout the Old Kingdom or was particularly common in the troubled first half of Dynasty 6, needs further documentation and research*."[1708] Possibly as part of a response to a changing climate and/or in reaction to a weakening central government, family ties became more durable with many administrative positions becoming 'inherited'.[1709] At the same time the kings were shoring up their power by marrying their offspring to powerful nobles.[1710] The tracing of interrelationships and familial links (the social 'network') may shed some light on the response processes to changing environmental circumstances.

While the term 'networks' has been used in archaeology for many years,[1711] a more formal approach to the idea of networks has arisen recently, especially with regard to the application of many computer programs specifically written to identify the relationships and 'connectivity' within social systems.[1712] Some projects investigate societal response to external stressors,[1713] using some form of 'social index' to measure a society's inherent toughness.[1714] The FRAGSUS project, for example, brings together many disciplines in order to explore the multifarious factors that underpinned the sustainability of a specific European island society, prehistoric Malta.[1715]

1708 Kanawati, *Nepotism*, 57.

1709 Duliková & Mařík, *Complex Network Analysis*, 63, 74.

1710 Duliková, *Old Kingdom Viziers,* 327–336; Bárta & Duliková, *Divine & Terrestrial*, 31–48.

1711 Brughmans, *Connecting the Dots*, 289–291; Knappett, *Why Networks?,* 1–2; Terrell, *SNA & History*, 17–42; van der Leeuw, *Archaeology, Networks & Beyond*, 335; Mills, *SNA in Archaeology*, 380; Collar et al., *Networks in Archaeology*, 1; For an Egyptological approach see Cline & Cline, *Amarna Social Networks*, 17–44.

1712 Östborn & Gerding, *Archaeological Data Network Analysis*, 87; Mills, *SNA in Archaeology*, 381. Brughmans, *Connecting the Dots*, 288; Collar et al., *Networks in Archaeology*, 1–2, plus a helpful glossary of related terms, 17–25.

1713 See Mills, *SNA in Archaeology*, 383; Pearce, *Hunter-Gatherer Networks*, 410–411; Brughmans et al., *Inter-settlement Visibility*, 89–94.

1714 Borck et al., *Social Networks as Survival Networks,* 51.

1715 This research, using innovative fieldwork analysis and synthesis to investigate prehistoric Malta, is claimed to provide answers that are as relevant today at a continental and even global scale as they were in the time of the society under investigation, https://www.arch.cam.ac.uk/research/projects/fragsus, (Apr. 4, 2017).

Tracing Change

The interlocking influences and interactions of what van der Leeuw has conceptualised as 'Settlement, Sustainability, Subsistence and Society' can impact upon the long-term survival of a society.[1716] Some cultures manage to sustain their civilisation for centuries or millennia, while others collapse in response to the impact of changing conditions in the wider environment.[1717] How some societies successfully adapted to change, while others failed, is becoming an important issue in understanding the persistence of some ancient cultures, with the interaction between the society and its environment recognised as a dynamic consisting of a continually changing balance between influences sometimes leading in opposite directions.[1718] Change and instability imposed stress on these societies, causing either extinction or adaptation and evolution.[1719]

Despite a wide variety of network types existing in ancient Egypt,[1720] there seems, however, when compared to other aspects of archaeology, a hesitation to apply these methods in the field of Egyptology.[1721] This will slowly change as more cross-discipline analyses are undertaken.[1722] Recently, a detailed investigation of nepotism in Old Kingdom society has been undertaken by Duliková & Mařík,[1723] and this, along with newly published studies using multi-disciplinary approaches,[1724] has led to a number of conclusions that may be relevant to the current study. Duliková's & Mařík's analysis traced titles and relationships. The relationships of kings to the nobles were shown to be specifically affected by marriage

---

1716 Where "[r]esources should under most circumstances be seen as a constraint"– van der Leeuw, Archaeology, Networks & Beyond, 336. See also, Middleton, *Nothing Lasts Forever*, 257–307; Borck et al., *Social Networks as Survival Networks*, 33–57.

1717 Trøjelesgaard & Olesen, *Networks in Motion*, 1926.

1718 van der Leeuw, *Archaeology, Networks & Beyond*, 338–339.

1719 A form of 'punctuated equilibrium' perhaps? See Bárta, *Punctuated Equilibrium*, 1–17.

1720 Brughmans, *Connecting the Dots*, 288–292; Collar et al., *Networks in Archaeology*, fig. 2; Evans, *Which Network Model?,* 149–74; Peeples & Roberts, *To Binarize or Not*, 3001–3008; Trøjelsgaard & Olesen, *Networks in Motion*, 1931–1934.

1721 In the reviews of the research varieties – for example, in Brughmans, *Thinking through Networks,* 632–635; Östborn & Gerding, *Archaeological Data Network Analysis*, 77–79; Terrell, *SNA & History*, 17–42; Trøjelsgaard & Olesen, *Networks in Motion*, 1926–1928; Mills, *SNA in Archaeology*, 380–384; Collar et al, *Networks in Archaeology*, 6–8 – no mention of any Egypt-specific investigations is made. Brughmans, *Connecting the Dots*, 293, mentions Egypt only in terms of Mediterranean trade routes.

1722 Brughmans, *Thinking Through Networks*, 630; Östborn & Gerding, *Archaeological Data Network Analysis*, 87; Brughmans, *Connecting the Dots,* 299; Östborn & Gerding, *Archaeological Data Network Analysis*, 75; Collar et al., *Networks in Archaeology*, 15–16; Mills, *SNA in Archaeology*, 380.

1723 Duliková & Mařík, *Complex Network Analysis*, 63–83.

1724 Bárta, *Kings, Viziers & Courtiers*, 153–175; Bárta, *Abusir Paradigm,* 51–73; Cline & Cline, *Amarna Social Networks,* 17–44.

alliances, with at least thirteen 'king's daughters' married to major (non-royal) officials.[1725] The network analysis map that was produced[1726] identified the familial inter-relationships and the societal linkages that Ptahhotep enjoyed and clearly show the intrinsic power base behind him that provided the impetus for him to inherit power and become the vizier.

Continuity, Change or Collapse during A River In Drought?

A project designed around the A.R.I.D. hypothesis in the latter Old Kingdom would have to incorporate a number of interdisciplinary approaches. These would include the disciplines of ecology, environmental studies, chronology, sociology, archaeology and anthropology, to name a few.[1727] Investigating linkages between artistic themes may provide another insight into the interrelationships and responses to external factors that took place.[1728] As well as cultural change due to ecological responses,[1729] evidence of conflict as a cause of collapse should also be looked for.[1730]

Considering the length of the river, different responses may be identified along the length of the river, as latitude has been shown to have some variable impact upon the development of social networks.[1731] Bearing in mind the overwhelming influence of the river upon the Egyptian civilization, it seems most fitting that the 'ecological' framework of network analysis may be best suited to explore how environmental changes impacted upon local population networks. Changes in settlement sites due to changing local situations can be plotted.[1732] Populations with significant reliance on a local resource would require a specifically designed series of questions to develop a network analysis.[1733]

1725 Duliková & Mařík, *Complex Network Analysis*, 76–78, fig. 17
1726 Duliková & Mařík, *Complex Network Analysis*, 70, fig. 9.
1727 As those outlined, for example, in Borck et al., *Social Networks as Survival Networks*, 51–52.
1728 As outlined in Brughmans, *Connecting the Dots,* 293–294, fig. 10; Collar et al., *Networks in Archaeology*, 9, and Mills, *SNA in Archaeology*, 386.
1729 As presented in Trøjelsgaard & Olesen, *Networks in Motion*, 1931–1934, figs 1, 3 & 4.
1730 A measurable factor suggested in Borck et al., *Social Networks as Survival Networks*, 34.
1731 Pearce, *Hunter-Gatherer Networks*, 412–413.
1732 For example, Brughmans et al., *Inter-settlement Visibility*, 70–71, fig. 13 and Mills, *SNA in Archaeology*, 389–391.
1733 For example, as outlined in Pearce, *Hunter-Gatherer Networks,* 404–405.

As well as geographical position being a factor, social networks vary over time, and this variance can also be plotted.[1734] Also, the interaction with non-riverine human populations may also affect the social networks that develop in times of water stress. As the river weakened and retained its nutrients, some marsh plants flourished, attracting more fish and increasing avian biodiversity. Cattle and eventually desert animals gravitated closer to the source of new food. The society that relied on these sources of food must have had to re-adjust to the new situation. Societal inter-relationships would have changed as they responded to this new situation, with the significant discrepancies identified able to lead to new pathways of investigation.[1735] All of this data, when added together could be used to eventually measure the resilience of the population during the time frame under investigation.[1736]

1734 Borck et al., *Social Networks as Survival Networks*, 54; Trøjelsgaard & Olesen, *Networks in Motion*, 1928–1930; Brughmans, *Connecting the Dots*, 277; Brughmans, *Thinking Through Networks,* 655–658; Östborn & Gerding, *Archaeological Data Network Analysis*, 76–77; Collar et al, *Networks in Archaeology*, 15–16.

1735 Östborn & Gerding, *Archaeological Data Network Analysis*, 82–86.

1736 Borck et al., *Social Networks as Survival Networks*, 33; Daoud et al., *Adaptation & Resilience*, 209–250.

Summation: Chapter Twelve

An Ongoing Investigation?

The major points raised in the chapter include:

- ⇒ The unlikelihood of scientific 'proof.'
- ⇒ Despite this, many tangents exist to enable the testing of the A.R.I.D. hypothesis across a number of fields of study.
- ⇒ With improved technological expertise, geoarchaeological and bioarchaeological testing will enable greater precision to the identification and dating of archaeological findings, and this will enable a more accurate rendering of the diet at specific times.
- ⇒ Greater use of dental evidence will enable the more precise localisation of individuals and provide a more precise interpretation of the dietary changes they experienced.
- ⇒ Greater exploration of the role that DNA investigations can play in this field will allow for a more explicit refinement of human evidence from archaeological findings.

A number of future projects have been identified, pointing out that with increasing sophistication of the technology available, the likelihood traditional archaeological methods can now be supplemented by scientific analyses of soil, seeds and skeletons to identify diet and disease. It is expected that within the near future, scientific means will be more readily available to test the hypothesis that, at the end of the Old Kingdom and into the First Intermediate Period, the ancient Egyptian had a more diverse diet than that in the Early dynastic and early Old Kingdom. With the continually increasing sophistication of dating and sampling technologies, the addition of new data analyses will result in many of the current understandings and existing interpretations of the 'decline' at the end of the Old Kingdom becoming superseded. Also, future chronological refinements may enable the proposed linkage of the recognition of the 'drought' more precisely to the time of a particular king, helping to explain the apparent change to the tomb decoration programme that occurred mid-Dynasty Five.

CHAPTER THIRTEEN

Conclusion ➔ Resilience, not Regression

While it is imprudent to say that the goal of 'proving' a record of Old Kingdom environmental change as being depicted in the art has been completely achieved, a number of highly suggestive circumstantial relationships and connexions between the ecology and tomb wall scenes have been identified. Despite the inability to precisely link these correlations to a definitive cause, the associations identified may help improve our understanding of the cultural circumstances in Egypt at the end of the Old Kingdom.
The main points may be summarised as follows…

1. Riverine Ecosystems and A River In Drought (A.R.I.D.)

With the focus shifted away from the land and the analyses directed towards 'A River In Drought,' a re-evaluation of the significance of the 'drought' and the subsequent repercussions this may have had upon the society as a whole, has been advocated. The 'drought' was recognised as an inappropriate term because of its land-based bias. It was realised that in times of weak or no inundation, the nutrients normally lost from the river to the surrounding land were retained in the river, thereby altering the biological balance. An 'excess' of nutrients in the river would have changed its biological profile. This led to the expectation of a different floral diversity developing along the edge of the river, with modern research identifying papyrus and phragmites as species that respond well to those hypothesised conditions, while typha and lotus appear to respond with less vigour. An increasing density of plant growth along the riverbanks may have required changes to some traditional fishing and boating practices. The findings may lead to certain aspects of the culture of late Old Kingdom/First Intermediate Period Egypt requiring reconsideration.

2. *Tomb Decoration Analyses Suggest a Changing Ecology*

A distribution and abundance analysis that was performed on tomb decorations showed changes within artistic themes over the time frame under investigation. Importantly, instead of focussing upon the quality or execution of the art, this study focussed on the significance of the *subject* of the scene, especially with regard to the representation of resources. A comparative decline in the proportion of representations relating to the agricultural cycle and other aspects of cultivation was identified, with an increasing emphasis on decorations relating to the river and its associated products recognised. The distribution of the data suggested that the 'watershed' reign of Niuserra was apparently a turning point where artwork whose subject was related to resources predominate. Similarly, but less dramatically, from the time of Teti to the time of the so-called 'drought', other depictions became relatively more important.

3. *A Developing Pictorial Narrative within Tomb Decorations*

With regard to the choices made for the composition of wall scenes, subconsciously or not, the tomb owners or artists were, with regard to the choices made for the composition of wall scenes, indicating a changing environmental awareness. Papyrus thickets began to be depicted in a larger, more chaotic manner, perhaps representing uncontrolled growth due to an excess of nutrients. No representations of gardens and orchards occurred during the Sixth Dynasty and into the early First Intermediate Period. A greater variety of fishing apparatus was depicted, and an assortment of varied fishing activities became apparent. Catfish swimming upside down were first depicted at this time. Goats browsing upon trees felled specifically for their use began to be depicted more readily. Representations of cattle became more significant at this time. Depictions of the poultry yard entered the lexicon at this time. Waterfowl became a predominant factor in offering processions. This developing pictorial narrative could be related to societal responses to an environment that was slowly changing around them.

These changes suggest the following…

4. New Depictions of Fishing Indicate Its Increasing Significance

Fishing scenes increased in overall proportion over the time frame of the investigation. Some fishing scenes enter the lexicon from this time, while others declined in apparent importance: for example, dragnet scenes. Increasing numbers and varieties of fish bones found in the waste heaps of excavated settlement sites dating to the end of the Old Kingdom and into the First Intermediate Period have been noted. This suggested that fish had become an increasingly important protein source during the time frame under investigation. The decrease in depictions of larger nets was explained by the suggestion that unrestrained plant growth would have resulted in a more cluttered river, making it less likely for large nets to remain untangled. The increasing proportion of depictions of other types of fishing behaviours, including the use of smaller, more manoeuvrable nets, can be explained by the same reasoning. The number of individuals depicted working these nets decreased, suggesting more family-sized groupings rather than the 'industrialised' efforts needed to handle the larger drag and seine nets that were depicted at the start of the era.

5. Increased Depictions of Waterfowl Suggest Thriving Birdlife

As the amount of plant cover increased, the diversity of habitats available for organisms living below the water would have increased. Animals living above the water would have experienced a similar increase in the amount and variety of habitats of available for them. Birds specifically associated with the riverbank, the waterfowl, were noted as becoming increasingly present in the tomb scenes produced at this time, perhaps explaining why fowling scenes came to outnumber spearfishing scenes on tomb walls. The significant increase in the relative prominence of birds in wall scenes was almost certainly related to an increase in habitats, a phenomenon known in the modern era in central and southern Africa, where greater avian biodiversity during times of decreasing water availability is experienced. Poultry yard depictions and processions, in the form of waterfowl parades, also increased in relative proportion when compared to other types of decorations depicting birds. Parallel to the increasing frequency of waterfowl depictions, attestations of their mammalian predators were added to the decorative repertoire at this time.

6. Cattle in Marshlands Taking Advantage of New Feed Sources

As the riverbank ecotone became more crowded, the floral balance changed. Some plants benefit from the mild pruning that grazing animals provide, as this further encourages their growth; while others did not. A weaker, shallower river would have become criss-crossed with more secondary channels as the erosive force of water diminished. The rapid increase in cattle herd size may be a consequence of an increase in feed becoming available. Cattle were suggested as being better able to take advantage of these conditions than crops, due to the fact that they are a more mobile form of food. The ability to move cattle meant that the likelihood of localised damage would be better controlled. Cattle travel with the 'flood' allowing the grazed land behind a chance to re-invigorate itself. As well as the Delta making a feeding ground for cattle, from this time it was recorded that cattle moved to marshland both up and down the river, grazing as they went. The rise of the 'cattle barons' may be traced on the walls as these scenes became more varied and widespread.

7. Desert Hunt Scenes Imply a Rising Reliance on the 'Wild'

While the desert hunt had been an iconic tomb scene early in the Old Kingdom, its composition began to change over the time frame represented by this study. When this scene type re-entered the tomb decorative repertoire, the scenes produced appeared to suggest a more pragmatic approach to the hunting process, with the outcome of the desert hunt related more to the production and supply of food resource than purely for symbolic representation. Traps and hunting dogs give the impression of an 'industrialised' acquisition process glorifying the volume of the harvest and not the skill. The depiction of the mingling of desert animals and other pastureland animals in processions and field representations may suggest that, as climatic conditions changed, the desert and riverbank ecotones became less distinct from one another and the zones occupied by the animals exploiting these areas overlapped. Eventually, desert animals appear to have become habituated to the presence of humans and their domesticated stock.

8. A Partial Reprise of the Herder-Forager Lifestyle?

As the ability of the river to provide enough water for an agricultural surplus declined, its irregularity may have resulted in the general population needing to become more flexible with regard to the resources that were now available, how they were acquired and how these were exploited. The menu may have needed to broaden to compensate for times when an agricultural surplus was undependable, expanding the food base to more transient and varied resources. Earlier, Badarian hunter-foragers had utilised the produce arising from riverine exploitation, crop cultivation and selective herding practices, which resulted in a semi-sedentary way of life. Since the evidence suggests that, during this era the society utilised a similar resources base to this earlier time, so it may have witnessed a partial return to these practices on a wider scale; where groups within society practiced a periodic nomadism.

Final Statements: Innovation and Invention, NOT Inertia

The idea of a drought changing the history of the latter part of the Old Kingdom should be seen as a simplification of the overall situation. The end of the Old Kingdom and into the First Intermediate Period has been thought by many to represent a time of regression to a culture and administration less sophisticated than that celebrated in the Old Kingdom itself. This may not be the case. While it is true that the amount of water available was less than at the beginning of dynastic times, most current scientific evidence suggests that ancient Egypt had been experiencing a gradual aridification since the Third Dynasty. Despite some nearby cultures failing to respond adequately, generally, Egyptian society seems to have adapted to this change. The changing artistic evidence, as attested at the time under investigation, suggests that the ancient Egyptians were able to respond to changing environmental circumstances by adapting the way they exploited local food resources. While there may have been a developing political vacuum, rather than reverting to a more primitive stage of existence, the latter stages of the Old Kingdom and early First Intermediate Period may, in fact, display evidence of the great resilience of the civilisation of ancient Egypt.

Thankyou.

A.R.I.D. BIBLIOGRAPHY

Abd-El Monsef et al., *Aswan Impact.* Abd-El Monsef, H., Smith, S.E. and K. Darwish, 2015. Impacts of the Aswan high dam after 50 years. Water Resources Management, 29: 6, 1873–1885.

Abdel-Magid, *Archaeo-ethnobotanical Plant Domestication*. Abdel-Magid, A., 1989. Plant domestication in the Middle Nile Basin. An archaeo-ethnobotanical case study. British Archaeological Reports IS 532.

Abdo, *Water Quality*. Abdo, M. H. 2013., Physico-chemical studies on the pollutants effect in the aquatic environment of Rosetta branch river Nile, Egypt. Life Science Journal, 104, 493–501.

Aboul-Naga, et al., *Goats as Adaptation Process*. Aboul-Naga, A., Osman, M. A., Alary, V., Hassan, F., Daoud, I. and J. F. Tourrand, 2014. Raising goats as adaptation process to long drought incidence at the Coastal Zone of Western Desert in Egypt. Small Ruminant Research, 1211, 106–110.

Abtew & Melesse, *Nile River Basin*. Abtew, W., and A. M. Melesse. 2014. The Nile River Basin. In Melesse, A., Abtew, W., and S. Setegn, (eds). Nile River basin: ecohydrological challenges, climate change and hydropolitics, 7–22. Dordrecht.

Abtew, *Land & Water*. Abtew, W. 2014. Land and Water in the Nile Basin. In Melesse, A., Abtew, W. and S. Setegn, (eds). Nile River basin: ecohydrological challenges, climate change and hydropolitics, 119–129. Dordrecht.

Abu El-Kasim, *Delta Problems*. Abu El-Kasim, R. A. 1988. The Northwestern Nile Delta: Problems and Priorities. The Archaeology of the Nile Delta, Egypt: Problems and Priorities. In Brink, E. C. M. van den (ed.) The archaeology of the Nile delta, Egypt: problems and priorities: proceedings of the seminar held in Cairo, 19-22 October 1986, on the occasion of the fifteenth anniversary of the Netherlands Institute of Archaeology and Arabic Studies in Cairo, 279–282. Amsterdam.

Adams, *Egypt in Nubia*. Adams, W. Y. 1984. The First Colonial Empire: Egypt in Nubia, 3200-1200 B.C. Comparative Studies in Society and History 261: 36-71.

Adams, *Old Kingdom Mendes*. Adams, M. J. 2007. The early dynastic through Old Kingdom stratification at Tell er-Rub'a, Mendes. Thesis. The Pennsylvania State University.

Adamson et al., *Nile Tectonic Inheritance*. Adamson, D., McEvedy, R. and M. A. J. Williams. 1992. Tectonic inheritance in the Nile basin and adjacent areas. Israel Journal of Earth-Sciences, 412-4: 75–85.

Admasu et al, *Genetta in Farmlands*. Admasu, E., Thirgood, S. J., Bekele, A. and M. Laurenson. 2004. A note on the spatial ecology of African civet Civettictis civetta and common genet Genetta genetta in farmland in the Ethiopian Highlands. African Journal of Ecology 42: 160–162.

Ailstock, *Phragmites Adaptions.* Ailstock, S.M. 2000 Adaptive strategies of Common Reed Phragmites australis. In Arnold, M.D. (ed.) The Role of Phragmites in the Mid-Atlantic Region, Princess Anne, MD, April 17, Environmental Center, Anne Arundel College, Online at: http://www.aacc.edu/envcenter/file/adaptivestrategiesphragmitesaustralis.pdf.

Akode et al., *Nile Bank Erosion*. Akode, O.M., Saad, S.I., Ibrahim, A.A., Adam, I.A. and S. Hamed. 2016. Bank Protection Methods Against Bank Erosion: The Case of River Nile. Journal of Building and Road Research, 10: 1–15.

Al-Hassan & Ofori-Danson, *Plankton Abundance Factors*. Alhassan, E. H. and P. K. Ofori-Danson. 2016. Plankton abundance in relation to physicochemical factors in the Bui reservoir of Ghana's Black Volta River. African Journal of Ecology: 1–9. doi:10.1111/aje.12303.

Al-Khafif & El-Banna, *Ancient Egyptian Diet*. Al-Khafif, G. D. and R. El-Banna, 2015. Reconstructing ancient Egyptian diet through bone elemental analysis using LIBS Qubbet el Hawa Cemetery. BioMed Research International, 1–7. http://dx.doi.org/10.1155/2015/281056.

Aldred, *Days of the Pharaohs*. Aldred, C. 1996. Egypt art in the days of the Pharaohs. London.

Alison, *Waterfowl Hunting.* Alison, R. M. 1978. The earliest records of waterfowl hunting. Wildlife Society Bulletin, 196–199.

Allam et al., *Atherosclerosis*. Allam, A., Thompson, R., Wann, L., Miyamoto, M., El-Din, A., el-Maksoud, G., Soliman, M., Badr, I., Amer, H., Sutherland, L., Sutherland, J. and G. Thomas. 2011. Atherosclerosis in Ancient Egyptian Mummies: The Horus Study. JACC: Cardiovascular Imaging, 44: 315–327.

Allan & Castillo, *Stream Ecology*. Allan, J. D. and M. M. Castillo, 2007. Stream ecology: structure and function of running waters. Dordrecht.

Allan, *Stream Ecology*. Allan, J. D., 1995. Stream Ecology: structure and function of running waters. London.

Allen & Pye, *Saltmarsh Morphodynamics*. Allen, J. and K. Pye, 1992. Saltmarshes: Morphodynamic, Conservation and Engineering Significance. Cambridge.

Allen, *Agriculture & Origins*. Allen, R. C., 1997. Agriculture and the Origins of the State in Ancient Egypt. Explorations in Economic History 34: 135–154.

Allen, *Power in the Detail*. Allen, M., 2005 Power is in the Details: Administrative Technology and the Growth of Ancient Near Eastern Cores. In: Chase-Dunn C., Anderson E.N. (eds). The Historical Evolution of World-Systems. The Evolutionary Processes in World Politics Series, 75–91. New York.

Allen, *Pyramid Texts*. Allen, J., 2005.The Ancient Egyptian Pyramid Texts. Atlanta.

Allen, *Reading a Pyramid*. Allen, J., 1991. Reading a Pyramid. In Berger, C., Clerc, G. and N. Grimal (éds), Hommages à Jean Leclánt, 1: 5–28. Cairo.

Alpert et al., *Paradoxical Rainfall*. Alpert P., Ben-Gai, T., Baharad, A., Benjamini Y., Yekutieli, D., Colacino, M., Diodato, L., Ramis, C., Homar, V., Romero, R., Michaelides, S. and A. Manes, 2002. The paradoxical increase of Mediterranean extreme daily rainfall in spite of decrease in total values. Geophysical Research Letters 29: 135–154.

Altenmüller, *Mehu.* Altenmüller, H., 1998. Die Wanddarstellungen im Grab des Mehu in Saqqara, Archäologische Veröffentlichungen. Mainz: Zabern [Archäologische Veröffentlichungen 42].

Amills et al., *Domestic Pigs in Africa*. Amills, M., Ramírez, O., Galman-Omitogun, O. and A. Clop. 2013. Domestic pigs in Africa. African Archaeological Review, 30: 1, 73–82.

Anđelković, *Hegemony for Beginners*. Anđelković, B. 2012. Hegemony for Beginners: Egyptian Activity in the Southern Levant during the Second Half of the Fourth Millennium BC. Issues in Ethnology and Anthropology, 73: 789–808.

Andrassey, *Ägyptens zu Vorderasien.* Andrassy, P. 1991. Die Beziehungen Ägyptens zu Vorderasien bis zum Ende des Alten Reiches. In Probleme der frühen Gesellschaftsentwicklung im Alten Ägypten, 103–154. Berlin.

Angel, *Anemias, Malarias, & Marshes*. Angel, J. L., 1966. Porotic hyperostosis, anemias, malarias, and marshes in the prehistoric eastern Mediterranean. Science, 153: 3737, 760–763.

Angel, *Porotic hyperostosis*. Angel, J. L., 1978. Porotic hyperostosis in the eastern Mediterranean. MCV/Q, Medical College of Virginia Quarterly, 141: 10–16.

Angelier, *Streams & Rivers*. Angelier, E., 2003. Ecology of Streams and Rivers. Boca Raton.

Archer, *PlantZAfrica*. Archer, C., 2004. PlantZAfrica. http://pza.sanbi.org.

Armelagos et al., *Historical Perspectives.* Armelagos, G. J., Brown, P. J. and B. Turner, 2005. Evolutionary, historical and political economic perspectives on health and disease. Social Science & Medicine, 61: 4, 755–765.

Armit et al., *Climate Change & Population Collapse.* Armit, I., Swindles, G. T., Becker, K., Plunkett, G. and M. Blaauw, 2014. Rapid climate change did not cause population collapse at the end of the European Bronze Age. Proceedings of the National Academy of Sciences, 111: 48, 17045–17049.

Arnold, *North Lisht Settlement*. Arnold, F., 1996. Settlement Remains at Lisht-North. Haus und Palast im Alten Ägypten, 13–21.

Art, *Dictionary of Ecology.* Art, H.W., 1993 A dictionary of ecology and environmental science. New York.

Arthington et al., *Habitat Disturbance.* Arthington, A. H., S. Hamlet, and D. R. Blühdorn, 1990. The role of habitat disturbance in the establishment of introduced warm-water fishes in Australia. In Pollard, D. A. (ed.), Introduced and Translocated Fishes and their Ecological Effects. Bureau of Rural Resources Proceedings No. 502: 61–66. Canberra.

Arthington et al., *River Ecosystems*. Arthington, A. H., Bunn, S. E., Poff, N. L. and R. J. Naiman, 2006. The challenge of providing environmental flow rules to sustain river ecosystems. Ecological Applications, 164: 1311–1318.

Arz et al., *Red Sea Dry Event*. Arz, H. W., Lamy, F. and J. Pätzold, 2006. A pronounced dry event recorded around 4.2ka in brine sediments from the northern Red Sea. Quaternary Research 66: 3, 432–441.

Ash, *North Australia Food Supply*. Ash, A. J., 2014. Factors driving the viability of major cropping investments in northern Australia – a historical analysis. Canberra.

Ashley, *Tracks, Trails & Trampling*. Ashley, G. and C. M. Liutkus, 2003. Tracks, trails and trampling by large vertebrates in a rift valley paleo-wetland, lowermost Bed II, Olduvai Gorge, Tanzania. Ichnos, 91: 2, 23–32.

Austin, *Deir el-Medina Health Care*. Austin, A., 2014. Contending with illness in ancient Egypt: A textual and osteological study of health care at Deir el-Medina. PhD, University of California, Los Angeles.

Avnaim-Katav, et al., *Shallow Marine Record*. Avnaim-Katav, S., Almogi-Labin, A., Sandler, A., Sivan, D., Porat, N. and A. Matmon, 2012. The chronostratigraphy of a Quaternary sequence at the distal part of the Nile littoral cell, Haifa Bay, Israel. Journal of Quaternary Science, 27: 7; 675–686.

Awadin et al, *Parasitic Catfish Disease*. Awadin, W., Zahran, E. and V. H. Zaki, 2012. Impact of some prevalent parasitic diseases on pathological alterations in African catfish Clarias garpienus in Dakahlyia Governorate, Egypt. In Proceedings of the 5th Global Fisheries and Aquaculture Research Conference, Faculty of Agriculture, Cairo University, Giza, Egypt, 1-3 October 2012, 16–32. Cairo.

Ayyad et al., *Mudbrick Pollen Information*. Ayyad, S.M., Krzywinski, K. and R. I. Pierce, 1992. Mudbrick as a bearer of agricultural information: an archaeopalynological study. Norwegian Archaeological Review, 24: 2; 77–96.

Ayyad, *Pollen Grain Ecology.* Ayyad, S. M., 1988. Pollen Grain Ecology of the Mediterranean Sea Coast, Egypt. PhD, University of Mansoura, Egypt.

Ayyad, *Salt Marsh Vegetation*. Ayyad, M. A. and R. E.M. El-Ghareeh., 1982. Salt marsh vegetation of the western Mediterranean desert of Egypt. Vegetatio, 491: 3-19.

Ayyad, *Vegetation & Environment*. Ayyad, M. A., 1973, Vegetation and Environment of the Western Mediterranean Coastal Land of Egypt: I. The Habitat of Sand Dunes. Journal of Ecology. 61: 2; 509–523.

Azza et al., *Papyrus Permeability*. Azza, N. G., Kansiime, F., Nalubega, M., and P. Denny, 2000. Differential permeability of papyrus and Miscanthidium root mats in Nakivubo swamp, Uganda. Aquatic Botany, 673: 169–178.

Badawy, *Nyhetep-Ptah & Ankhmahor*. Badawy, A., 1978. The Tomb of Nyhetep-Ptah at Giza and the Tomb of Ankhmahor at Saqqara. Berkeley.

Bahnasawy, etal, *Heavy Metal Plankton*. Bahnasawy, M., Khidr, A. A. and N. Dheina, 2011. Assessment of heavy metal concentrations in water, plankton, and fish of Lake Manzala, Egypt. Turkish Journal of Zoology, 352: 271–280.

Bailey & Litterick, *Water Hyacinth*. Bailey, R. G., and M. R. Litterick, 1993. The macroinvertebrate fauna of water hyacinth fringes in the Sudd swamps River Nile, southern Sudan. Hydrobiologia, 2502: 97–103.

Bailey, *Circumcision*. Bailey, E., 1996. Circumcision in ancient Egypt. The Bulletin of the Australian Centre for Egyptology 7: 15–28. Sydney.

Bailleul-Lesuer, *Avian Resources.* Bailleul-Lesuer, R., 2016. The exploitation of live avian resources in Pharaonic Egypt: A socio-economic study. Thesis; The University of Chicago.

Baines & Malek, *Cultural Atlas*. Baines, J. and J. Malek ,1980. The Cultural Atlas of Ancient Egypt. Oxford.

Baines & Yoffee, *Order, Legitimacy & Wealth*. Baines, J. and N. Yoffee, 1998. Order, legitimacy, and wealth in ancient Egypt and Mesopotamia. Santa Fe.

Baines, *Communication & Display*. Baines, J., 1989. Communication and Display: The Integration of Early Egyptian Art and Writing. Antiquity. 63: 240, 471–482.

Baines, *Religious Practice.* Baines, J., 1991. Society, Morality and Religious Practice. In Schafer, B. E., (ed.) Religion in Ancient Egypt. London.

Baines, *Schäfer & Egyptian Art.* Baines, J., 1988. Theories and Universals of Representation: Heinrich Schäfer and Egyptian Art. Art History. 8: 1, 1–25.

Baines, *Status & Purpose*. Baines, J., 1994. On the Status and Purposes of Ancient Egyptian Art. Cambridge Archaeological Journal, 4: 67–94.

Baioumy, *Lake Qarun Reconstruction*. Baioumy, H. M., Kayanne, H. and R. Tada., 2010. Reconstruction of lake-level and climate changes in Lake Qarun, Egypt, during the last 7000 years. Journal of Great Lakes Research, 362: 318–327.

Baker & Worley, *Animals & Archaeology*. Baker, P. and F. Worley., 2014. Animal Bones and Archaeology: Guidelines for Best Practice. Swindon.

Balagurunathan & Shanmugasundaram, *Microbial Biodiversity*. Balagurunathan, R. and T. Shanmugasundaram., 2015. Microbial biodiversity of selected major river basins of India. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj, (eds.) Environmental Management of River Basin Ecosystems, 575–591. Dordrecht.

Baralat, *Schistosomiasis in Egypt*. Baralat, R., 2013. Epidemiology of Schistosomiasis in Egypt: travel through time: review. J Adv Res 45: 425–432.

Baran, et al., *Reed as Roughage*. Baran, M., Z. Váradyová, S. Kráčmár, and J. Hedvábný., 2002. The common reed Phragmites australis as a source of roughage in ruminant nutrition. Acta Veterinaria 71: 4, 445–449.

Bard, *Archaeology*. Bard, K. A., 2008. An introduction to the archaeology of ancient Egypt. New York.

Bard, *Egyptian Dynastic*. Bard, K. A., 1994. The Egyptian Dynastic; A Review of the Evidence. Journal of Field Archaeology 213: 265–288.

Bard, *Emergence*. Bard, K. A., 2000. The Emergence of the Egyptian State. In Shaw, I. (ed) The Oxford History of Ancient Egypt, 57–82. Oxford.

Bard, *Encyclopaedia*. Bard, K. A., 1999. Encyclopaedia of the Archaeology of Ancient Egypt. New York.

Bard, *Ideology*. Bard, K. A., 1992. Toward an interpretation of the role of ideology in the evolution of complex society in Egypt. Journal of Anthropological Archaeology 11: 1, 1–24.

Bardaji et al., *Dra Abu el-Naga Geomorphology*. Bardají, T., Martínez-Graña, A., Sánchez-Moral, S., Pethen, H., García-González, D., Cuezva, S., Cañaveras, J.C. and A. Jiménez-Higueras, 2017. Geomorphology of Dra Abu el-Naga Egypt: The basis of the funerary sacred landscape. Journal of African Earth Sciences, 131, 233–250.

Bares, *Introduction Abusir & Saqqara 2000*. Bares, L., 2000 Introduction. n Bárta, M. and J. Krejci, (eds), Abusir and Saqqara in the Year 2000, 1–12. Prague.

Barich, *North Africa Neolithic*. Barich, B., 2016. The introduction of Neolithic resources to North Africa: A discussion in light of the Holocene research between Egypt and Libya. Quaternary International, 410: 198–216.

Barich, *People, Water & Grain*. Barich, B. E., 1998. People, Water and Grain: The Beginning of Domestication in the Sahara and the Nile Valley Vol. 98. Roma.

Baridon, *Les Jardins.* Baridon, M., 1998. Les jardins: paysagiste, jardiniers, poètes. Paris.

Barkworth et al., *Flora*. Barkworth, M. E., Capels, K. M., Long, S. and M. B. Piep, (eds), 2003. Flora of North America north of Mexico. Volume 25: Magnoliophyta: Commelinidae in part: Poaceae, part 2. Oxford.

Barrett, *Neolithic Revolution*. Barrett, J., 2011. The Neolithic revolution: an ecological perspective. In Hadjikoumis, A., Robinson, E. and S. Viner. (eds), Dynamics of Neolithisation in Europe: Studies in Honour of Andrew Sherratt, 66–89. London.

Barros, etal, *Egyptian Mongoose Expansion*. Barros, T., Carvalho, J., Pereira, M.J.R., Ferreira, J.P. and C. Fonseca, 2015. Following the trail: factors underlying the sudden expansion of the Egyptian mongoose Herpestes ichneumon in Portugal. PloS one, 10: 8, 1–18.

Bárta & Bezdek, *Beetles & Decline*. Bárta, M. and A. Bezdek, 2008. Beetles and the decline of the Old Kingdom: climate change in ancient Egypt. In Vymazalová, H. and M. Bárta, (eds), Chronology and Archaeology in Ancient Egypt The Third Millennium B.C. Proceedings of the Conference Held in Prague June 11–14, 2007, 214–222. Prague.

Bárta & Dulíková, *Rhetoric of Power*. Bárta. M and V. Dulíková, 2013. Divine and Terrestrial: The power of rhetorics in Ancient Egypt the case of Nyuserra. In F, Coppens, F., J. Janák, J. and H. Vymazalová (eds), 7th Symposium on Egyptian Royal Ideology: Royal versus Divine Autority. Acquisition, Legitimization and Renewal of Power, June 26-28, 2013, 31-48. Prague.

Bárta et al., *Abusir South 2012*. Bárta, M., Vymazalová, H., Dulíková, V., Arias, K., Megahed, M., and L. Varadzin, 2014. Exploration of the Necropolis at Abusir South in the Season of 2012. Preliminary Report. Ägypten und Levante, 24: 15–38.

Bárta, *Abusir Paradigm*. Bárta, M., 2016. 'Abusir Paradigm' and the Beginning of the Fifth Dynasty. In Hein, I., Billing, N. and E. Meyer-Dietrich (eds), The Pyramids: Between Life and Death. Proceedings of the Workshop Held at Uppsala University, Uppsala, May 31st - June 1st, 2012, 51–74. Uppsala.

Bárta, *Abusir* V. Bárta, M., 2001. Abusir V; The Cemeteries at Abusir South I. Prague.

Bárta, *Architectural Innovations*. Bárta, M., 2006. Architectural Innovations in the development of the non-royal tomb during the reign of Nyuserra. In Janosi, P. (ed.), Structure and Significance; Vol. 25, Thoughts on Ancient Egyptian Architecture, 105–130. Vienna.

Bárta, *Biblical Archaeology & Egyptology*. Bárta, M., 2010. 'Biblical Archaeology' and Egyptology. Old and Middle Kingdom Perspective. In Levy, T. E. (ed.), Historical Biblical Archaeology and the Future. The New Pragmatism, 99–122. London.

Bárta, *Collapse Hidden in Success.* Bárta, M., 2014. Collapse Hidden in Success: Rise and Fall of the Old Kingdom. KMT 251: 18–28.

Bárta, *In Mud Forgotten*. Bárta, M., 2013. In mud forgotten: Old Kingdom palaeoecological evidence from Abusir. Studia Quaternaria, 302: 75–82.

Bárta, *Journey to the West.* Bárta, M., 2011. Journey to the West: The World of the Old Kingdom Tombs in Ancient Egypt, Prague.

Bárta, *Kings, Viziers & Courtiers*. Barta, M., 2013. Kings, Viziers and Courtiers. In Morenó García, J. C. (ed.), Ancient Egyptian Administration, 153–176. Leiden/Boston.

Bárta, *Long term Short term*. Bárta, M., 2015. Long Term or Short Term? Climate Change and the Demise of the Old Kingdom. In Kerner, S., Dann, R. and P. Bangsgaard, (eds), Climate and ancient societies, 177–196. Copenhagen.

Bárta, *Old Kingdom Kingship*. Bárta, M., 2013. Egyptian Kingship during the Old Kingdom. In A. J. Hill, P. Jones and J. A. Morales (eds), Experiencing power, generating authority. Cosmos, Politics, and the Ideology of Kingship in Ancient Egypt and Mesopotamia, 257–283. Philadelphia.

Bárta, *Ptahshepses Junior II*. Bárta, M., 2000. The Mastaba of Ptahshepses Junior II at Abusir. In Bietak, M. (ed.), Ägypten und Levante/Egypt and the Levant, 10: 45–66.

Bárta, *Punctuated Equilibrium.* Bárta, M., 2015. Ancient Egyptian History as an Example of Punctuated Equilibrium: An Outline. In Der Manuelian, P. and T. Schneider, (eds), Towards a New History for the Egyptian Old Kingdom: Perspectives on the Pyramid Age, 1–17. Leiden/Boston.

Bárta, *Speakers of Nekhen*. Bárta, M., 2013. The sun kings of Abusir and their entourage: 'Speakers of Nekhen of the King'. In Bárta, M. and H. Küllmer (eds), Diachronic Trends in Ancient Egyptian History. Studies dedicated to the memory of Eva Pardey, 24–31. Prague.

Bates, *Ancient Egyptian Fishing*. Bates, O., 1917. Ancient Egyptian Fishing. Harvard.

Baumgartel, *Predynastic Egypt.* Baumgartel, E. J., 1970. Predynastic Egypt. In Edwards, I.E.S., Gadd, C.J., and N.G.L. Hammond, (eds), The Cambridge Ancient History, 463–498. Cambridge.

Bayon et al., *Weathering & Land Use.* Bayon, G., Dennielou, B., Etoubleau, J., Ponzevera, E., Toucanne, S. and S. Bermell, 2012. Intensifying weathering and land use in Iron Age Central Africa. Science 335: 1219–1221.

Beare & Zedler, *Cattail Invasion & Resistance*. Beare, P. A. and J. B. Zedler, 1987. Cattail invasion and persistence in a coastal salt marsh: the role of salinity reduction. Estuaries, 102: 165–170.

Beierkuhnlein, *Occurrence & Ecology*. Beierkuhnlein, C., 2015. Bos primigenius in Ancient Egyptian art–historical evidence for the continuity of occurrence and ecology of an extinct key species. Frontiers of Biogeography, 7: 3, 107–118.

Beinart & Hughes, *Environment & Empire*. Beinart, W. and L. Hughes, 2007. Environment and Empire. Oxford.

Bell, *Dark Age Egypt*. Bell, B., 1971. The Dark Ages in Ancient History, I. The First Dark Age in Egypt. American Journal of Archaeology, 75: 1–26

Bell, *Oldest Nile Floods*. Bell, B., 1970. The Oldest Records of the Nile Floods. The Geographical Journal, 136: 4, 569–573.

Ben-Yaacov & Yom-Tov, *Egyptian Mongoose*. Ben-Yaacov, R. and Y. Yom-Tov, 1983. On the biology of the Egyptian mongoose, Herpestes ichneumon, in Israel. Zeitschrift für Säugetierkunde, 481, 34–45.

Benito et al., *Holocene Flooding*. Benito, G., Macklin, M. G., Zielhofer, C., Jones, A. F., and M. J. Machado, 2015. Holocene flooding and climate change in the Mediterranean. Catena, 130, 13–33.

Bergoffen, *Trade in Northern Sinai*. Bergoffen, C. J., 1991. Overland Trade in Northern Sinai: The Evidence of Late Cypriot Pottery. Bulletin of the American Schools of Oriental Research 284: Nov., 59–76.

Bernhardt et al., *Rapid Pollen Response*. Bernhardt, C.E., Stanley, J. D. and B. P. Horton, 2011. Wetland vegetation in Manzala lagoon, Nile delta coast, Egypt: rapid responses of pollen to altered Nile hydrology and land use. Journal of Coastal Research, 27: 4, 731–737.

Bernhardt, *Delta Vegetation*. Bernhardt, C. E., Horton, B. P., and J. D. Stanley, 2012. Nile Delta vegetation response to Holocene climate variability. Geology, 407, 615–618.

Bhaduri & Skarstein, *Agricultural Development.* Bhaduri, A., and R. Skarstein (eds), 1997. Economic development and agricultural productivity. Cheltenham.

Bietak, *Egypt & Canaan Middle Bronze Age*. Bietak, M., 1991. Egypt and Canaan during the Middle Bronze Age. Bulletin of the American Schools of Oriental Research 281: Feb, 27–72.

Bietak, *Nubia in Review*. Bietak, M., 1993. Review of Säve-Söderbergh, Middle Nubian Sites. Bibliotheca Orientalis Leiden 50: 3, 85–91.

Binder, *The Physical World*. Binder, S., 2000. representing the Physical World. In Donovan, L. and K. McCorquodale (eds), Egyptian Art, Principles and Themes in Wall Scenes Prism Archaeological Series 6, 29–36. Guizeh.

Bintliff, Time, *Process & Catastrophism*. Bintliff. J., 2002. Time, process and catastrophism in the study of Mediterranean alluvial history: A review, World Archaeology, 33: 3, 417–435.

Bittel, *Ausgrabungen in Bogazkoy*. Bittel, K., 1969. Bericht iiber die Ausgrabungen in Bogazkoy im Jahre 1968. Mitteilungender Deutschen Orientgesellschaft 101, 5–13.

Blackman & Apted, *Meir* I. Blackman, A.M. and M.R. Apted, 1914. The Rock Tombs of Meir. Part I; The Tomb-Chapel of Ukh-hotep's Son Senbi. London.

Blackman, *Meir* III. Blackman, A., 1915. The Rock Tombs of Meir. Part III; The tomb-chapel of Ukh-hotp son of Ukh-hotp and Mersi (B, No. 4). London.

Blackman, *Meir* IV. Blackman, A.M., 1924. The Rock Tombs of Meir. Part IV; The Tomb-Chapel of Pepi'onkh the Middle Son of Sebkhotpe and Pekhernefert. London.

Blackman, *Meir* V. Blackman, A. M., and M. R. Apted, 1953. The Rock Tombs of Meir. Part V; The Tomb-Chapels A, No. 1 that of Ni-'ankh-pepi the Black A, No. 2 that of Pepi'onkh with the "Good Name" of Heny the Black, A, No. 4 that of Hepi the Black, D, No. 1 that of Pepi, and E, Nos. 1-4 those of Meniu, Nenki, Pepi'onkh and Tjetu. London.

Blanchet et al., *Nile River Watershed Erosion.* Blanchet C. L., Frank M. and S. Schouten, 2014. Asynchronous Changes in Vegetation, Runoff and Erosion in the Nile River Watershed during the Holocene. PLoS ONE 912: 1–18. e115958. doi: 10.1371/journal.pone.0115958

Blench & MacDonald, *Chickens*. Blench, R. M. and K.C. MacDonald, 2008. Chickens. Cambridge World History of Food, 496–499. Cambridge.

Blench, *Pigs in Africa*. Blench, R. M., 2000. A history of pigs in Africa. In Blench, R. M. and K. MacDonald (eds), Origins and development of African livestock: Archaeology, genetics, linguistics and ethnography; 355–367. Oxford.

Blondel, *Mediterranean Landscapes*. Blondel, J., 2006. The 'Design' of Mediterranean Landscapes: A Millennial Story of Humans and Ecological Systems during the Historic Period. Human Ecology 34: 713–729.

Boar et al., *Biomass Allocation*. Boar, R. R., Harper, D. M., and C. S. Adams, 1999. Biomass Allocation in Cyperus papyrus in a Tropical Wetland, Lake Naivasha, Kenya1. Biotropica 313: 411–421.

Boar, *Papyrus Water Level Response*. Boar, R. R., 2006. Responses of a fringing Cyperus papyrus L. swamp to changes in water level. Aquatic Botany 84: 2, 85–92.

Boessneck, *Riesige Hausgänse*. Boessneck, J., 1991. Riesige Hausgänse aus der Spätzeit des alten Ägypten. Archiv für Geflügelkunde 55: 105–10.

Bogaard, *Garden Agriculture*. Bogaard, A., 2005 'Garden agriculture' and the nature of early farming in Europe and the Near East, World Archaeology 37: 2, 177–196.

Bolshakov, *Boatmen Jousting*. Bolshakov, A., 1993. The Scene of the Boatmen Jousting in Old Kingdom Tomb Representations, Bulletin de la Société d'Égyptologie de Genève 17: 29–39.

Bolshakov, *Fourth Dynasty Osiris?* Bolshakov, A. O., 2001. Osiris in the Fourth Dynasty Again? The false door of Jntj, MFA 31.781. In Györy, H. (ed.), Mélanges offerts à Edith Varga le lotus qui sort de terre", Budapest: [Bulletin du Musée Hongrois des Beaux-Arts. Supplément-2001], 65–80.

Bolshakov, *Murals as Principle.* Bolshakov, A. O., 2007. Arrangement of Murals as a Principle of Old Kingdom Tomb Decorations. Internet Beitrage zur Agyptologie und Sudanarchaologie. Vol. 6. Dekorierte Grabanlangen in Alten Reich Methodik und Interpretation: 37–60.

Bolton & Brown, *Grass Species Photosynthesis*. Bolton, J. K. and R. H. Brown, 1980. Photosynthesis of grass species differing in carbon dioxide fixation pathways V. Response of Panicum maximum, Panicum milioides and tall fescue Festuca arundinacea to nitrogen nutrition. Plant Physiol 66: 97–100.

Boozer, *Social Impact*. Boozer, A. L., 2015. The Social Impact of Trade and Migration: The Western Desert in Pharaonic and Post-Pharaonic Egypt. Oxford Handbooks Online, DOI: 10.1093/oxfordhb/9780199935413.013.37.

Borchardt, *Sahure II*. Borchardt, L., 1913 Das Grabdenkmal des Königs Sahu-re II. Leipzig.

Borck, et al, *Social networks as survival networks.* Borck, L., Mills, B. J., Peeples, M. A. and J. J. Clark, 2015. Are social networks survival networks? An example from the Late Prehispanic U.S. Southwest. Journal of Archaeological Method and Theory 22: 1, 33–57.

Borsch, *Environment & Population*. Borsch, S. J., 2004. Environment and population: the collapse of large irrigation systems reconsidered. Comparative studies in society and history, 4603: 451-468.

Boulos & Fahmy, *Ancient Egyptian Grasses*. Boulos, L. and A. G. E. Fahmy, 2007. Grasses in Ancient Egypt. Kew Bulletin 62: 3, 507–511.

Bowe, *Early Garden Making*. Bowe, P., 2017. The early development of garden making c. 3000–c. 2000 BCE. Studies in the History of Gardens and Designed Landscapes 37:3, 231–241.

Boyd et al., *Interpretation of pH*. Boyd C. E., Tucker C. S. and R. Viriyatum, 2011 Interpretation of pH, acidity and alkalinity in aquaculture and fisheries. North American Journal of Aquaculture 734: 403–408.

Boyd, *Water Quality*. Boyd, C. E., 2015. Water quality: an introduction. Dordrecht.

Brass, *Cattle Cult Origins*. Brass, M., 2003. Tracing the origins of the Ancient Egyptian cattle cult. In A. Eyma & C. Bennett (eds), A delta-man in Yebu: occasional volume of the Egyptologists' Electronic Forum 1: 101–110. Parkland.

Brass, *Cattle Domestication Reassessment*. Brass, M., 2018. Early North African Cattle Domestication and Its Ecological Setting: A Reassessment. Journal of World Prehistory 31: 81–115. https://doi.org/10.1007/s10963-017-9112-9

Bravard & Petit, *Geomorphology*. Bravard, J. P. and F. Petit, 2015. Geomorphology of Streams and Rivers. In Likens, G. (ed.), The Encyclopedia of Inland Waters, 387–395. Amsterdam.

Brewer & Friedman, *Fishing*. Brewer, D. J., and R. F. Friedman, 1989. Fish and fishing in ancient Egypt. Warminster.

Brewer et al., *Domestic Egypt*. Brewer, D. J., Redford, D. B., and S. Redford, 1994. Domestic plants and animals: the Egyptian origins. Warminster.

Brewer, *Beyond Pharaohs*. Brewer, D. J., 2012. The Archaeology of Ancient Egypt; Beyond Pharaohs. Cambridge.

Brewer, *Predynastic Temperatures*. Brewer, D. J., 1991. Temperature in Predynastic Egypt inferred from the Remains of Nile Perch. World Archaeology 223: Archaeology and Arid Environments, 288–303.

Brier, *Infectious Diseases.* Brier, B., 2004. Infectious diseases in ancient Egypt. Infectious disease clinics of North America 181: 17–27.

Brierly et al., *Green Sahara Pastoralism*. Brierley, C., Manning, K. and M. Maslin, 2018. Pastoralism may have delayed the end of the green Sahara. Nature communications 91: 1–9.

Britton, *Papyrus Swamps*. Britton, P. L., 1978. Seasonality, Density and Diversity of Birds of a Papyrus Swamp in Western Kenya. Ibis 120: 4, 450–466.

Bronk Ramsay et al., *Radiocarbon Chronology*. Bronk. F., Ramsay W., Dee, M., Rowland, J., Higham, T., Harris, S., Quiles, A., Wild, E., Marcus, E. and A. Shortland, 2010. Radiocarbon-based Chronology for Dynastic Egypt. Science 328: 1554–1557.

Brouwer et al., *Irrigation Methods*. Brouwer, C., Prins, K., Kay, M and M. Heibloem, 1990. Irrigation Water Management. Training Manual 3: Irrigation Methods. Food and Agriculture Organisation of the United Nations: Land and Water Development Division. Italy.

Brovarski, *Senedjemib* I. Brovarski, E., 2000. The Senedjemib Complex Part I. Boston.

Brown et al., *Fertile Crescent Domestication*. Brown, T. A., Jones, M. K., Powell, W. and R. G. Allaby, 2009. The complex origins of domesticated crops in the Fertile Crescent. Trends in Ecology and Evolution 242: 103–109.

Brown, *Alluvial Geoarchaeology*. Brown, A. G., 1997. Alluvial Geoarchaeology. Floodplain Archaeology and Environmental Change. Cambridge.

Brughmans, *Connecting the Dots*. Brughmans, T., 2010. Connecting the dots: towards archaeological network analysis. Oxford Journal of Archaeology 293: 277–303.

Brughmans, et al., *Inter-settlement Visibility*. Brughmans, T., Keay, S. and G. Earl, 2015. Understanding Inter-settlement Visibility in Iron Age and Roman Southern Spain with Exponential Random Graph Models for Visibility Networks. Journal of Archaeological Method and Theory 221: 58-143.

Brughmans, *Thinking Through Networks*. Brughmans, T., 2013. Thinking through networks: A review of formal network methods in archaeology. Journal of Archaeological Method and Theory,204: 623–662.

Bruins, *Dating Pharaonic Egypt*. Bruins, H. J., 2010. Dating Pharaonic Egypt. Science 328; 1489–1490.

Brundage, *Grazing as Management* . Brundage, J., 2010. Grazing as a management tool for controlling Phragmites australis and restoring native plant biodiversity in wetlands. PhD, University of Maryland.

Brunner-Traut, *Epilogue*. Brunner-Traut, E., 1986, Epilogue. In Schäfer, H., Brunner-Traut, E. and J. Baines (trans.), Principles of Egyptian Art, 421–426. Oxford.

Bryant el al., *Nutritive Content*. Bryant, F.C., Kothmann, M.M., and L.B. Merril, 1980. Nutritive content of sheep, goat and white-tailed deer diets on excellent condition rangeland in Texas. J. Range Manage. 33: 410–414.

Bryson, *Archaeoclimatology*. Bryson, R., 2005. Archeoclimatology. In Oliver, J. E., Fairbridge, R. W., and M. Rampino, Michael (eds.), Encyclopedia of world climatology: Encyclopedia of earth sciences series, 58–63. Dordrecht.

Bryson, et al., *Mycenaean Decline*. Bryson, R. A., Lamb, H. H., and D. L. Donley, 1974. Drought and the decline of Mycenae. Antiquity, XLVIII: 46–50.

Bukaveckas, *Rivers*. Bukaveckas, P. A., 2015. Rivers. In Likens, G. E. (ed.), Encyclopedia of inland waters Vol. 1, 721–732. Amsterdam.

Bunbury & Lutley, *Nile on the Move*. Bunbury, J. and K. Lutley, 2008. The Nile on the move. Egyptian Archaeology 32: 3–5.

Bunbury etal., *Holocene Nile @ Karnak*. Bunbury, J. M., Graham, A. and M. A. Hunter, 2008. Stratigraphic landscape analysis: charting the Holocene movements of the Nile at Karnak through ancient Egyptian time. Geoarchaeology 233: 351–373.

Bunbury, *Development in Nile Flood Zone*. Bunbury, J., 2010. The Development of the Capital Zone within the Nile Floodplain. In Subías, E. Azara, P., Carruesco, J., Fiz, I. and R. Cuesta (eds), The Space of the City in Graeco-Roman Egypt Image and Reality, 211–218. Tarragona.

Bunbury, *Memphite Floodplain Landscape*. Bunbury, J., 2013. Geomorphological development of the Memphite floodplain over the past 6,000 years. Studia Quaternaria, 30: 2, 61–67.

Bunbury, *Nile River Development*. Bunbury, J. M., 2010. The Development of the River Nile and the Egyptian Civilization: A Water Historical Perspective with Focus on the First Intermediate Period. A History of Water, Series II, 2: 52–71.

Bunn & Arthington, *Altered Flow Regimes*. Bunn, S. E. and A. H. Arthington, 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management 30: 4, 492–507.

Bunson, *Encyclopaedia*. Bunson, M., 1991. The Encyclopaedia of Ancient Egypt. New York.

Büntgen et al., *Climate & Human Susceptibility*. Büntgen, U., Tegel, W., Nicolussi, K., McCormick, M., Frank, D., Trouet, V., Kaplan, K., Herzig, F., Heussner, K., Wanner, H., Luterbacher, J. and J. Esper, 2011. 2500 years of European climate variability and human susceptibility. Science 3316017: 578–582.

Burchard, *Hunting Climatic Impact*. Burchard, I., 1998. Anthropogenic impact on the climate since man began to hunt. Palaeogeography, Palaeoclimatology, Palaeoecology, 1391: 1-14.

Burn, *Environment*. Burn, J. W., 2012. Ancient Egypt and its Environment. In McFarlane, A. and A. Mourad eds, Behind the scenes: Daily life in Old Kingdom Egypt, 1–12. Oxford.

Burn, *Fishing & OK Climate Change*. Burn, J. W., 2014. Climate Change, Fishing and the Nile: Changes in Fishing Techniques and Technologies at the End of the Old Kingdom. In Bartá, M. and J. Janák (eds), Profane Landscapes, Sacred Spaces. Publication of the Proceedings of the Conference held by The Czech Institute of Egyptology, Charles University, Prague, 26th - 27th June 2014. Equinox eBooks Publishing, United Kingdom. May 2019. ISBN 981781794098. https://www.equinoxpub.com/home/view-chapter/?id=29015.

Burn, *Marshlands & OK Famine*. Burn, J. W. 2014. Marshlands, drought and the great famine: on the significance of marshlands to the end of the Old Kingdom. In Accetta, K., Fellinger, R., Lourenco Goncalves, P., Musselwhite, S. and W. P. Van Pelt (eds), Publications of the Proceedings of CRE XIV - Crossing Boundaries, 34–48. Cambridge.

Burn, *Mehu*. Burn, J. W. 2011. The Pyramid texts and tomb decoration in Dynasty Six: the tomb of Mehu at Saqqara. In Binder, S. (ed.), Bulletin of the Australian Centre for Egyptology, 22: 17–34.

Burn, *Pyramid Texts*. Burn, J. W. 2012. An Ecological Approach to Determine the Potential Influence that The Pyramid Texts had upon Dynasty Six Tomb Decorations. In Bárta, M., Coppens, F., and J. Krejčí, (eds), Abusir and Saqqara in the Year 2010, 233–245. Prague.

Bussmann, *Scaling the State*. Bussmann, R., 2014. Scaling the State: Egypt in the Third Millennium BC. Archaeology International 17: 79–93.

Butzer & Enfield, *Critical Perspectives*. Butzer, K. and G. H. Engield, 2012. Critical Perspectives on Historical Collapse. Proceedings of the National Academy of Sciences, March: 3628–3631.

Butzer & Hansen, *Desert & River*. Butzer, K. and C. Hansen, 1968. Desert and river in Nubia: geomorphology and prehistoric environments at the Aswan Reservoir. Madison.

Butzer et al, *Urban Geoarchaeology*. Butzer, K. W., Butzer, E. and S. Love, 2013. Urban geoarchaeology and environmental history at the Lost City of the Pyramids, Giza: synthesis and review. Journal of Archaeological Science 408: 3340–3366.

Butzer et al., *East African Lake Levels*. Butzer, K. W., Isaac, G. L., Richardson, J. L. and C Washbourn-Kamau, 1972. Radiocarbon dating of East African lake levels. Science 175: 4026, 1069–1076.

Butzer, *Before Agriculture*. Butzer, K.W., 1970 Physical Conditions in Eastern Europe, Western Asia and Egypt Before the Period of Agricultural and Urban Settlement. In Edwards, I. E. S., Gadd, C. J. and N. G. L. Hammond (eds), The Cambridge Ancient History, 35–69. Cambridge.

Butzer, *Archaeology & Geology*. Butzer, K. W., 1960. Archaeology and geology in ancient Egypt. Science 1323440: 1617–1624.

Butzer, *Collapse*. Butzer, K. W., 2012. Collapse, Environment, and Society. Proceedings of the National Academy of Sciences. March: 3632–3639.

Butzer, *Context in Archaeology*. Butzer, K. W., 1980. Context in archaeology: an alternative perspective. Journal of Field Archaeology 7: 417–422.

Butzer, *Cross-Disciplinary Geoarchaeology*. Butzer, K. W., 2008. Challenges for a cross-disciplinary geoarchaeology: The intersection between environmental history and geomorphology. Geomorphology 101; 402–411.

Butzer, *Desert in Flood*. Butzer, K.W., 2001. When the desert was in flood. Environmental history of the Giza Plateau. Aeragram: Newsletter of the Ancient Egypt Research Associates 5: 1, 3–5. Boston.

Butzer, *Discontinuity*. Butzer, K. W., 1997. Sociopolitical discontinuity in the Near East c. 2200 BCE: Scenarios from Palestine and Egypt. In Dalfes, N., Kukla, G. and H. Weiss (eds), Third Millennium BC Climate Change and Old World Social Collapse, 245–295. New York and Berlin.

Butzer, *Ecological Archaeology*. Butzer, K. W., 1975. The Ecological Approach to Archaeology: Are We Really Trying? American Antiquity: 106–111.

Butzer, *Environment & Human Ecology*. Butzer, K. W., 1959. Environment and human ecology in Egypt during predynastic and early dynastic times. Reprinted from Bulletin de la Societé de Géographie d'Egypte, 32, 43–87.

Butzer, *Geological Deposits*. Butzer, K. W., 1959. Some recent geological deposits in the Egyptian Nile Valley. Geographical Journal: 75–79.

Butzer, *Human Ecology*. Butzer, K. W., 1982. Archaeology as human ecology: method and theory for a contextual approach. Cambridge.

Butzer, *Hydraulic Egypt*. Butzer, K. W., 1976. Early Hydraulic Civilisation in Egypt: A Study in Cultural Ecology. Chicago.

Butzer, *Near East Environmental Change*. Butzer, K. W., 1995. Environmental change in the Near East and human impact on the land. In Sasson, J. M. 9ed.), Civilizations of the Ancient Near East 1: 123-51. New York.

Butzer, *Nile Valley Pleistocene*. Butzer, K. W., 1980. Pleistocene history of the Nile Valley in Egypt and Lower Nubia. In Williams, M. A. J. and H. Faure (eds), The Sahara and the Nile: Quaternary Environments and Prehistoric Occupation in Northern Africa, 253–280. Rotterdam.

Butzer, *Organisms or Systems*? Butzer, K. W., 1980. Civilizations: Organisms or Systems? American Scientist 68: 44–58.

Butzer, *Palaeographic Near East*. Butzer, K. W., 1958. The near East during the last glaciation: a palaeogeographical sketch. The Geographical Journal, 1243: 367–69.

Butzer, *Variation & Discontinuities*. Butzer, K. W., 1984. Long-term Nile flood variation and political discontinuities in pharaonic Egypt. In Clark, J. and S. Brandt (eds), From Hunters to Farmers: The Causes and Consequences of Food Production in Africa, 102–112. Berkeley.

Buzon & Bombak, *Nile Valley Dental*. Buzon, M. R. and A. Bombak, 2010. Dental disease in the Nile Valley during the New Kingdom. International Journal of Osteoarchaeology 204: 371–387.

Buzon & Simonetti, *Nile Valley Strontium Isotope Variability*. Buzon, M. R. and A. Simonetti, 2013. Strontium isotope 87Sr/86Sr variability in the Nile Valley: identifying residential mobility during ancient Egyptian and Nubian sociopolitical changes in the New Kingdom and Napatan periods. American Journal of Physical Anthropology 151: 1, 1–9.

Cable et al., *Global Change & Disease Control*. Cable, J., Barber, I., Boag, B., Ellison, A. R., Morgan, E. R., Murray, K., Pascoe, E. L., Sait, S. M., Wilson, A. J. and M. Booth, 2017. Global change, parasite transmission and disease control: lessons from ecology. Philosophical Transactions of the Royal Society B: Biological Sciences 372: 1719, 1–17.

Callaway, *Fowl Domination*. Callaway, E., 2014. Ornithology: Fowl domination. Nature 515: 490–491.

Callaway, *Positive Interactions*. Callaway, R.M., 1995 Positive interactions among plants. Botanical Review 61: 306–349.

Camberlin, *Nile Basin Climates*. Camberlin, P., 2009. Nile Basin Climates. In Dumont, H. J. (ed.), The Nile: Origin, Environments, Limnology and Human Use, 307–333. Dordrecht.

Campbell et al., *Concepts & Connections*. Campbell, N. A., 2003 Biology: concepts and connections. San Francisco.

Camps, *Berber Origins*. Camps, G., 2008. Beginnings of pastoralism and cultivation in north-west Africa and the Sahara: origins of the Berbers. In Clark, J. D. (ed.), The Cambridge History of Africa, Volume 1: 548–623. Cambridge.

Cant & Morris, *Geographies of Art*. Cant, S. G. and N. J. Morris, 2006. Geographies of art and the environment. Social and cultural geography 7: 6, 857–861.

Cappers, *Reconstructing Agriculture*. Cappers, R. T. J., 2006. The reconstruction of agricultural practices in Ancient Egypt: an ethnoarchaeobotanical approach. Palaeohistoria, 47: 48, 429–446.

Caracuta et al., *Dakhleh Archaeobotancal*. Caracuta, V., Fiorentino, G., Davoli, P. and R. Bagnall, 2015. The archaeobotanical analysis at Amheida Dakhleh Oasis–Egypt, preliminary results. Supplemento Vol. CXL: 45–48.

Carroll, et al., *Holocene Climate Change*. Carroll, F. A., Hunt, C. O., Schembri, P. J., and A. Bonanno, 2012. Holocene climate change, vegetation history and human impact in the Central Mediterranean: evidence from the Maltese Islands. Quaternary Science Reviews, 52, 24-40.

Cary & Weerts, *Growth & Water Temperature*. Cary, P.R. and P.G. Weerts, 1983. Growth of Salvinia molesta as affected by water temperature and nutrition I. Effects of nitrogen level and nitrogen compounds. Aquatic Botany 162: 163–172.

Chabwela, *Habitat Selection*. Chabwela, H., Chomba, C., Kaweche, G., and A. Mwenya, 2017. Habitat Selection by Large Mammals in South Luangwa National Park, Zambia. Open Journal of Ecology 703: 179-192.

Chambers et al., *Phragmites Ecology*. Chambers, R. M., Meyerson, L. A., and K. Dibble, 2012. Ecology of Phragmites australis and responses to tidal restoration. In Roman, C. T., and D. M. Burdick (eds), Tidal Marsh Restoration, 81–96. Washington.

Chambers et al., *Phragmites Expansion*. Chambers, R. M., Osgood, D. T., Bart, D. J. and F. Montalto, 2003. Phragmites australis invasion and expansion in tidal wetlands: interactions among salinity, sulfide, and hydrology. Estuaries 262B: 398–406.

Chapman et al, *Swimming Upside Down*. Chapman, L., Kaufman, L. and C. Chapman.,1994. Why swim upside down? A comparative study of two Mochokid catfishes, Copeia 1: 130–135.

Chapman et al., *Papyrus Swamp Variations*. Chapman, L. J., Chapman, C. A., Brazeau, D. A., McLaughlin, B. and M. Jordan, 1999. Papyrus Swamps, hypoxia and faunal diversification: variation among population of Barbus Neumayer. Journal of Fish Biology 54: 310–327.

Chapman, et al., *Limnological Observations*. Chapman, L.J., Chapman, C.A. and T. L. Crisman, 1998. Limnological observations of a papyrus swamp in Uganda: Implications for fish faunal structure and diversity, Verh. Internat. Verein. Limnol. 26: 1821–1826.

Chase-Dunn et al., *Power & Size*. Chase-Dunn, C., Alvarez, A. and D. Pasciuti, 2005. Power and Size: Urbanization and Empire Formation in World-Systems. In Chase-Dunn, C. and E. N. Anderson (eds), Historical Evolution of World Systems, 92–112. Basingstoke.

Chew, *Harappa to Mesopotamia*. Chew, S., 2005. From Harappa to Mesopotamia and Egypt to Mycenae: Dark Ages, Hegemonial Shifts, and Environmental/Climactic Changes, 2200 B.C.-700 B.C. In Chase-Dunn, C. and E. N. Anderson, (eds), Historical Evolution of World Systems, 52–74. Basingstoke.

Church & Bell, *Settlement Patterns*. Church, R. L. and T. L. Bell., 1988. An Analysis of Ancient Egyptian Settlement Patterns Using Location-Allocation Covering Models. Annals of the Association of American Geographers 784: 701-714.

Cílek et al., *Lake Abusir*. Cílek, V., Bárta, M., Lisá, L., Pokorná, A., Juříčková, L., Brůna, V., Moniem, A., Mahmoud, A., Bajer, A., Novak, J. and J. Beneš, 2012. Diachronic development of the Lake of Abusir during the third millennium BC, Cairo, Egypt. Quaternary International 266: 14-24.

Clarke et al., *Climate Change & Social Transformation*. Clarke, J., Brooks, N., Banning, E., Bar-Matthews, M., Campbell, S., Clare, L., Cremaschi, M., di Lernia, S., Drake, N., Gallinaro, M., Manning, S., Nicoll, K., Philip, G., Rosen, R., Schoop, U., Tafuri, M., Weninger, B. and A. Zerboni, 2015. Climatic changes and social transformations in the Near East and North Africa during the 'long'4th millennium BC: A comparative study of environmental and archaeological evidence. Quaternary Science Reviews: 1–26.

Clayton, *Chronicle*. Clayton, P. A., 1994. Chronicle of the Pharaohs. London.

Clement, *Caries*. Clement A., 1958. The antiquity of caries. Br Dent Journal104: 115–123.

Cleuziou, *Archaeology & Climate*. Cleuziou, S., 2009. Extracting wealth from a land of starvation by creating social complexity: A dialogue between archaeology and climate? Comptes Rendus Geoscience 3418: 726–738.

Cline & Cline, *Amarna Social Networks*. Cline, D. H. and E. H. Cline, 2015. Text Messages, Tablets, and Social Networks: The "Small World" of the Amarna Letters. In: Mynářová, J., Onderka, P. and P. Pavúk (eds), There and Back Again – Crossroads II. Proceedings of an International Conference Held in Prague, September 15–18, 2014, 17–44. Prague.

Clutton-Brock, *Cattle*. Clutton-Brock, J., 2014. Cattle in Ancient North Africa. In Clutton-Brock, J. (ed.), The walking larder: patterns of domestication, pastoralism, and predation, 200–206. London.

Clutton-Brock, *Domestic Animals*. Clutton-Brock, J., 2014. The spread of domestic animals in Africa. In Andah, B., Okpoko, A., Shaw, T. and P. Sinclair (eds), The Archaeology of Africa: food, metals and towns, 61–70. London.

Clutton-Brock, *The Walking Larder.* Clutton-Brock, J., 1989 The Walking Larder. Patterns of Domestication, Pastoralism, and Predation. London.

Collar et al., *Networks in Archaeology*. Collar, A., Coward, F., Brughmans, T. and B. Mills, 2015. Networks in Archaeology: Phenomena, Abstraction, Representation. Journal of Archaeological Method and Theory 221: 1–32.

Collon, *Ancient Near Eastern Art*. Collon, D., 1995. Ancient Near Eastern Art. Berkeley.

Coltherd, *Domestic Fowl*. Coltherd, J. B., 1966. The domestic fowl in ancient Egypt. Ibis 1082: 217–223.

Conard, *Waterlilies*. Conard, H. S., 1905. The waterlilies: a monograph of the genus Nymphaea. Washington.

Connif et al., *Nile Water & Agriculture*. Conniff, K., Molden, D., Peden, D. and S. B. Awulachew, 2012. Nile water and agriculture: past present and future. In Awulachew, S. B.; Smakhtin, V.; Molden, D. and D. Peden (eds), The Nile River Basin: Water, Agriculture, Governance and Livelihoods, 5–29. New York.

Connolly et al., *Origins of Animal Husbandry*. Conolly, J., Colledge, S., Dobney, K., Vigne, J. D., Peters, J., Stopp, B., Manning, K and S. Shennan, 2011. Meta-analysis of zooarchaeological data from SW Asia and SE Europe provides insight into the origins and spread of animal husbandry. Journal of Archaeological Science 383: 538–545.

Connor & Marks, *High Water Adaptations*. Connor, D. and A. Marks, 1986. The terminal pleistocene on the Nile. In Straus, L. G. (ed.), The End of the paleolithic in the Old World. British Archaeological Reports: 171–199.

Contardini, *Rhythm of the Nile*. Contardini, F., 2015. Disasters Connected to the Rhythm of the Nile in the Textual Sources. In Vittozz, G. C. (ed.), A Research on Ancient Catastrophes, 11–26. Rome.

Copley, et al., *Foraging & Foddering*. Copley, M. S., Jim, S., Jones, V., Rose, P., Clapham, A., Edwards, D. N., Horton, M., Rowley-Conwy, P. and R. P. Evershed, 2004. Short-and long-term foraging and foddering strategies of domesticated animals from Qasr Ibrim, Egypt. Journal of Archaeological Science, 319: 1273–1286.

Corby et al., *Archaeology & Art*. Corbey, R. H. A., Layton, R. and J. Tanner, 2004. Archaeology and Art. In Bintliff, J. L., Earle, T. K., and C. S. Peebles (eds), A companion to archaeology, 357–379. Oxford.

Cornevin, *Paléoclimatologie*. Cornevin, M., 1996. Paléoclimatologie et peuplement de l'Égypte ancienne. Revue d'égyptologie, 47: 183–203.

Coulon, *Famine*. Coulon, L., 2008. Famine. In Frood, E. and W. Wendrich (eds), UCLA Encyclopedia of Egyptology, Los Angeles. http://escholarship.org/uc/item/2nv473z9.

Coulon, *Véracité et Rhétorique*. Coulon, L., 1997. Véracité et rhétorique dans les autobiographies égyptiennes de la Première Période Intermédiaire. Bulletin de l'Institut français d'archéologie orientale 97: 109–138.

Cramer et al., *Paleopathologies in Mummies*. Cramer, L., Brix, A., Matin, E., Rühli, F. and K. Hussein, 2018. Computed Tomography–Detected Paleopathologies in Ancient Egyptian Mummies. Current problems in diagnostic radiology 474: 225–232.

Cramp & Brooks, *Warblers*. Cramp, S. and D. J. Brooks, 1992. Handbook of the birds of Europe, the Middle East and North Africa. The birds of the western Palearctic, Vol. VI. Warblers, 396–405. Oxford.

Crumley, *Historic Ecotonal Shifts*. Crumley, C. L., 1993. Analyzing historic ecotonal shifts. Ecological Applications 3: 3, 377–384.

Cullen et al., *Akkadian Collapse*. Cullen, H. M., Hemming, S., Hemming, G., Brown, F. H., Guilderson, T. and F. Sirocko, 2000. Climate change and the collapse of the Akkadian empire: Evidence from the deep sea. Geology 284: 379–382.

Currie et al., *Past Agricultural Productivity*. Currie, T., Bogaard, A., Cesaretti, R., Edwards, N.R., Francois, P., Holden, P., Hoyer, D., Korotayev, A., Manning, J., Morenó García, J. C. Petrie, C., Turchin, P. Whitehouse, H., Williams, A. and O. K. Oyebamiji, 2015. Agricultural productivity in past societies: Toward an empirically informed model for testing cultural evolutionary hypotheses. Cliodynamics: The Journal of Quantitative History and Cultural Evolution: 6; 24–56.

Curto, *Egypt from the Paleolithic*. Curto, S., 1972. Archaeological outline of Egypt from the Paleolithic to the modern Arab state. Journal of Human Evolution 12: 141-146.

Cushing & Allan, *Streams*. Cushing, C. E. and J. D. Allan, 2001. Streams: their ecology and life. San Diego.

Czarnowicz, et al., *Trade or Conquest*? Czarnowicz, M., Ochał-Czarnowicz, A., Rosinska-Balik, K., and J. Dębowska-Ludwin, 2014. Trade or conquest? The nature of Egyptian-South Levantine relations in Early Bronze I from the perspective of Tell el-Farkha, Egypt and Tel Erani, Israel. Recherches Archeologiques NS4: 113–125.

Dalfes et al., *Third Millenium Climate Change*. Dalfes, H. N., Kukla, G., and H. Weiss, 1997. Third millennium BC climate change and Old World collapse. Proceedings of the NATO advanced workshop, held at Kemer, Turkey, September 19-24, 1994. Berlin.

Daoud et al., *Adaptation & Resilience*. Daoud, I., Oman, M. A.E. Z., Alary, V., Moselhy, N., Salal, E., Naga, A. A., Salama, O., Duarte, L. G. and J. F. Tourrand, 2016. Adaptation and Resilience in Pastoral Management of the Mediterranean Bedouin Social–Ecological System in the Northwestern Coastal Zone of Egypt. In Dong, S., Kassam, K. A. S., Tourrand, J. F. and R. B. Boone (eds), Building Resilience of Human-Natural Systems of Pastoralism in the Developing World, 209–250. Dordrecht.

Darby etal, *Gift of Osiris*. Darby, W.J., Ghalioungui, P. and L. Grivetti, 1977. The gift of Osiris. London.

Darnell, *The Message of King Wahankh*. Darnell, J. C., 1997. The message of king Wahankh Antef II to Khety, ruler of Heracleopolis. Zeitschrift für Ägyptische Sprache und Altertumskunde 124: 101–108.

David et al., *Artherosclerosis*. David, A. R., Kershaw, A. and A. Heagerty, 2010. Atherosclerosis and diet in ancient Egypt. The Lancet. 375: 9716, 718–719.

David, *Pyramid Builders*. David, A. R., 2003. Pyramid Builders of Ancient Egypt: A Modern Investigation of Pharaoh's Workforce. London and New York.

David, *Religion & Magic*. David, R., 2002. Religion and Magic in Ancient Egypt. London.

Davies, *Deir el-Gebrâwi* I. Davies, N.D.G., 1902. The rock tombs of Deir el Gebrâwi, Part 1, Tomb of Aba and smaller tombs of the southern group. London–Boston.

Davies, *Deir el-Gebrâwi* II. Davies, N.D.G., 1902. The rock tombs of Deir el Gebrâwi, Part 2, Tomb of Zau and tombs of the northern group. London–Boston.

Davies-Colley & Nagels, *Light Penetration*. Davies-Colley, R. and J. W. Nagels, 2008. Predicting light penetration into river waters. Journal of Geophysical Research: Biogeosciences, 113G3; 1–9.

Davis & Thompson, *North African mega-drought*. Davis, M. E. and L. G. Thompson, 2006. An Andean ice-core record of a Middle Holocene mega-drought in North Africa and Asia. Annals of Glaciology 43, 34–41.

Davis, *Canonical Traditions*. Davis, W., 1989. The Canonical Tradition in Ancient Egyptian Art. Cambridge.

Davis, *Death, Burial & Rebirth*. Davis, J. L., 1999. Death, Burial and Rebirth in the Religions of Antiquity. London.

Day, *Botany Meets Archaeology*. Day, J., 2013. Botany meets archaeology: people and plants in the past. Journal of Experimental Botany, 64: 18, 5805–5816.

de Jonge & Elliott, *Eutrophication*. de Jonge, V. N. and M. Elliott, 2008, Eutrophication. In Steele, J. H., Thorpe, S. A. and K. K. Turekian, (eds), Encyclopedia of Ocean Sciences, 306–323. Amsterdam.

de Miroschedji, *Socio-Political Dynamics*. de Miroschedji, P., 2002. The Socio-Political Dynamics of Egyptian-Canaanite Interaction in the Early Bronze Age. In van den Brink, E. C. M. and T. E. Levy (eds), Egypt and the Levant, Interrelations from the 4th Through to the 3rd Millennium BC, 39–57. London.

de Meyer, *Restoring the Tombs*. de Meyer, M., 2005. Restoring the Tombs of His Ancestors? Djehutinakht, Son of Teti, at Deir al-Barsha and Sheikh Said, IBAES 5: 125–135.

de Meyer, *Shadow of the Nomarchs*. de Meyer, M., 2007. In the Shadow of the Nomarchs. New Excavations in the Rock Tombs of Deir al-Barsha. In Goyon, J. C. and C. Cardin (eds), Proceedings of the Ninth International Congress of Egyptologists, Grenoble, 6-12 September 2004, OLA 150, 421-427. Leuven.

de Meyer, *Two Cemeteries One Provincial Capital*. de Meyer, M., 2011. Two cemeteries for one provincial capital? Deir el-Bersha and el-Sheikh Said in the fifteenth Upper Egyptian nome during the Old Kingdom. In Strudwick, N. and H. Strudwick (eds), Old Kingdom: New Perspectives. Egyptian Art and Archaeology 2750–2150 BC. Proceedings of a Conference at the Fitzwilliam Museum Cambridge, May 2009, 42–49. Oxford.

de Morgan, *Catalogue*. De Morgan, J. J., 1898. Catalogue des monuments et inscriptions de l'Égypte antique. Vienna.

Dean, *Dynastic Warfare*. Dean, R. A., 2017. Warfare and Weaponry in Dynastic Egypt. Barnsley.

Decker & Herb, *Blidlatlas zum Sport*. Decker, W. and M. Herb, 1994. Bildatlas zum Sport im alten Ägypten: Corpus der bildlichen Quellen zu Leibesübungen, Spiel, Jagd, Tanz und verwandten Themen. Leiden.

Decker et al., *Cattle Ancestry Patterns*. Decker J. E., McKay, S. D., Rolf, M. M., Kim, J., Molina Alcala ́ A., Sonstegard, T. S., Hanotte, O., Götherström, A., Seabury, C. M., Praharani, L. and M. E. Babar, 2014 Worldwide Patterns of Ancestry, Divergence, and Admixture in Domesticated Cattle. PLoS Genet 10: 3: e1004254.

Dee et al., *Chronology Reanalysis*. Dee, M. W., Ramsey, C. B., Shortland, A. J., Higham, T. F. G., and J. M. Rowland, 2009. Reanalysis of the chronological discrepancies obtained by the Old and Middle Kingdom Monuments Project. Radiocarbon 513: 1061-1070.

Dee et al., *Reservoir Offset*. Dee, M. W., Brock, F., Harris, S. A., Bronk-Ramsay, C., Shortland, A. J., and J. M. Rowland, 2009. Investigating the Likelihood of a Reservoir Offset in the Radiocarbon Record of Ancient Egypt. Journal of Archaeological Science 37: 2010, 687–693.

Deelder et al., *Schistome in Mummies*. Deelder, A. M., Miller, R. L., De Jonge, N. and F. W. Krijger, 1990. Detection of schistosome antigen in mummies. Lancet 3358691:724–725.

Delibes, *Herpestes ichneumon*. Delibes, M., 1999. Herpestes ichneumon. In: Mitchell-Jones, A. J., Amori, G., Bogdanowicz, W., Kryštufek, B., Reijnders, P., Spitzenberger, F., Stubbe, M., Thissen, J., Vohralík, V and J. Zima, (eds), The Atlas of European Mammals, 356–357. London.

Denny et al., *Upper Nile Swamp Vegetation*. Denny, P., 1984. Permanent swamp vegetation of the Upper Nile. In Dumont, H. J., El Moghraby, A. I. and L. A. Desougi (eds), Limnology and marine biology in the Sudan Vol. 21, 79–90. Dordrecht.

Deocampo, *Hippo Structures*. Deocampo, D.M., 2002. Sedimentary structures generated by Hippopotamus amphibius in a lake-margin wetland, Ngorongoro Crater, Tanzania. Palaios 172: 212–217.

Dhanakumar et al., *Phosphorous Fractionation*. Dhanakumar, S., Murthy, K. R., Mohanraj, R., Kumaraswamy, K., and S. Pattabhi, 2015. Phosphorous fractionation in surface sediments of the Cauvery Delta region, Southeast India. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj (eds), Environmental Management of River Basin Ecosystems, 477–489. Dordrecht.

Di Marco & Aello, *Cattle Walking.* Di Marco, O.N., and M. S. Aello, 1998. https://journals.uair.arizona.edu/index.php/jrm/article/viewFile/9272/8884

Di Marco & Aello, *Energy Expenditure*. Di Marco, O.N., and M. S. Aello, 2001. Energy expenditure due to forage intake and walking of grazing cattle. Arquivo Brasileiro de Medicina Veterinária e Zootecnia, 53: 1, 105–110.

Diodato & Bellocchi, *Rainfall Erosivity*. Diodato, N. and G. Bellocchi, 2009. Assessing and modelling changes in rainfall erosivity at different climate scales. Earth Surface Processes and Landforms 347: 969–980.

Diodato et al., *Erosive Rainfall Anomalies*. Diodato N, Ceccarelli M. and G. Bellocchi, 2008. Decadal and century-long changes in the reconstruction of erosive rainfall anomalies at a Mediterranean fluvial basin. Earth Surface Processes and Landforms 33: 2078–2093.

Do Linh San, et al; *Herpestes ichneumon*. Do Linh San, E., Maddock, A. H., Gaubert, P. and F. Palomares. 2016. Herpestes ichneumon. The IUCN Red List of Threatened Species: e.T41613A45207211.

Donaldson et al, *Proteins & Health* . Donaldson, A. I., Johnstone, A. M., de Roos, B. and P. K. Myint, 2018. Role of proteins in healthy ageing. European Journal of Integrative Medicine 23: 32–36.

Donohue & Fullerton, *Ancient Art & Historiography*. Donohue, A. A., and M. D. Fullerton, 2003. Ancient art and its historiography. Cambridge.

Donovan & McCorquodale, *Principles & Themes*. Donovan, L. and K. McCorquodale, 2000. Egyptian Art, Principles and Themes in Wall Scenes Prism Archaeological Series 6. Guizehs.

Dow & Reed, *Stagnation & Innovation*. Dow, G. K., and Reed, C. G., 2011. Stagnation and innovation before agriculture. Journal of Economic Behavior and Organization 773: 339–350.

Downing, *African Climate Change*. Downing, T. E., Ringius, L., Hulme, M., and D. Waughray, 1997. Adapting to climate change in Africa. Mitigation and adaptation strategies for global change, 21: 19–44.

Drake, *Climatic Change & the Greek Dark Ages*. Drake, B. L., 2012. The influence of climatic change on the Late Bronze Age Collapse and the Greek Dark Ages. Journal of Archaeological Science 396: 1862–1870.

Driaux, *Water Supply*. Driaux, D., 2016. Water supply of ancient Egyptian settlements: the role of the state. Overview of a relatively equitable scheme from the Old to New Kingdom ca. 2543–1077 BC. Water History, 8: 1, 43–58.

Drysdale et al., *Old World Collapse*. Drysdale, R., Zanchetta, G., Hellstrom, J., Maas, R., Fallick, A., Pickett, M., Cartwright, I. and L. Piccini, 2005. Late Holocene drought responsible for the collapse of Old World civilizations is recorded in an Italian cave flowstone. Geology 34: 2, 101–104.

Ducassou et al., *Nile floods in Sediments*. Ducassou, E., Mulder, T., Migeon, S., Gonthier, E., Murat, A,. Revel, M., Capotondi, L., Bernasconi, S., Mascle, J., and S. Zaragosi, 2008. Nile floods recorded in deep Mediterranean sediments. Quaternary Research 70: 3, 382–391.

Dudley et al., *Hippopotamus Carnivory*. Dudley, J. P., Hang'Ombe, B. M., Leendertz, F. H., Dorward, L. J., De Castro, J., Subalusky, A. L., and M. Clauss, 2016. Carnivory in the common hippopotamus Hippopotamus amphibius: implications for the ecology and epidemiology of anthrax in African landscapes. Mammal Review 463: 191–203.

Duell, *Mereruka*. Duell, P., 1938. The Mastaba of Mereruka. Chicago.

Duhig, *Eating People Here*. Duhig, C., 2000. They are eating people here! Skeletal indicators of stress in the Egyptian First Intermediate Period. PhD, University of Cambridge.

Duliková & Mařík, *Complex Network Analysis.* Dulíková, V. and R. Mařík, 2017. Complex network analysis in old kingdom society: a nepotism case. In Bárta, M., Coppens, F. and J. Krejčí (eds), Abusir and Saqqara in the Year 2015, 63–83. Prague.

Duliková, *Old Kingdom Viziers.* Dulíková, V., 2011. Some notes on the title of 'Vizier' during the Old Kingdom, especially on the hieroglyphic phallus-sign in the vizier's title. In Bárta, M., Coppens, F. and J. Krejčí (eds), Abusir and Saqqara in the Year 2010, 327–361. Prague.

Dulíková, *Transformation*. Dulíková, V., 2018. The reign of King Nyuserre: a time of transformation. Prague Egyptological Studies, XX: 46–56.

Dumont, *Nile Basin Synopsis*. Dumont, H. J., 2009. A description of the Nile Basin, and a synopsis of its history, ecology, biogeography, hydrology, and natural resources. In Dumont, H. J. (ed.), The Nile: Origin, Environments, Limnology and Human Use, 1–21. Dordrecht.

Dyson, *Old World Domestication*. Dyson, R. H., 1953. Archeology and the Domestication of Animals in the Old World. American Anthropologist 55: 5, 661–73.

Edel & Wenig, *Ne-User-Re*. Edel, E. and S. Wenig, 1974. Die Jahreszeitenreliefs aus dem Sonnenheiligtum des Königs Ne-user-re. Staatliche Museen zu Berlin, Mitteilungen aus der Ägyptischen Sammlung 7. Berlin.

Edenhofer et al., *IPCC 2014 Summary*. Edenhofer, O. R., Pichs-Madruga, Y., Sokona, E., Farahani, S., Kadner, K., Seyboth, A., Adler, I., Baum, S., Brunner, P., Eickemeier, B., Kriemann, J., Savolainen, S., Schlmer, C. ,von

Stechow, T., Zwickel and J. C. Minx (eds), IPCC Summary for Policymakers, In: Climate Change 2014, Mitigation of Climate Change: Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 1–21. Cambridge and New York.

Edwards, *Pigs*. Edwards, S., 2011. Pigs. In Webster, J., (ed.), Management and Welfare of Farm Animals: The UFAW Farm Handbook, 253–294. Hoboken.

Eggert & Lokina, *Lake Victoria Fisheries*. Eggert, H. and R. B. Lokina, 2010. Regulatory compliance in Lake Victoria fisheries. Environment and Development Economics, 1502, 197–217.

Eid et al., *Ecological Modelling*. Eid, E. M., Shaltout, K. H. and T. Asaeda, 2012. Modelling growth dynamics of Typha domingensis Pers. Poir. ex Steud. in Lake Burullus, Egypt. Ecological Modelling 243: 63–72.

Ejsmond, *Nubians of Gebelein*. Ejsmond, W., 2017. The Nubian mercenaries of Gebelein during the First Intermediate Period in light of recent field research. Journal of Ancient Egyptian Interconnections, 14: 11–13.

El-Fadel, et al., *Water Conflict Resolution*. El-Fadel, M., El-Sayegh, Y., El-Fadl, K. and D. Khorbotly, 2003. The Nile River Basin: A Case Study in Surface Water Conflict Resolution. Journal of Natural Resources; Life Science Education 32: 107–118.

El-Ghani et al., *Environmental Relationships*. El-Ghani, M. A., El-Fiky, A. M., Soliman, A. and A. Khattab, 2011. Environmental relationships of aquatic vegetation in the fresh water ecosystem of the Nile Delta, Egypt. African Journal of Ecology 49: 1, 103–118.

El-Kasim, *Problems & Priorities*. El-Kasim, R. A. A., 1988. The Northwestern Nile Delta. In van den Brink, E. C. M. (ed.), The Archaeology of the Nile Delta, Problems and Priorities, 279–282. Leiden.

El-Khadragy, *Asyut Soldier's Tomb*. El-Khadragy, M., 2006. The northern soldiers-tomb at Asyut. Studien zur altägyptischen Kultur 35: 147–164.

El-Khowli & Kanawati, *El-Hammimiya*. El-Khowli, A. and N. Kanawati, 1990. The Old Kingdom Tombs at El-Hammimiya. Sydney.

El-Khowli & Kanawati, *Quseir El Amarna*. El-Khowli, A. and N. Kanawati, 1989. Quseir El Amarna; The Tombs of Pepy-Ankh and Khewen-Wekh. Sydney.

El-Maghaby & Dowidar, *Zooplankton Community*. El-Maghraby, A. L. I. M. and N. M. Dowidar, 1973. Observations on the Zooplankton Community in the Egyptian Mediterranean Waters. Rapp. Comm. int. Mer Médit., 21: 8, 527–530.

El-Shabrawy & Dumont, *Zooplankton Variation*. El-Shabrawy, G. M., and Dumont, H. J., 2003. Spatial and seasonal variation of the zooplankton in the coastal zone and main khors of Lake Nasser Egypt. Hydrobiologia, 491: 1-3, 119–132.

El-Sheekh, *Nile River Ecosystems*. El-Sheekh, M. M., 2016. Impact of Water Quality on Ecosystems of the Nile River. In Negm. A. M. (ed.) The Handbook of Environmental Chemistry, 1–29. Dordrecht.

El-Wakeel, *Lake Qarun Deposits*. El-Wakeel, S. K., 1963. A study of the bottom deposits of Lake Qarun Egypt Part I: Chemical analysis. Bulletin of the Faculty of Sciences Alexandria University 5: 51–80.

Elfeky & Sayed, *Nile Rotifers*. Elfeky, F. A. and N. K. Sayed, 2014. Distribution and Abundance of Rotifers in the River Nile, Egypt. World 6: 6, 557–563.

Ellery et al., *Channel Blockage*. Ellery, W.N., Ellery, K., Rogers, K.H. and T. S. McCarthy, 1995. The role of Cyperus papyrus L. in channel blockage and abandonment in the northeastern Okavango Delta, Botswana. African Journal of Ecology 331: 25–49.

Elsharnouby, *Linen*. Elsharnouby, R. M. A., 2014. Linen in Ancient Egypt. Journal of General Union of Arab Archaeologists 1515: 1–22.

Elster & Jensen, *Fishery Investigation*. Elster, H. J., and K. W. Jensen, 1960. Limnological and Fishery Investigations of the Nozha Hydrodrome Near Alexandria, Egypt, 1954-1956. Cairo. .

Entz, *Lakes Nasser & Nubia*. Entz, B., 1976. Lake Nasser and Lake Nubia. In Rzóska, J. (ed.) The Nile: Biology of an Ancient Rive, 271–298. The Hague.

Epron et al. *Ti* I. Épron, L., Daumas, F. and G. Goyon, 1939. Le Tombeau de Ti, Fascicule I, Les approches de la chapelle. Mémoires publiés par les Membres de l'Institut Français d'Archéologie Orientale du Caire, LXV. Le Caire.

Erman, *Life in Egypt*. Erman, A., 1971. Life in ancient Egypt. London.

Espinel, *OK Egypt & Byblos*. Espinel, A. D. 2002. The Role of the Temple of Ba'alat Gebal as Intermediary between Egypt and Byblos during the Old Kingdom. Studien zur altägyptischen Kultur: 103–119.

Estes, *Behavior Guide*. Estes, R., 1991. The behavior guide to African mammals Vol. 64. Berkeley.

Evans, *Animal Behaviour*. Evans, L., 2010. Animal behaviour in Egyptian art: representations of the natural world in Memphite tomb scenes. Oxford.

Evans, *Domestic Animals*. Evans, L., 2000. Animals in the Domestic Environment. In Donovan, L. and K. McCorquodale (eds), Egyptian Art, Principles and Themes in Wall Scenes, 73–82. Cairo.

Evans, *Invertebrates in Egyptian Art*. Evans, L., 2015. Invertebrates in ancient Egyptian art: Spiders, ticks, and scorpions. In Massiera, M., Mathieu, B. and F. Rouffet (eds), Apprivoiser le sauvage / Taming the Wild, CENiM 11, 145-157. Montpellier.

Evans, *Pig Overboard*. Evans, L., 2017. Pig overboard? An enigmatic tomb scene from Beni Hassan. In Di Biase-Dyson, C. and L. Donovan (eds), The Cultural Manifestations of Religious Experience: studies in honour of Boyo G. Ockinga, 153-165. Münster.

Evans, *Which Network?* Evans T., 2016. Which network model should I use? Towards a quantitative comparison of spatial network models in archaeology. In Brughmans, T., Collar, A. and F. Coward (eds), The Connected Past: Challenges to Network Studies in archaeology and History, 149–174. Oxford.

Eyre, *Cannibal Hymns*. Eyre, C., 2002. The cannibal hymn: a cultural and literary study. Liverpool.

Eyre, *Pharaonic Economy*. Eyre, C., 2010. The Economy: Pharaonic. In Lloyd, A. B. (ed.), A companion to ancient Egypt Vol. 52, 291–308. Chicago.

Eyre, *Water Regime*. Eyre, C. J., 1994. The Water Regime for Orchards and the Plantations in Pharaonic Egypt. The Journal of Egyptian Archaeology 80: 57–80.

Fahmy, *Predynastic Plant Exploitation*. Fahmy, A. G. E. D., 2005. Missing plant macro remains as indicators of plant exploitation in Predynastic Egypt. Vegetation history and archaeobotany, 14: 4; 287–294.

FAO, *Weed Control & Utilization*. FAO 1985 Weed Control and Utilization of Aquatic Control and Utilization of Aquatic Plants of Lake Edku and Barsik Fish Farm - Egypt. Report for Project TCP/EGY/4506 based on the work of G. Sainty, Food and Agriculture Organization of the United Nations, Rome. http://www.fao.org/docrep/field/003/ R7236E/R7236E00.htm.

Faribanks, *Younger Dryas Melting*. Fairbanks, R.G., 1989. A 17,000-year glacio-eustatic sea level record: influence of glacial melting rates on the Younger Dryas event and deep-ocean circulation. Nature 342: 637–642.

Farley, *Bilharzia*. Farley, J., 2003. Bilharzia: a history of imperial tropical medicine. Cambridge.

Faulkner, *Military Organization*. Faulkner, R. O., 1953. Egyptian Military Organization. The Journal of Egyptian Archaeology 39: 32–47.

Faust, *Pigs in Space*. Faust, A., 2018. Pigs in Space (and Time): Pork Consumption and Identity Negotiations in the Late Bronze and Iron Ages of Ancient Israel. Near Eastern Archaeology, 81: 4, 276–299.

Feldman, *Rethinking the Canon*. Feldman, M. H., 2017. Rethinking the Canon of Ancient Near Eastern Art in the Internet Age. Journal of Ancient Near Eastern History 31: 57–79.

Fernandez et al., *Degradation & Recovery*. Fernandez, R.J., Archer, E.R., Ash, A.J., Dowlatabadi, H., Hiernaux, P., Reynolds, J.F., Vogel, C.H., Walker, B.H. and T. Wiegand, 2002. Degradation and recovery in socio-ecological systems: a view from the household/farm level. In Reynolds, J.F. and D. M. Stafford Smith (eds), Global desertification: do humans cause deserts, 297–323. Berlin.

Fields et al., *Sex & Agricultural Transition*. Fields, M., Herschaft, E. E., Martin, D. L., and J. T. Watson, 2009. Sex and the agricultural transition: Dental health of early farming females. Journal of dentistry and oral hygiene, 14: 42–51.

Fields et al., *Pharaoh's Soldiers.* Field, N. Reynolds, W. and P. Bull, 2007. Soldier of the Pharaoh: Middle Kingdom Egypt. London.

Finné, et al., *Late Bronze Age Climate Change.* Finné, M., Holmgren, K., Shen, C. C., Hu, H. M., Boyd, M. and S. Stocker, 2017. Late Bronze Age climate change and the destruction of the Mycenaean Palace of Nestor at Pylos. PloS one, 12: 12, e0189447. https://doi.org/10.1371/journal.pone.0189447.

Fiorentino et al*., Syrian Climate Change*. Fiorentino, G., Caracuta, V., Calcagnile, L., D'Elia, M., Matthiae, P., Mavelli, F. and G. Quarta, 2008. Third Millennium B.C. Climate Change in Syria Highlighted by Carbon Stable Isotopeanalysis of 14C-AMS Dated Plant Remains from Ebla. Palaeogeography, Palaeoclimatology, Palaeoecology 266; 51–58.

Fischer, *D5 Scribe*. Fischer, G. A., 1959. A Scribe of the Army in a Saqqara Mastaba of the Early Fifth Dynasty. Journal of Near Eastern Studies. 18: 4, 233–272.

Fischer, *Egyptian Women*. Fischer, H. G., 2000. Egyptian Women of the Old Kingdom and of the Heracleopolitan Period. New York.

Fishar & Williams, *Biotic Pollution Index*. Fishar, M.R. and W. P. Williams, 2008. The development of a biotic pollution index for the River Nile in Egypt. Hydrobiologia, 598: 1, 17–34.

Fisher & Sponseller, *Rivers as Ecosystems*. Fisher, S. G. and R. A. Sponseller, 2009. Streams and Rivers as Ecosystems. In Likens, G. (ed.), The Encyclopedia of Inland Waters, 491–498. Amsterdam.

Flaux et al, *Maryut Lagoon*. Flaux, C., El-Assal, M., Marriner, N., Morhange, C., Rouchy, J. M., Soulié-Märsche, I. and M. Torab, 2012. Environmental changes in the Maryut lagoon northwestern Nile delta during the last~ 2000 years. Journal of Archaeological Science 39: 12, 3493–3504.

Flaux et al, *Maryut Strontium Record*. Flaux, C., Claude, C., Marriner, N. and C. Morhange, 2013. A 7500-year strontium isotope record from the northwestern Nile delta Maryut lagoon, Egypt. Quaternary Science Reviews 78: 22–33.

Forshaw, *Dental Health*. Forshaw, R. J., 2009. Dental health and disease in ancient Egypt. British Dental Journal, 206: 9, 481–486. https://doi.org/10.1038/sj.bdj.2009.355.

Förster, *Abu Ballas Trail*. Förster, F., 2007. With donkeys, jars and water bags into the Libyan Desert: the Abu Ballas Trail in the late Old Kingdom/First Intermediate Period. International Conference of Nubian Studies, 3: 1–9.

Foster, *Forts & Garrisons*. Foster, A. L., 2005. Forts and Garrisons. In Redford, D. B. (ed.), The Oxford Encyclopedia of Ancient Egypt. Oxford.

Francis, *Ancient Egypt Garden*. Francis, D., 1999. The garden in ancient Egypt. Mortality 43: 329–340.

Frank et al*., Grazing History*. Frank, A. S. K., Dickman, C. R., Wardle, G. M. and A. C. Greenville, 2013 Interactions of Grazing History, Cattle Removal and Time since Rain Drive Divergent Short-Term Responses by Desert Biota. PLoS ONE 87: 1–13. https://doi.org/10.1371/journal.pone.0068466.

Franke, *Arme und* Geringe *im Alten Reich*. Franke, D., 2006. Arme und Geringe im Alten Reich Altägyptens: "Ich gab Speise dem Hungernden, Kleider dem Nackten...". Zeitschrift für ägyptische Sprache und Altertumskunde 133: 104–120.

Frankel et al., *Environment & Technology*. Frankel, D., Webb, J. and S. Lawrence, (eds), 2013. Archaeology in environment and technology: intersections and transformations. New York.

Fraser, *Early Tombs*. Fraser, G., 1903. The Early Tombs at Tehneh. Imprimerie de l'Institut français d'archéologie orientale.Frihy, *Delta-Alexandrian Coast*.

Frihy, *Nile Delta Coast*: Frihy, O. E., 2003. The Nile Delta-Alexandrian coast: vulnerability to sea level rise, consequence and adaptation. Mitigation and Adaptation Strategies for Global Change 82: 115–138.

Frils et al., *Fossil Water Lilies*. Friis, E. M., Pedersen, K. R. and P. R. Crane, 2001. Fossil evidence of water lilies Nymphaeales in the Early Cretaceous. Nature, 410: 6826, 357–360.

Fritsch, et.al., *Orthopedic Diseases*. Fritsch, K. O., Hamoud, H., Allam, A. H., Grossmann, A., Nur El-Din, A. H., Abdel-Maksoud, G., Al-Tohamy Soliman, M., Badr, I., Sutherland, J. D., Sutherland, L. M. and M. Akl, 2015. The Orthopedic Diseases of Ancient Egypt. The Anatomical Record, 298: 6, 1036–1046. https://doi.org/10.1002/ar.23136.

Fujita & Adachi, *Qau Palaeohealth.* Fujita, H. and H. Adachi, 2107. Paleohealth based on dental pathology and cribra orbitalia from the ancient Egyptian settlement of Qau. Anthropological Science 125: 1, 35–42.

Fuller & Lucas, *Archaeobotany*. Fuller, D. Q. and L. Leilani, 2014. Archaeobotany. In Smith, C.(ed.), The Encyclopedia of Global Archaeology, 305–310. Dordrecht.

Furman & Merritt, *Climate Change in Africa*. Furman, T. and E. Merritt, 2000. A Data Intensive Approach to Studying Climate and Climate Change in Africa. Journal of Geoscience Education 48: 464–68.

Gadgil, *Climate Change & Indian Agriculture*. Gadgil, S., 1995. Climate change and agricultrue-An Indian perspective. Current Science Bangalore,698: 649–659.

Gagnon Lupien, et al., *Bird Diversity*. Gagnon Lupien, N., Gauthier, G. and C. Lavoie, 2015. Effect of the invasive common reed on the abundance, richness and diversity of birds in freshwater marshes. Animal Conservation, 181: 32–43.

Galal & Garber, *Plankton Population Densities*. Galal, M. and N. Gaber, 2002. Population densities of the river in all seasons of the year and increased toward protozooplankton and their response to certain factors in the River Nile in El- Menofeyia province, summer. Egypt. Ger. Soc. Zool., 38: 1–14.

Galantinho & Mira, *Occurrence of Genet*. Galantinho, A. and A. Mira, 2009. The influence of human, livestock, and ecological features on the occurrence of genet Genetta genetta: a case study on Mediterranean farmland. Ecological Research, 243: 671–685.

Gallardo, *Séquito de Horus*. Gallardo, F. L. B., 2013. Séquito de Horus, Tripulación de Ra: aspectos religiosos de las luchas de poder durante la dinastía VI egipcia. ARYS: Antigüedad: Religiones y Sociedades, 11; 21–46.

García-Hernándeza et al., *Typha Wetlands Salinity Responses*. García-Hernández, J., Flessa, K., Santiago-Serrano, E., Romero-Hernández, S., Zamora-Arroyo, F. and J. Ramírez-Hernández, 2013. Salinity responses to inflow alterations in a 6500ha Typha wetland. Ecological Engineering 59: 18–29.

Gardiner, *Ancient Athletics*. Gardiner, E. N., 2002. Athletics in the ancient world. Chelmsford.

Garrod, *Primitive Man in Egypt*. Garrod, D.A.E., 1970. primitive Man in Ancient Egypt, Western Asia and Europe in Plalaeolithic times. In Edwards, I.E.S., Gadd, C.J., and N.G.L. Hammond (eds), The Cambridge Ancient History, 70–121. Cambridge.

Gaubert, etal, *Genetta genetta*. Gaubert, P., Carvalho, F., Camps, D. and E. Do Linh San, 2015. Genetta genetta. The IUCN Red List of Threatened Species: e.T41698A45218636.

Gaudet, *Papyrus Nutrients.* Gaudet, J. J., 1977. Uptake, accumulation, and loss of nutrients by papyrus in tropical swamps. Ecology 58: 415–422.

Gautier, *Domesticated Fauna*. Gautier, A., 2005 Domesticated Fauna. In Bard, K. A. (ed.), Encyclopedia of the Archaeology of Ancient Egypt, 300–306. London and NewYork.

Gee, *Egyptologists' Fallacies*. Gee, J., 2010. Egyptologists' Fallacies: Fallacies Arising from Limited Evidence. Journal of Egyptian History, 31: 137–158.

Gee, *Old Kingdom Collapse?* Gee, J., 2015. Did the Old Kingdom Collapse? A New View of the First Intermediate Period. In Der Manuelian, P. and T. Schneider (eds), Towards a new history for the Egyptian Old Kingdom: Perspectives on the pyramid age, Vol.1, 60–75. Harvard.

Geriesh, et al., *Nile Delta Geochemistry*. Geriesh, M. H., Balke, K. D., El-Rayes, A. E. and B. M. Mansour, 2015. Implications of climate change on the groundwater flow regime and geochemistry of the Nile Delta, Egypt. Journal of Coastal Conservation 194: 589–608.

Gerloni et.al., *Dental Status*. Gerloni, A., Cavalli, F., Costantinides, F., Costantinides, F., Bonetti, S. and C. Paganelli, 2009. Dental status of three Egyptian mummies: Radiological investigation by multislice computerized tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 107: 6, 58–64.

Ghilardi et al, *Nile River Evolution*. Ghilardi, M., Tristant, Y., and M. Boraik, 2012. Nile River evolution in upper Egypt during the Holocene; palaeoenvironmental implications for the Pharaonic sites of Karnak and Coptos. Geomorphologie: Relief, Processus, Environnement 18: 1, 7–22.

Ghilardi et. al, *Human-Environment Connectivity*. Ghilardi, M., Fouache, E. and R. Chiverrell, 2009. Introduction to special issue on Geoarchaeology: human-environment connectivity. Géomorphologie: Relief, Processus, Environnement, 15: 4, 227–228.

Gibbons, *Akkadian Empire*. Gibbons, A., 1993. How the Akkadian Empire was hung out to dry. Science 261: 5124, 985.

Gichuki et al., *Organic Matter in Papyrus*. Gichuki, J. W., Triest, L. and F. Dehairs, 2006. The fate of organic matter in a papyrus (Cyperus papyrus L.) dominated tropical wetland ecosystem in Nyanza Gulf Lake Victoria, Kenya inferred from δ13C and δ15N analysis. Isotopes in Environmental and Health Studies 41: 4, 379–390.

Gilbert, *Nomadic Pastoralism*. Gilbert, A. S., 1983. On the origins of specialized nomadic pastoralism in western Iran. World Archaeology 151: 105–119.

Giller & Malmqvist, *Streams & Rivers*. Giller, S. and B. Malmqvist, 1998. The Biology of Streams and Rivers. Oxford.

Glenn et al., *Growth & Evapotranspiration*. Glenn, E., Thompson, T. L., Frye, R., Riley, J. and D. Baumgartner, 1995. Effects of salinity on growth and evapotranspiration of Typha domingensis Pers. Aquatic Botany, 52:1, 75–91.

Global Invasive Species Database. http://www.issg.org/database/species/ecology.asp 2005.

Goedicke, *Abusir–Saqqara–Giza*. Goedicke, H., 2001. Abusir - Saqqara – Giza. In: Bárta, M. and J. Krejcí, (eds), Abusir and Saqqara in the Year 2000, 397–412. Prague.

Goldberg & Macphail*, Geoarchaeology*. Goldberg, P. and R. Macphail, 2006. Practical and Theoretical Geoarchaeology. London.

Gorai et al., *Phragmites Germination*. Gorai, M., Vadel, A. M. and M. Neffati, 2006. Seed Germination Characteristics of Phragmites Communis: Effects of Temperature and Salinity. Belgian Journal of Botany, 139: 1, 78–86.

Gorman & Karr, *Habitat Structure*. Gorman, O. T., and J. R. Karr, 1978. Habitat structure and stream fish communities. Ecology 59: 507–515.

Gornitz, *Ancient Cultures and Climate Change*. Gornitz, V., 2009. Ancient Cultures and Climate Change. In Gornitz, V. (ed.) Encyclopedia of paleoclimatology and ancient environments. Dordrecht.

Gorny, *Environment, Archaeology & History*. Gorny, R. L., 1989. Environment, archaeology, and history in Hittite Anatolia. The Biblical archaeologist, 52: 2-3, 78–96.

Goulden et al., *Typha Marsh Evapo-transpiration*. Goulden, M. L., Litvak, M. and S. D. Miller, 2007. Factors that control Typha marsh evapotranspiration. Aquatic Botany 86: 2, 97–106.

Govaerts et al., *Cyperaceae*. Govaerts, R. and D. A. Simpson, with Bruhl, J., Egorova, T., Goetghebeur, P. and K. Wilson, 2007. World Checklist of Cyperaceae: Sedges. Kew.

Gowland & Western, *Morbidity in the Marshes*. Gowland, R. L., and A. G. Western, 2012. Morbidity in the marshes: Using spatial epidemiology to investigate skeletal evidence for malaria in Anglo-Saxon England AD 410–1050. American Journal of Physical Anthropology, 147: 2, 301-311.

Grace & Wetzel, *Typha Population Dynamics*. Grace, J. B. and R. G. Wetzel, 1998. Long-term dynamics of Typha populations. Aquatic Botany 61: 2, 137–146.

Grace, *Effects of Water Depth*. Grace, J. B., 1989. Effects of water depth on Typha latifolia and Typha domingensis. American Journal of Botany: 762–768.

Grace, *Nutrient Addition Effects*. Grace, J. B., 1988. The effects of nutrient additions on mixtures of Typha latifolia L. and Typha domingensis P. along a water-depth gradient. Aquatic Botany, 31: 1-2, 83–92.

Gramsch, *Culture, Change & Identity*. Gramsch, A., 2015 Culture, Change, Identity – Approaches to the Interpretation of Cultural Change. Anthropologie LIII: 3, 341–349.

Greenberg, *No Collapse: Transmutation*. Greenberg, R., 2017. No Collapse: Transmutations of Early Bronze Age Urbanism in the Southern Levant. In Höflmayer, F. (ed.), The Late Third Millennium in the Ancient Near East: Chronology, C14, and Climate Change, 31–58. Chicago.

Greenwood, *Kenyan Fishes*. Greenwood, P. H., 1966. The Fishes of Uganda. Kampala.

Greenwood, *Nile Fish Fauna*. Greenwood, P. H. 1976. Fish Fauna of the Nile. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 127–141. The Hague.

Griffith, *Beni Hasan* III. Griffith, F.L., 1896. Beni Hasan, Part III. London.

Grimal, *History.* Grimal, N., 1994. A history of ancient Egypt; translated by Ian Shaw. Oxford.

Gronenborn, *Socio-political Crises*. Gronenborn, D., 2007. Climate change and socio-political crises: some cases from Neolithic Central Europe. In Pollard, T. and I. Banks (eds), War and Sacrifice. Studies in the Archaeology of Conflict,13–32. Leiden and Boston.

Guisan & Thuiller, *Species Distribution*. Guisan, A. and W. Thuiller, 2005. Predicting species distribution: offering more than simple habitat models. EcolLett. 8: 993–1009.

Győry, *Ancient Egypt Surgery*. Győry, H., 2008. Surgery in Ancient Egypt. In seline, H. (ed.), Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures, 2053–2059. Dordrecht.

Habib & Samah, *Catfish Protein Biosynthesis*. Habib, S. A. and A. A. S. Samah, 2013. Effect of heavy metals pollution on protein biosynthesis in catfish. Journal of Water Resource and Protection 505: 555–558.

Hafsaas, *Lower Nubian Cattle Pastoralists*. Hafsaas-Tsakos, H., 2006. Cattle Pastoralists in a Multicultural Setting: The C-group People in Lower Nubia 2500-1500 BCE. Bergen.

Hairassowitz, *Lexicon*. Hairassowitz, O. (ed.), 1982. Lexicon Der Agyptologie. Weisbad.

Haldane & Henderson, *Egyptian Shadouf.* Haldane, J. S. and Y. Henderson, 1926. The rate of work done with an Egyptian shadouf. Nature, 118: 2965, 308–309.

Halim et al., *Last Nile Flood*. Halim, Y., Guergues, S. K. and H. H. Saleh, 1967. Hydrographic conditions and plankton in the south east Mediterranean during the last normal Nile flood 1964. Internationale Revue der gesamten Hydrobiologie und Hydrographie 52: 3; 401–425.

Hall, *A Perfect Storm?* Hall, T. D. 2014., A 'Perfect Storm' in the Collapse of Bronze Age Civilization? Useful Insights and Roads not Taken. Cliodynamics: The Journal of Quantitative History and Cultural Evolution 5: 1, 75–86.

Haltenorth & Diller, *Field Guide*. Haltenorth, T. and H. Diller, 1986 A Field Guide to the Mammals of Africa: Including Madagascar. Charlottesville.

Hambrecht & Gielen, *Hunter-gatherer to Sedentary*. Hambrecht, R., and S. Gielen, 2005. Essay: hunter-gatherer to sedentary lifestyle. The Lancet, 366: 60–61.

Hamdan, et al., *Nile Floodplain Sediments*. Hamdan, M. A., Hassan, F. A., Flower, R. J., Leroy, S. A. G., Shallaly, N. A. and A. Flynn, 2019. Source of Nile sediments in the floodplain at Saqqara inferred from mineralogical, geochemical, and pollen data, and their palaeoclimatic and geoarchaeological significance. Quaternary International, 501: 272–288.

Hamden et al., *Faiyum Sedimentary Record*. Hamdan, M. A., Ibrahim, M. I. A., Shiha, M. A., Flower, R. J., Hassan, F. A. and S. A. M. Eltelet, 2016. An exploratory Early and Middle Holocene sedimentary record with palynoforms and diatoms from Faiyum lake, Egypt. Quaternary International. 1–13.

Hamed, *Artistic Perspectives*. Hamed, A. E. A., 2015. Sport, leisure: artistic perspectives in ancient Egyptian temples part II. Recorde: Revista de História do Esporte, 81: 1–28.

Hamilton, *Ancient Egypt*. Hamilton, R., 2006. Ancient Egypt; Kingdom of the Pharaohs. Bath.

Hammer, *Freshwater Wetlands*. Hammer, D. A., 1997. Creating Freshwater Wetlands. Boca Raton.

Hanneder, *Water Lilies & Lotus*. Hanneder, J., 2007. Some common errors concerning water-lilies and lotuses. Indo-Iranian Journal, 50: 2, 161–164.

Hardy et al., *Starch Granules*. Hardy, K., Blakeney, T., Copeland, L., Kirkham, J., Wrangham, R., and M. Collins, 2009. Starch granules, dental calculus and new perspectives on ancient diet. Journal of Archaeological Science, 362; 248–255.

Harer, *Properties of the Egyptian Lotus*. Harer, W. B., 1985. Pharmacological and biological properties of the Egyptian lotus. Journal of the American Research Center in Egypt 22: 49–54.

Harpur & Scremin, *Kagemni*. Harpur, Y. and P. Scremin, 2006. The Chapel of Kagemni Scene Details. Oxford.

Harpur, *Decorations*. Harpur, Y., 1987. Decoration in Egyptian Tombs of the Old Kingdom: Studies in Orientation and Scene Content. London.

Harpur, *Epigraphical Survey*. Harpur, Y., 1977. Epigraphical Survey. London.

Harrington, *Art & Social Theory*. Harrington, A., 2004. Art and social theory: sociological arguments in aesthetics. London.

Harris et.al, *Dental Health*. Harris, J. E., Ponitz, P. V. and B. K. Ingalls, 1998. Dental health in ancient Egypt. In Cockburn A, Cockburn E, and T. A. Reyman (eds), Mummies, disease & ancient cultures, 59–68. Cambridge.

Hartung, *Livestock Production*. Hartung, J., 2013. A short history of livestock production. In Aland, A. and T. Banhazi (eds), Livestock housing: Modern management to ensure optimal health and welfare of farm animals, 81–146. Wageningen. DOI 10.3920/978-90-8686-771-4_01.

Hartwig, *Painting & Identity*. Hartwig, M. K., 2004. Tomb painting and identity in ancient Thebes, 1419–1372 BCE, Turnhout.

Harvey, *Wooden Statues*. Harvey, J., 2001. Wooden Statues of the Old Kingdom: A Typological Study. Leiden.

Hasgeth, *Livestock Transport*. Hagseth, M. C., 2015 Nilotic Livestock Transport in Ancient Egypt. MA, Texas A and M University.

Haslam, *Reed*. Haslam, S.M., 2009 The Reed. Updated edition, British Reed Growers Association, Brown and Co., Norwich.

Hassan & Iskander, *Neb-Kaw-Her*. Hassan, S. and Z. Iskander, 1975. Excavations at Saqqara 1937-1938. Vol.1; The Mastaba of Neb-Kaw-Her. Cairo.

Hassan & Stucki, *Climatic Change*. Hassan, F. and B. Stucki, 1987. Nile floods and climatic change. In Rampino, R., Sanders, J., Newman, W. and L. Konigsson (eds), Climate: history, periodicity, and predictability, 37–46. New York.

Hassan et al., *Nile Flooplain Alluvium*. Hassan, F. A., Hamdan, M. A., Flower, R. J., Shallaly, N. A., and E. Ebrahem, 2017. Holocene alluvial history and archaeological significance of the Nile floodplain in the Saqqara-Memphis region, Egypt. Quaternary Science Reviews, 176: 51–70.

Hassan, *Climate & Cattle*. Hassan, F. A., 2006. Climate and cattle in North Africa: a first approximation. In Blench, R. and K. MacDonald (eds), The Origins and Development of African Livestock: Archaeology, Genetics, Linguistics and Ethnography, 61–86. London and New York.

Hassan, *Floods & Civilisation*. Hassan, F. A., 1998. Climatic change, Nile floods and civilization. Nature and resources, 342: 34–40.

Hassan, *Giza* I. Hassan, S., 1932. Excavations at Giza; 1929-1930. Vol. I. Cairo.

Hassan, *Giza* IV. Hassan, S., 1943. Excavations at Giza; Vol. IV. Cairo.

Hassan, *Giza* V. Hassan, S., 1944. Excavations at Giza; Vol. V. Cairo.

Hassan, *Historical Nile Floods*. Hassan, F. A., 1981. Historical Nile Floods and their Implications for Climate Change. Science New Series, 212: 4499, 1141–1145.

Hassan, *Holocene Lakes*. Hassan, F. A., 1986. Holocene lakes and prehistoric settlements of the Western Faiyum, Egypt. Journal of Archaeological Science 135: 483-501.

Hassan, *Nile Floods & Civilisation*. Hassan, F. A., 2005. A River Runs through Egypt; Nile Floods and Civilisation. Geotimes 50: 4, 22–26.

Hassan, *Nile Floods & Political Disorder*. Hassan, F. A., 1997. Nile floods and political disorder in early Egypt. In Dalfes, H. N., Kukla, G., and H. Weiss (eds), Third millennium BC climate change and old world collapse, 1–23. Berlin.

Hassan, *Paleoenvironments*. Hassan, F. A., 1985. Paleoenvironments and Contemporary Archaeology: A Geoarchaeological Approach. In Rapp, G. and J. Gifford (eds), Archaeological Geology, 85-102. New Haven.

Hassan, *Re-reading Ipuwer*. Hassan, F. A., 2007. Droughts, Famine and the Collapse of the Old Kingdom: Re-Reading Ipuwer. In Hawass, Z. A. and J. Richards (eds), The Archaeology and Art of Ancient Egypt. Essays in Honor of David B. O'Connor, Vol. I, 357–377. Cairo.

Hassan, *Riverine Civilisations*. Hassan, F. A., 1997. The dynamics of a riverine civilization: A geoarchaeological perspective on the Nile Valley, Egypt. World archaeology 29: 1, 51–74.

Hassan, *Saqqara* II. Hassan, S., 1975. Excavations at Saqqara 1937-1938: Vol. II. Cairo.

Hassan, *Town & Village*. Hassan, F., 1995. Town and village in ancient Egypt: ecology, society and urbanization. In Shaw, T., Sinclair, P., Andah, B. and A. Okpoko (eds), The Archaeology of Africa: food, metals and towns, 551–569. London and New York.

Hastorf & Popper, *Current Paleoethnobotany*. Hastorf, C. A. and V. S. Popper (eds), 1989. Current Paleoethnobotany: Analytical Methods and Cultural Interpretations of Archaeological Plant Remains Prehistoric Archeology and Ecology series. Chicago.

Hatziminaoglou & Boyazoglu, *Ancient Goats*. Hatziminaoglou, Y., and Boyazoglu, J. 2004. The goat in ancient civilisations: from the Fertile Crescent to the Aegean Sea. Small Ruminant Research 512: 123–129.

Hauschteck, *Goats in Houses*. Hauschteck, E., 2004. Goats in houses on Elephantine during the Middle Kingdom and the Second Intermediate Period. Göttinger Miszellen Beiträge zur ägyptologischen Diskussion, 202: 59–70.

Hawkins, *Geography & Art*. Hawkins, H., 2013. Geography and art. An expanding field site, the body and practice. Progress in Human Geography 371: 52–71.

Hayes, *Scepter of Egypt, .* Hayes, W. C., 1978. The Scepter of Egypt: A Background for the Study of the Egyptian Antiquities in The Metropolitan Museum of Art. Vol. 1, From the Earliest Times to the End of the Middle Kingdom. New York.

Hays, *Unreading the Pyramids*. Hays, H. M., 2009. Unreading the Pyramids. Bulletin de l'Institut Français Archéologie Orientale, 109: 26, 195–220.

Healy, *Armies of the Pharaohs*. Healy, M., 1992. Armies of the Pharaohs. London

Hebelstrup, *Wild versus Domesticated Grains*. Hebelstrup, K. H., 2017. Differences in nutritional quality between wild and domesticated forms of barley and emmer wheat. Plant Science 256: 3, 1–4.

Hecker, *Pork Consumption*. Hecker, H.M., 1982. A zooarchaeological inquiry into pork consumption in Egypt from prehistoric to New Kingdom times. Journal of the American Research Center in Egypt 19: 59–71.

Helbaek, *Domestication*. Helbaek, H., 1959. Domestication of Food Plants in the Old World: Joint efforts by botanists and archeologists illuminate the obscure history of plant domestication. Science 130: 365–372.

Heller & Byczyńska, *Environmental Factors & Flax*. Heller, K. and M. Byczyńska, 2015. The Impact of Environmental Factors and Applied Agronomy on Quantitative and Qualitative Traits of Flax Fiber. Journal of Natural Fibers 121: 26–38.

Hellings & Gallagher, *Flooding on Phragmites*. Hellings, S. E. and J. L. Gallagher, 1992. The Effects of Salinity and Flooding on Phragmites australis. Journal of Applied Ecology, 29: 1, 41–49.

Hély & Lézine, *Holocene Vegetation Changes*. Hély, C. and A. M. Lézine, 2014. Holocene changes in African vegetation: tradeoff between climate and water availability. Clim. Past. 10: 681–686.

Hendrickx, *Bovines*. Hendrickx, S., 2002. Bovines in Egyptian predynastic and early dynastic iconography. In Hassan, F. A. (ed.), Droughts, Food and Culture. Ecological Change and Food Security in Africa's Later Prehistory, 275–319. New York.

Hendrickx, *Hunting & Social Complexity*. Hendrickx, S., 2011. Hunting and Social Complexity in Predynastic Egypt. Bulletin des Séances Academie Royale des Sciences d'Outre-mer/ Koninklijke Academie voor Overzeese Wetenschappen, Mededelingen der Zittingen, 57: 2-4, 237–263.

Herb & Derchain, *Landscapes of Ancient Egypt*. Herb, M. and P. Derchain, 2009. The 'Landscapes' of Ancient Egypt: Intellectual Reactions to the Environment of the Lower Nile Valley. In Bollig, M. and D. Bubenzer (eds), African Landscapes, 201–225. New York.

Herb & Förster, *Desert to Town*. Herb, M and F. Förster, 2009. From desert to town: The economic role of desert game in the Pyramid Ages of ancient Egypt as inferred from historical sources c. 2600 – 1800 BC. In Riemer, H., Forster, F., Herb, M. and N. Pöllath (eds), Desert Animals in the Eastern Sahara: Status, Economic Significance, and Cultural Reflection in Antiquity: Proceedings of an Interdisciplinary ACACIA Workshop Held at the University of Cologne, December 14-15, 2007, 17–45. Cologne.

Hes et al., *Papyurus Nitrogen Cycling*. Hes, E. M., Niu, R., and A. A. van Dam, 2014. A simulation model for nitrogen cycling in natural rooted papyrus wetlands in East Africa. Wetlands ecology and management 222: 157–176.

Higginbotham, *Ways of Horus*. Higginbotham, C., 2002. Travelling the Ways of Horus: Studying the Links between Egypt and the Levant: The House That Albright Built. Near Eastern Archaeology 651: 30–34.

Hildebrand & Schilling, *Early Nile Agriculture*. Hildebrand, E.A. and T. M. Schilling, 2016. Storage amidst early agriculture along the Nile: Perspectives from Sai Island, Sudan. Quaternary International, 412: 81–95.

Hillman & Davies, *Domestication Rates*. Hillman, G. C., and M. S. Davies, 1990. Measured domestication rates in wild wheats and barley under primitive cultivation, and their archaeological implications. Journal of World Prehistory 4: 157–222.

Hillson, *Dental Disease.* Hillson, S. ,1979. Diet and dental disease. World Archaeology, 11: 147–162.

Hoelzmann et al., *Saharan Succession*. Hoelzmann, P. Gasse, F., Dupont, L. M., Salzmann, U., Staubwasser, M. Leuschner, D. C. and F. Sirocko, 2004. Palaeoenvironmental changes in the arid and sub arid belt (Sahara-Sahel-Arabian Peninsula) from 150 kyr to present. In Battarbee, R. W., Gasse, F. and C. E. Stickley (eds), Past Climate Variability Through Europe and Africa, 219–256. Dordrecht.

Hoffman et al., *Hierakonpolis Development*. Hoffman, M. A., Hany, A. H. and R. O. Allen, 1986. A model of urban development for the Hierakonpolis region from Predynastic through Old Kingdom times. Journal of the American Research Center in Egypt 23: 175–187.

Hoffman, *Before the Pharaohs*. Hoffman, M. A.,1984. Egypt before the Pharaohs. London.

Höflmayer et al., *Radiocarbon Early Bronze Age Levant*. Höflmayer, F., Dee, M. W., Genz, H., and S. Riehl, 2014. Radiocarbon evidence for the Early Bronze Age Levant: The site of Tell Fadous-Kfarabida Lebanon and the end of the Early Bronze III period. Radiocarbon,562: 529–542.

Höflmayer, *Dating Catastrophes*. Höflmayer, F., 2014. Dating Catastrophes and Collapses in the Ancient Near East: The End of the First Urbanization in the Southern Levant and the 4.2 ka BP Event. In Nigro, L. (ed.), Overcoming Catastrophic, ROSAPAT 11, 117–40. Rome.

Hofman, *Ruminant Digestive Diversification*. Hofmann, R. R., 1989. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. Oecologia 78: 443–457.

Holdaway et al., *Mobility & Lithics.* Holdaway, S., Wendrich, W., and R. Phillipps, 2010. Identifying low-level food producers: detecting mobility from lithics. Antiquity, 84: 323, 185-194.

Holm et al., *World's Worst Weeds*. Holm, L. G., Plocknett, D. L., Pancho, J. V. and J. P. Herberger, 1977. The world's worst weeds: distribution and biology. Honolulu.

Holmgren et al., *Plant Communities*. Holmgren, M., Scheffer, M. and M. Huston, 1997. The interplay of facilitation and competition in plant communities. Ecology 78: 1966–1975.

Holz, *Man-made Landforms*. Holz, R. K., 1969. Man Made Landforms in the Nile Delta. Geographical Review 592: 253–269.

Homewood & Roders, *Pastoralism & Conservation*. Homewood, K. M. and W. A. Rodgers, 1984. Pastoralism and conservation. Hum. Ecol. 12: 431–441.

Hope, *Libya and the Dakhleh Oasis*. Hope, C., 2007 Egypt and 'Libya' to the end of the Old Kingdom: a view from Dakhleh Oasis. In Hawass, Z and J. Richards (eds), The Archaeology and Art of Ancient Egypt: essays in honor of David B. O'Connor, Volume 1, 349–415.Cairo.

Hornung et al. *Chronology*. Hornung, E., Krauss, R., Warburton, D. and M. Eaton-Krause (eds), 2006. Ancient Egyptian Chronology. Boston.

Hornung, *Conceptions of God*. Hornung, E., 1983 Conceptions of God: The One and the Many. [trans. J. Baines]. Ithaca.

Hosier, *Unwelcome Phragmites*. Hosier, P., 2014. The ecology of an unwelcome exotic, phragmites australis. http://nceppc.weebly.com/uploads/6/8/4/6/6846349/14_hosier_the_ecol_of__phragmites.pdf.

Houlihan, *Animal World*. Houlihan, P., 1996. The Animal World of the Pharaohs. London.

Houlihan & Goodman, *Birds*. Houlihan, P. and S. M. Goodman, 1986. The Birds of Ancient Egypt. Warminster.

Houlihan, *Ti Swampland Scene*. Houlihan, P.F., 1996. A guide to the wildlife represented in the great swampland scene in the offering-chapel of Ti no. 60 at Saqqara. Göttinger Miszellen. 155, 19–53.

Houston, et al., *Protein Intake*. Houston, D. K., Nicklas, B. J., Ding, J.; Harris, T. B., Tylavsky, F. A., Newman, A. B., Lee, J. S., Sahyoun, N. R., Visser, M. and S. B. Kritchevsky, 2008. Health ABC Study. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: The Health, Ageing, and Body Composition Health ABC Study. Am. J. Clin. Nutr. 87: 150–155.

Howarth, et al., *Control on Eutrophication*. Howarth, R. W., Swaney, D. P., Butler T. J. and R. Marino, 2000. Climatic control on eutrophication of the Hudson River estuary. Ecosystems 3: 210–215.

Hughes, *Narrative Themes.* Hughes, J. D., 1995. Ecology and development as narrative themes of world history. Environmental History Review, 191: 1–16.

Hughes, *Sustainable Agriculture*. Hughes, J. D., 1992. Sustainable Agriculture in Ancient Egypt. Agricultural History 66: 2, 12–22.

Huhta, *Common Reed*. Huhta, A., 2009 Decorative or Outrageous - The significance of the Common Reed Phragmites australis on water quality. Comments from Turku University of Applied Sciences 48: 1–33.

Iacumin et al., *Palaeoenvironmental Studies*. Iacumin, P., Bocherens, H., Mariotti, A., and A. Longinelli, 1996. An isotopic palaeoenvironmental study of human skeletal remains from the Nile Valley. Palaeogeography, Palaeoclimatology, Palaeoecology, 126: 1-2, 15–30.

Ikram, *Choice Cuts.* Ikram, S., 1995. Choice cuts: meat production in ancient Egypt. Leeuven.

Ikram, *Meat Processing*. Ikram, S., 2000. Meat processing. In Nicholson, P. T., and I. Shaw (eds), Ancient Egyptian materials and technology, 656–671. Cambridge.

Iñiguez, *Goats in Dry Environments*. Iñiguez, L., 2004. Goats in resource-poor systems in the dry environments of West Asia, Central Asia and the Inter-Andean valleys. Small Ruminant Research 512: 137–144.

IPCC, *Summary 2013*. IPCC, 2013: Summary for Policymakers. In Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge and New York.

Isager, *Humanissima ars.* Isager, J. 2003. *Humanissima ars:* Evaluation and Devaluation in Pliny, Vasan and Baden. In Donohue, A. A., and M. D. Fullerton (eds), Ancient art and its historiography, 48–68. Cambridge.

Issar & Zohar, *Great Transition*. Issar, A. S., and M. Zohar, 2007. The Great Transition—From Farming Villages to Urban Centers. Climate Change—Environment and History of the Near East 67–102.

Issar, *Levant Climate Change*. Issar, A.S., 2003. Climate Changes during the Holocene and Their Impact on Hydrological Systems. Cambridge.

Iverson & Shibata, *Canon & Proportion*. Iverson, E. and Y. Shibata, 1975. Canon and Proportions in Egyptian Art. Warminster.

Izham, *Molecular Characterisation*. Izham, N. A. B. M., 2014. Morphological and Molecular Characterisation of Water Lily Family: Nymphaeaceae in UNIMAS Lake East Campus. PhD, Universiti Malaysia Sarawak.

Jacomet, *Archaebotany*. Jacomet, S., 2013. Archaebotany: the potential of analyses of plant remains from waterlogged archaeological sites. In Menotti, F. and A. O'Sullivan (eds), The Oxford Handbook of Wetland Archaeology, 497–514. Oxford.

Jacquet-Gordon, *Mendes* I. Jacquet-Gordon, H., 1986. Regarding Mendes I. Journal of Egyptian Archaeology 72: 207–208.

James et al., *Environmental Integrity*. James, R. A., Purvaja, R. and R. Ramesh, 2015. Environmental Integrity of the Tamiraparani River Basin, South India In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj (eds), Environmental Management of River Basin Ecosystems, 507–523. Dordrecht.

James et al., *Secondary Salinisation Impact*. James, K. R., Hart, B. T., Bailey, P. C. and D. W. Blinn, 2009. Impact of secondary salinisation on freshwater ecosystems: effect of experimentally increased salinity on an intermittent floodplain wetland. Marine and freshwater research, 60: 3, 246–258.

James, *Khentika*. James, T. G. H., 1953. The Mastaba of Khentika called Ikhekhi. London.

Janák et al., *Sun Temples*. Janák, J., Vymazalová, H. and F. Coppens, 2011. The Fifth Dynasty 'sun temples' in a broader context. In Bárta, M., Coppens, F. and J. Krejčí (eds), Abusir and Saqqara in the Year 2010, 430–442. Prague.

Janák, *Early Ba Attestations*. Janák, J., 2011. A Question of Size. A Remark on Early Attestations of the Ba Hieroglyph. SAK 40: 143–153.

Janák, *Extinction of Gods*. Janák, J., 2018. Extinction of gods: impact of climatic change on religious concepts. Visualizing Knowledge and Creating Meaning in Ancient Writing Systems, Berliner Beiträge zum Vorderen Orient, 23: 121–131.

Janák, *Spotting the Akh*. Janák, J., 2011. Spotting the akh. The presence of the northern bald ibis in ancient Egypt and its early decline. JARCE 40: 17–31.

Janick, *Origins of Horticulture*. Janick, J., 2000. Ancient Egyptian agriculture and the origins of horticulture. In Hadid, A. A. and S. Sansavini (eds), International Symposium on Mediterranean Horticulture: Issues and Prospects, 582: 23–39.

Jansen-Winklen, *Der Untergang*. Jansen-Winkeln, K., 2010. Der Untergang des Alten Reiches. Orientalia 79: 3, 273–303.

Jansen-Winklen, *Die Rolle des Unbekannten*. Jansen-Winkeln, K., 2009. Die Rolle des Unbekannten in der ägyptischen Geschichte. In Fitzenreiter, M. (ed.), Das Ereignis: Geschichtsschreibung zwischen Vorfall und Befund, Internet-Beiträge zur Ägyptologie und Sudanarchäologie 10: 155–161. London.

Jeffreys, *Egyptian Landscapes*. Jeffreys, D., 2012. Egyptian Landscapes and Environmental Archaeology. Bulletin of the Egypt Exploration Society. 41, Autumn, 8–10.

Jelinek, *Pastoralism & Social Stratification*. Jelinek, J., 2003 Pastoralism, burials and social stratification in central Sahara. Les Cahiers de L'AARS 8: 41–44.

Jirásková, *Egypt & Syria-Palestine*. Jirásková, L., 2011. Relations Between Egypt and Syria-Palestine in the Latter Part of the Old Kingdom. In Duistermaat, K., and I. Regulski (eds), Intercultural Contacts in the Ancient Mediterranean. Proceedings of the International Conference at the Netherlands-Flemish Institute in Cairo, 25th to 29th October 2008, 539–568. Cairo.

Johnels, *Catfish Terrestrial Locomotion*. Johnels, A. G., 1957. The mode of terrestrial locomotion in Clarias, Oikos 82: 122–129.

Jones & Muthuri, *Biomass in Papyrus*. Jones, M. B. and F. M. Muthuri, 1997. Standing Biomass and Carbon Distribution in a papyrus Cyperus Papyrus swamp on Lake Naivasha, Kenya. Journal of Tropical Ecology, 13: 347–356.

Jones & Muthuri, *Papyrus Canopy Structure*. Jones, M. B. and F. M. Muthuri, 1985. The Canopy Structure and Microclimate of Papyrus Cyperus Papyrus Swamps. Journal of Ecology 73: 481–491.

Jones et al., *Sediment Microbes*. Jones, J. G., R. A. Berner, P. S. Meadows, B. Durand, and G. Eglinton, 1985. Microbes and microbial processes in sediments [and Discussion]. Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 315: 1531, 3–17.

Jones, *Freshwater Ecosystems*. Jones, J. G., 2001. Freshwater ecosystems structure and response. Ecotoxicology and Environmental Safety 50: 1090–2414.

Jones, *Garden Cultivation*. Jones. G., 2005 Garden cultivation of staple crops and its implications for settlement location and continuity, World Archaeology, 37: 2, 164–176.

Jones, *Microbial Processes*. Jones, J. G., 1985. "Microbes and microbial processes in sediments." Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences 315: 1531, 3–17.

Jones, *Papyrus Photosynthesis*. Jones, M. B., 1987. The photosynthetic characteristics of papyrus in a tropical swamp. Oecologia Berlin 71: 355–359.

Julian et al., *Optical Water Quality*. Julian, J. P., Doyle, M. W., Powers, S. M., Stanley, E. H. and J. A. Riggsbee, 2008. Optical water quality in rivers. Water resources research, 44: 10, 1–19.

Jursa & García, *Fiscal Regimes*. Jursa, M. and J.C.M García, 2015. The ancient Near East and Egypt. In monsoon, A. and W. Scheidel (eds), Fiscal Regimes and the Political Economy of Premodern States, 115–165. Cambridge.

Kamrin, *Papyrus*. Kamrin, J., 2015. Papyrus in Ancient Egypt. In Heilbrunn Timeline of Art History, The Metropolitan Museum of Art. New York. http://www.metmuseum.org/toah/hd/papy/hd_papy.htm.

Kanawati & Abder-Raziq, *Hesi*. Kanawati, N. and M. Abder-Raziq, 1999. The Teti cemetery at Saqqara Vol. IV; The tomb of Hesi. Warminster.

Kanawati & Abder-Raziq, *Nikauisesi*. Kanawati, N. and M. Abder-Raziq, 2000. The Teti Cemetery at Saqqara. Vol. VI; The Tomb of Nikauisesi. Warminster.

Kanawati & Abder-Raziq, *Teti* III. Kanawati, N. and M. Abder-Raziq 1998. The Teti Cemetery at Saqqara. Vol. III; The Tombs of Neferseshemre and Seaknhuiptah. Warminster.

Kanawati & Abder-Raziq, *Unis* II. Kanawati, N. and M. Abder-Raziq, 2003. The Unis Cemetery at Saqqara. Vol. II; The Tomb of Iynefert and Ihy re-used by Idut. Oxford.

Kanawati & Abder-Raziq, *Waatetkhetor*. Kanawati, N. and M. Abder-Raziq 2008. Mereruka and his Family. Part II; The Tomb of Waatetkhetor. Oxford.

Kanawati & El-Khouli, *El-Hammimiya*. Kanawati, N. and A. El-Khouli, 1990. The Old Kingdom Tombs of El-Hammimiya. Sydney.

Kanawati & Evans, *Beni Hassan* I. Kanawati, N. and L. Evans, 2014. Beni Hassan, I; The Tomb of Khnumhotep II. Oxford.

Kanawati & Evans, *Beni Hassan* III. Kanawati, N. and L. Evans, 2016. Beni Hassan, III; The Tomb of Amenemhat. Oxford.

Kanawati & Hassan, *Ankhmahor*. Kanawati, N. and A. Hassan 1997. The Teti Cemetery at Saqqara. Vol. II; The Tomb of Ankhmahor. Warminster.

Kanawati & Hassan, *Teti* I. Kanawati, N. and A. Hassan, 1996. The Teti Cemetery at Saqqara. Vol. 1; The tombs of Nedjet-empet and Ka-aper. Warminster.

Kanawati & McFarlane, *Akhmin*. Kanawati, N. and A. McFarlane, 1988. The Rock Tombs of El-Hawawish. The Cemetery of Akhmim; Vol. VIII. Sydney.

Kanawati & McFarlane, *Deshasha*. Kanawati, N. and A. McFarlane, 1993. Deshasha; The Tombs of Inti, Sheshu and Others. Sydney.

Kanawati & Woods *OK Artists*. Kanawati, N., Woods, A. and Z. Hawass, 2009. Artists in the Old Kingdom: Techniques and achievements. Cairo.

Kanawati & Woods, *Art & Daily Life*. Kanawati, N. and A. Woods, 2010. Beni Hassan. Art and Daily Life in an Egyptian Province. Cairo.

Kanawati, *Administration*. Kanawati, N., 1977. The Egyptian administration in the Old Kingdom: evidence on its economic decline. Warminster.

Kanawati, *Art & Gridlines*. Kanawati, N., 2011. Art and Gridlines: The copying of Old Kingdom scenes in later periods. In Bárta, M., Coppens, F. and J. Krejčí (eds), Abusir and Saqqara in the Year 2010, 483–496, Prague.

Kanawati, *Conspiracies*. Kanawati, N., 2003. Conspiracies in the Egyptian Palace: Unis to Pepy I. New York.

Kanawati, *Deir El-Gabrawi* I. Kanawati, N., 2005. Deir El-Gabrawi. Vol I; The Northern Cliffs. London.

Kanawati, *El-Hawawish* I. Kanawati, N., 1980. Rock Tombs of El-Hawawish Cemetery of Akmim; Vol I. Sydney.

Kanawati, *El-Hawawish* II. Kanawati, N., 1981. Rock Tombs of El-Hawawish Cemetery of Akmim; Vol II. Sydney.

Kanawati, *El-Hawawish* III. Kanawati, N., 1982. Rock Tombs of El-Hawawish Cemetery of Akmim; Vol III. Sydney.

Kanawati, *Innovations*. Kanawati, N., 2012. Innovations in the Tomb of Khnum-Hotep II at Beni Hassan. Newsletter of the Rundle Foundation of Egyptian Archaeology. 118: 1–2. Sydney.

Kanawati, *Inumin*. Kanawati, N., 2006. The Teti Cemetery at Saqqara. Vol VIII; The Tomb of Inumin. Oxford.

Kanawati, *Mereruka & Teti*. Kanawati, N., 2007. Mereruka and King Teti: The Power behind the Throne. Cairo.

Kanawati, *Meryteti*. Kanawati, N., 2004. Mereruka and his Family. Part I; The Tomb of Meryteti. Oxford.

Kanawati, *Nepotism*. Kanawati, N., 2003. Nepotism in the Egyptian Sixth Dynasty. In Binder, S. (ed.),The Bulletin of the Australian Centre for Egyptology, 14: 39–60.

Kanawati, *Papyrus Thickets*. Kanawati, N., 2017. Papyrus thickets in the Old and Middle Kingdoms, with reference to the scenes in the tombs of Baqet III and Khety at Beni Hassan. In Di Biase-Dyson, C. and L. Donovan (eds), The Cultural Manifestations of Religious Experience: studies in honour of Boyo G. Ockinga, 119–132. Münster.

Kanawati, *Reforms*. Kanawati, N., 1980. Governmental Reforms in Old Kingdom Egypt. Warminster.

Kanawati, *Tomb & Beyond*. Kanawati, N., 2001. Tomb and Beyond, The: Burial Customs of Egyptian Officials. Warminster.

Kanchan et. al., *Enamel Hypoplasia*. Kanchan, T., Machado, M., Rao, A., Krishan, K. and A. K. Garg, 2015. Enamel hypoplasia and its role in identification of individuals: A review of literature. Indian J Dent Revisión. 6: 2, 99–102. doi:10.4103/0975-962X.155887.

Kaniewski et al., *Abrupt Climate Change*. Kaniewski, D., Paulissen, E., Van Campo, E., Al-Maqdissi, M., Bretschneider, J., and K. Van Lerberghe, 2008, Middle East coastal ecosystem response to middle-to-late Holocene abrupt climate changes: Proceedings of the National Academy of Sciences of the United States of America 105: 37, 13,941–13,946.

Kaniewski, et al., *4.2 kaBP Levant*. Kaniewski, D., Marriner, N., Cheddadi, R., Joel, G. and E. Van Campo, 2018. The 4.2 ka BP event in the Levant. Clim. Past 14: 1529–1542.

Kaniewski, *Late Bronze Age Crisis*. Kaniewski, D., Van Campo, E., Guiot, J., Le Burel, S., Otto, T., and C. Baeteman, 2013. Environmental roots of the Late Bronze Age crisis. Plos One, 8: 8, e71004.

Kantor, *2nd Millennium Aegean*. Kantor, H. J., 1947. The Aegean and the Orient in the Second Millennium. American Journal of Archaeology 511: 1–103.

Karstad & Hudson, *Riverine Hippopotami*. Karstad, E. L. and R. J. Hudson, 1986. Social organization and communication of riverine hippopotami in southwestern Kenya. Mammalia, 50: 2, 153–164.

Katz & Voight, *Bread & Beer*. Katz, S. and M. Voigt, 1986. Bread and beer. Expedition 28: 23–34.

Kay, *Responses to Drought*. Kay, R. N. B., 1997. Responses of African livestock and wild herbivores to drought. J. Arid Environ. 37: 683–694.

Kees, *Cultural Topography*. Kees, H., 1961. A cultural topography. London.

Keimer, *Agriculture in Ancient Egypt*. Keimer, L., 1926. Agriculture in Ancient Egypt. The American Journal of Semitic Languages and Literatures: 4: 283–288.

Keimer, *Le Sanglier*. Keimer, D. L., 1935. Le sanglier égyptien. Chronique d'Egypte, 10: 19, 26–33.

Keita & Boyce, *Dental Hypoplasias*. Keita, S. O. and A. J. Boyce, 2001. Diachronic patterns of dental hypoplasias and vault porosities during the Predynastic in the Naqada Region, Upper Egypt. American Journal of Human Biology 13: 733–743.

Keith etal., *Water Resource Adequacy*. Keith, B., Enos, J., Garlick, C.B., Simmons, G., Copeland, D. and M. Cortizo, 2013. Limits to Population Growth and Water Resource Adequacy in the Nile River Basin, 1994-2100. In Eberlein, R. and I. J. Martínez-Moyan (eds), Proceedings of the 31st international conference of the system dynamics society, 21–25. Cambridge.

Kemp, *Intermediate Egypt*. Kemp, B., 1982. Old Kingdom, Middle Kingdom and Second Intermediate Period in Egypt. In J. Clark (ed.), The Cambridge History of Africa, 658–769. Cambridge.

Kenawy, *Malaria in Ancient Egypt*. Kenawy, M. A., 1988. Anopheline mosquitoes Diptera: Culicidae as malaria carriers in AR Egypt 'History and present status.' Journal of the Egyptian Public Health Association 63: 1-2, 67–85.

Kenward & Hall, *Urban Organic Archaeology*. Kenward, H. and A. Hall, 2014. Urban organic archaeology: an irreplaceable palaeoecological archive at risk. World Archaeology 40: 4, 584–596.

Kerr, *Akkadian Empire Fall*. Kerr, R.A., 1998. Sea-floor dust shows drought felled Akkadian Empire. Science 279: 5349, 325–326.

Kettenring et al., *Phragmites Invasion*. Kettenring, K. M., McCormick, M. K., Baron, H. M., and D. F. Whigham, 2011. Mechanisms of Phragmites australis invasion: feedbacks among genetic diversity, nutrients, and sexual reproduction. Journal of Applied Ecology, 485: 1305–1313.

Kew World Checklist. Kew World Checklist of Selected Plant Families.

Khalifa & Sabae, *Bacteria & Zooplankton Relations*. Khalifa, N. S. and S. Z. Sabae, 2012. Investigation on mutual relations between bacteria and zooplankton in Dameitta branch, River Nile, Egypt. Journal of Applied Sciences Research, 8: 5; 2679–2688.

Khan & Ansari, *Eutrophication*. Khan, F. A., and A.A. Ansari, 2005. Eutrophication: an ecological vision. The Botanical Review, 71: 4; 449–482.

Khedr & El-Demerdash, *Distribution of Aquatic Plants*. Khedr, A. H. A. and M. A. El-Demerdash, 1997. Distribution of aquatic plants in relation to environmental factors in the Nile Delta. Aquatic Botany 56: 75–86.

Khedr & Hegazy, *Ecology of Lotus*. Khedr, A. H. A. and A. K. Hegazy, 1998. Ecology of the rampant weed Nymphaea lotus L. Willdenow in natural and ricefield habitats of the Nile delta, Egypt. Hydrobiologia, 386: 1-3, 119–129.

Kikemboi, *Enhancing Fish Production*. Kipkemboi J, Kilonzi, C., van Dam, A., Kitaka N, Mathooko, J. and P. Denny, 2010. Enhancing the fish production potential of Lake Victoria papyrus wetlands, Kenya, using seasonal flood-dependent ponds. Wetland Ecological Management 18: 471–483.

Kim et al., *Arid Environment Adaptations*. Kim, E. S., Elbeltagy, A. R., Aboul-Naga, A. M., Rischkowsky, B., Sayre, B., Mwacharo, J. M. and M. F. Rothschild, 2016. Multiple genomic signatures of selection in goats and sheep indigenous to a hot arid environment. Heredity, 116: 3, 255–264.

King et.al., *Enamel Hypoplasia.* King, T., Hillson, S. and L. T. Humphrey, 2002. A detailed study of enamel hypoplasia in a post-medieval adolescent of known age and sex. Arch. Oral Biol.;47: 29–39.

Kingdon, *East African Mammals*. Kingdon, J., 1988. East African Mammals: An Atlas of Evolution in Africa, Volume 3, Part A: Carnivores Vol. 4. Chicago.

Kinzig, et al., *Resilience & Regime Shifts*. Kinzig, A. P., Ryan, P. A., Etienne, M., Allison, H. E., Elmqvist, T., and B. H. Walker, 2006. Resilience and regime shifts: assessing cascading effects. Ecology and Society 111: 1–20.

Kiple & Ornelas, *Geese*. Kiple, K. and K. Ornelas, 2012. Geese. In Kiple, K. (ed.), The Cambridge World History of Food, 529–531. Cambridge.

Kiple & Ornelas, *What Our Ancestors Ate*. Kiple, K. and K. Ornelas, 2000. Determining What Our Ancestors Ate. In Kiple, K. and K. Ornelas (eds), The Cambridge World History of Food, 11–12. Cambridge.

Kitchen, *Chronology*. Kitchen, K. A., 1991. The Chronology of Ancient Egypt. World Archaeology 23: 2, 201–208.

Kiwango & Wolanski, *Papyrus Wetlands*. Kiwango, Y. A., and E. Wolanski, 2008. Papyrus wetlands, nutrients balance, fisheries collapse, food security, and Lake Victoria level decline in 2000–2006. Wetlands Ecology and Management, 162: 89–96.

Klebs, *Die Reliefs*. Klebs, L. 1915. Die Reliefs des Alten Reiches. Heidelberg.

Knappet, *Why Networks?* Knappett, C., 2013. Introduction: Why Networks? In Knappett, C. (ed.), Network Analysis in Archaeology: New Approaches to Regional Interaction, 1–17. Oxford.

Knudson, et al., *Cultural Interpretation*. Knudson, D., Cable, T., and L. Beck, 2003. In Knudsen, D. M. (ed.), Interpreting Cultural and Natural Resources. Pennsylvania.

Köbbing, et al., *Reed Utilisation*. Köbbing, J. F., Thevs, N., and S. Zerbe, 2013. The utilisation of reed Phragmites australis–a review. Mires Peat 13: 1–14.

Koepke & Baten, *Agricultural Specialisation*. Koepke, N., and J. Baten, 2008. Agricultural specialization and height in ancient and medieval Europe. Explorations in Economic History, 452: 127–146.

Kohl, *Archaeology of Trade*. Kohl, P. L., 1975. The archeology of trade. Dialectical Anthropology 11: 43–50.

Kohler, *Early Delta Pottery*. Köhler, E. C., 1998. Socio-Economic Aspects of Early Pottery Production in the Nile Delta. In Binder, S. (ed.) The Bulletin of the Australian Centre of Egyptology IX: 65–66.

Köhler, *State Formation*. Köhler, E. C., 2010. Theories of state formation. In Wendrich, W. (ed.), Egyptian Archaeology, 36–54. Oxford.

Kotoky et al., *Flood Management*. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj (eds), Environmental Management of River Basin Ecosystems. Dordrecht, Springer, 161–176.

Krebs, *Ecology*. Krebs, C. J., 2001. Ecology: The Experimental Analysis of Distribution and Abundance. San Francisco.

Krebs, *World View*. Krebs, C. J., 2008. The Ecological World View. Collingwood.

Krejčí, et al., *Queen Khentkaus* III. Krejčí, J. Arias Kytnarová, K. and M. Odler, 2015. Archaeological excavation of the mastaba of Queen Khentkaus III (Tomb AC 30). Prague.

Krejčí, *Ptahshepses Remarks*. Krejčí, J., 2011. The Abusir Pyramid Field and the Mastaba of Ptahshepses – Several Remarks. In Callender, V. G., Bareš, L., Bárta, M. and J. Janák (eds), Times, Signs and Pyramids: Studies in Honour of Miroslav Verner on the Occasion of His Seventieth Birthday, 253–276. Prague.

Kristensen, *Illusion or Reality?* Kristensen, M., 2015. Illustration or Reality: How should Depictions of Gardens in Ancient Egyptian Tomb Paintings be Perceived? In Pinarello, M. S., Yoo, J., Lundock, J. and C. Walsh (eds), Current Research in Egyptology 2014: Proceedings of the Fifteenth Annual Symposium University College London & King's College London, 229–238. Oxford.

Krom et al., *Nile Sediment Fluctuations*. Krom, M. D., Stanley, J. D., Cliff, R. A. and J. C. Woodward, 2002. Nile River sediment fluctuations over the past 7000 yrs and their key role in sapropel development. Geology 30: 1, 71–74.

Kröpelin et al., *Saharan Succession*. Kröpelin, S., Verschuren, D., Lézine, A. M., Eggermont, H., Cocquyt, C., Francus, P., Cazet, J. P., Fagot, M., Rumes, B., Russell, J. M., Darius, F., Conley, D. J., Schuster, M., Von Suchodoletz, H. and D. Engstrom, 2008: Climate-Driven Ecosystem Succession in the Sahara: The Past 6000 Years. Science 320: 765–768. doi:10.1126/science.1154913.

Krzyżaniak, et al., *Environmental & Human Culture*. Krzyżaniak, L., Kobusiewicz, M. and J. A. Alexander, 1993. Environmental change and human culture in the Nile Basin and Northern Africa until the Second Millennium BC Vol. 4. Poznan.

Kulshreta et al., *Eutrotrophoc Phytoplankton*. Kulshreshtha, S. K., Saxena, R., George, M. P., Srivastava, M., and A. Tiwari, 1989. Phytoplankton of eutrophic Mansarovar reservoir of Bhopal. International Journal of Ecology & Environmental Science 15: 205–215.

Kumar, *Health at Hierakonpolis*. Kumar, A., 2009. Health at Hierakonpolis, a predynastic settlement in Upper Egypt. PhD, University of Arkansas.

Kuper & Kropelin, *Saharan Holocene*. Kuper, R., Kropelin, S., 2006. Climate-Controlled Holocene Occupation in the Sahara: Motor of Africa's Evolution. Science 313: 803–807.

Kuraszkiewicz, *Architectural Innovations*. Kuraszkiewicz, K. O., 2016. Architectural innovations influenced by climatic phenomena 4.2 ka event in the Late Old Kingdom Saqqara, Egypt. Studia Quaternaria, 331: 27–34.

Kushlan, *Environmental Stability*. Kushlan, G. A., 1976. Environmental stability and fish community diversity. Ecology 57: 821–825.

Lambertini et al., *genus Phragmites*. Lambertini, C., Gustafsson, M. H. G., Frydenberg, J., Lissner, J., Speranza, M. and H. Brix, 2006 A phylogeographic study of the cosmopolitan genus Phragmites Poaceae based on AFLPs. Plant systematics and evolution 258: 161–182.

Langsjoen, *Diseases of Dentition*. Langsjoen O., 1998. Diseases of the dentition. In Aufderheide, A. C., and C. Rodriguez-Martin (eds), The Cambridge Encyclopedia of human paleopathology, 393-412. Cambridge.

Langutt et al., *Late Bronze Collapse*. Langgut, D., Finkelstein, I., and T. Litt, 2013. Climate and the Late Bronze Collapse: new evidence from the Southern Levant. Tel Aviv, 40: 2, 149–175.

Langutt et al., *Mediterranean Climate Change*. Langgut, D., Almogi-Labin, A., Bar-Matthews, M., and M. Weinstein-Evron, 2011. Vegetation and climate changes in the South Eastern Mediterranean during the Last Glacial-Interglacial cycle 86 ka: new marine pollen record. Quaternary Science Reviews 302: 7, 3960–3972.

Lariviére & Calzada, *Genetta genetta*. Larivière, S. and J. Calzada, 2001. Genetta genetta. Mammalian species, #608, 1-6. https://doi.org/10.1644/1545-14102001680<0001:GG>2.0.CO;2.

Larsen, *Agriculture as Catastrophe*. Larsen, C. S., 2006. The agricultural revolution as environmental catastrophe: implications for health and lifestyle in the Holocene. Quaternary International, 150: 1, 12–20.

Larsen, *Biological Changes*. Larsen, C. S., 1995. Biological changes in human populations with agriculture. Annual Review of Anthropology, 185–213.

Lawler, *Collapse Revisited*. Lawler, A., 2010. Collapse? What collapse? Societal change revisited. Science 330: 907–909.

Lawton & Wilke, *Dry Region Ancient Agriculture*. Lawton, H. W. and P. J. Wilke, 1979. Ancient agricultural systems in dry regions. In Hall, A. E., Cannell, G. H. and H. W. Lawton (eds), Agriculture in semi-arid environments, 1–44. Berlin and Heidelberg.

Leek, *Dental Pathology*. Leek F. F., 1966. Observations of the dental pathology seen in ancient Egyptian skulls. J Egypt Archaeol. 52: 59–64.

Leek, *Dentistry*. Leek F. F., 1967. The practice of dentistry in Ancient Egypt. J Egypt Archaeol. 53: 51–58.

Leek, *Teeth & Bread*. Leek F. F., 1972. Teeth and bread in ancient Egypt. J Egypt Archaeol. 58: 126–132.

Lefebvre & Moret, *Tehnèh*. Lefebvre, G. and P. Moret, 1919. Nouvel Acte de Fondation de l'Ancien Empire a Tehnèh. Revue Égyptologique I; 30–38.

Lehner, *Villages and the Old Kingdom*. Lehner, M., 2010. Villages and the Old Kingdom. In Wendrich, W. (ed.), Egyptian Archaeology, 85-101. Chichester.

Leick, *Invention of the City*. Leick, G., 2001. Mesopotamia: the Invention of the City. London.

Lepsius, *Denkmäler.* Lepsius, K. R., (1842-1845). Denkmäler aus Ägypten und Äthiopien nach den Zeichnungen der von Seiner Majestät dem Könige von Preußen Friedrich Wilhelm IV nach diesen Ländern gesendeten und in den Jahren 1842–1845. ausgeführten wissenschaftlichen Expedition auf Befehl Seiner Majestät herausgegeben und erläutert.

Les et al*., Classification of Water Lilies*. Les, D. H., Schneider, E. L., Padgett, D. J., Soltis, P. S., Soltis, D. E. and M. Zanis, 1999. Phylogeny, classification and floral evolution of water lilies Nymphaeaceae; Nymphaeales: a synthesis of non-molecular, rbcL, matK, and 18S rDNA data. Systematic Botany, 28–46.

Lichtheim, *Old & Middle Kingdom Literature*. Lichtheim, M., 2006. Ancient Egyptian Literature. The Old and Middle Kingdoms. Volume 1. Berkeley.

Lind, *Ugandan Swamps*. Lind, E. M., 1956. Studies in Ugandan Swamps. Uganda Journal, 20: 2, 166–176.

Linseele & Van Neer, *Archaeology of Exploitation*. Linseele, V. and W. Van Neer, 2009. Exploitation of desert and other wild game in ancient Egypt: The archaeozoological evidence from the Nile Valley. In Riemer, H., Forster, F., Herb, M. and N. Pöllath (eds), 2009. Desert Animals in the Eastern Sahara: Status, Economic Significance, and Cultural Reflection in Antiquity: Proceedings of an Interdisciplinary ACACIA Workshop Held at the University of Cologne, December 14-15, 2007, 47–78. Köln.

Linseele & Zerboni, *Done with Fish*. Linseele, V. and A. Zerboni, 2018. Done with fish? A diachronic study of fishing in the Holocene Nile basin of Sudan. Quaternary International 471: 229–240.

Lister & Jones, *Naked Barley*. Lister, D. and L. Jones, 2013. Is naked barley an eastern or a western crop? The combined evidence of archaeobotany and genetics. Vegetation History and Archaeobotany 225: 439–446.

Litchman et al., *Photosynthstic Growth Responses*. Litchman, E., D. Steiner, and P. Bossard, 2003. Photosynthetic and growth responses of three freshwater algae to phosphorus limitation and daylength. Freshwater Biology 48; 2141–2148.

Liu et al., *Tooth Wear & Diet Implications*. Liu, W., Zhang, Q. C., Wu, X. J. and H. Zhu, 2010. Tooth wear and dental pathology of the Bronze–Iron Age people in Xinjiang, Northwest China: Implications for their diet and lifestyle. HOMO-Journal of Comparative Human Biology 612: 102–116.

Liverani, *Reconstructing Rural Landscapes*. Liverani, M., 1996. Reconstructing the rural landscape of the Ancient Near East. Journal of the Economic and Social History of the Orient/Journal de l'histoire economique et sociale de l'Orient, 1–41.

Livingstone, *Palaeoliminology*. Livingstone, D. A., 1976. The Nile – Palaeoliminology of Headwaters. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 21–30. The Hague.

Lloyd, *Dialogue*. Lloyd, A. B. 2014. Dialogue with the Environment. In Ancient Egypt; State and Society. Oxford, University Press.

Lonnie et al., *Protein for Life*. Lonnie, M., Hooker, E., Brunstrom, J., Corfe, B., Green, M., Watson, A., Williams, E., Stevenson, E., Penson, S. and A. Johnstone, 2018. Protein for life: Review of optimal protein intake, sustainable dietary sources and the effect on appetite in ageing adults. Nutrients 103: 360, 1–18.

Loreau, *Bioviversity & Ecosystems*. Loreau, M., 2010. Linking biodiversity and ecosystems: towards a unifying ecological theory. Philosophical Transactions of the Royal Society Biology 365: 49–60.

Lorimer, *Cultural Geography*. Lorimer, H., 2005. Cultural geography: the busyness of being 'more-than-representational'. Progress in Human Geography 291: 83–94.

Love, *Abusir Drill Core*. Love, S., 2001. The Abusir Drill Core Survey, Egypt. Papers from the Institute of Archaeology 12: 110–113.

Lovell & Whyte, *Enamel Defects*. Lovell, N. C. and I. Whyte, 1999, Patterns of dental enamel defects at ancient Mendes, Egypt. American Journal of Physical Anthropology, 110: 69–80.

Luff & Bailey, *Aquatic Basis Ancient Civilisations*. Luff, R. and G. Bailey, 2000. The aquatic basis of ancient civilisations: The case *of Synodontis schall* and the Nile Valley. In Bailey, G., Charles, R., and N. Winder (eds), Human Ecodynamics: Proceedings of the Association for Environmental Archaeology Conference, held at the University of Newcastle upon Tyne, 1998, 100–113. Oxford.

Luff & Bailey, *Catfish Growth Structures*. Luff, R. M. and G. N. Bailey, 2000. Analysis of size changes and incremental growth structures in African catfish *Synodontis schall schall* from Tell el-Amarna, Middle Egypt. Journal of Archaeological Science, 279, 821–835.

Luff, *Ducks*. Luff, R., 2000. Ducks. Cambridge World History of Food, 517–24. Cambridge.

Luiselli, *Cultural Memory?* Luiselli, M. M., 2011. The Ancient Egyptian scene of "Pharaoh smiting his enemies": an attemtp to visualize cultural memory? In Bommas, M. (ed.), Cultural memory and identity in ancient societies Vol. 1, 10–25. London.

Lundqvist, *Avert Hydrocide*. Lundqvist, J., 1998. Avert looming hydrocide. Ambio 27: 428–433.

Lytle & Poff, *Natural Flow Regimes*. Lytle, D. A., and N. L. Poff, 2004. Adaptation to natural flow regimes. Trends in Ecology & Evolution 192: 94–100.

MacDonald, *Egypt & Climate Change*. MacDonald, G. M., 2009 Egypt and the Nile 2 – Climate Change and Early Agriculture in Egypt. http://www.gmmacdonald.com/

MacDonald & Edwards, *Chickens in Africa*. MacDonald, K. C., and D. N. Edwards, 1993. Chickens in Africa: The importance of Qasr Ibrim. Antiquity 67: 584–90.

Macek et al., *Typha Domingensis Spread*. Macek, P., Rejmánková, E. and J. Lepši, 2010. Dynamics of Typha domingensis spread in Eleocharis dominated oligotrophic tropical wetlands following nutrient enrichment. Evolutionary Ecology, 24: 6, 1505–1519.

Macias, *Degradación de los suelos*. Macias, M., 1994. Estimación de la degradación de los suelos por la erosion h´ıdrica en los valles de la provincia Campero Cochabamba, Bolivia [Soil degradation by erosion in the Campero Province, Cochabamba, Bolivia]. In: Iñiguez, L. and E. Tejada (eds.), roducción de Rumiantes Menores en los Valles Interandinos de Sudamérica. Memorias de un taller sobre metodolog´ıas de la investigación, Tarija, Bolivia, de Agosto 16-21, 3–18.

Macklin et al. *Nile Floodwater Farming*. Macklin, M. G., Woodward, J. C., Welsby, D. A., Duller, G. A., Williams, F. M., and M. A. Williams, 2013. Reach-scale river dynamics moderate the impact of rapid Holocene climate change on floodwater farming in the desert Nile. Geology, 416: 695–698.

Macklin et al., *River Dynamics.* Macklin, M. G., Toonen, W. H., Woodward, J. C., Williams, M. A., Flaux, C., Marriner, N., Nicoll, K., Verstraeten, G., Spencer, N. and D. Welsby, 2013. A new model of river dynamics, hydroclimatic change and human settlement in the Nile Valley derived from meta-analysis of the Holocene fluvial archive. Quaternary Science Reviews 130; 109–123.

Maclean et al. *Avian Habitat Degradation*. Maclean, I., Hassall, M., Boar, R., and O. Nasirwa, 2003. Effects of habitat degradation on avian guilds in East African papyrus Cyperus papyrus swamps. Bird Conservation International, 13: 4, 283–297.

Maclean et al. *Passerine Habitat Loss*. Maclean, I. M., Hassall, M., Boar, R. R. and I. R. Lake 2006. Effects of Disturbance and Habitat Loss on Papyrus-dwelling Passerines. Biological Conservation 131: 349-358.

Madella, *African Domestic Cereals*. Madella, M., García-Granero, J. J., Out, W. A., Ryan, P. and D. Usai, 2014. Microbotanical evidence of domestic cereals in Africa 7000 years ago. PloS one, 9: 10,e110177.

Mahmoud, *Vögel in Alten Reich*. Mahmoud, O., 1991. Die wirtschaftliche Bedeutung der Vögel im Alten Reich. Frankfurt am Main.

Makarewicz, *Pastoralist Manifesto*. Makarewicz, C. A., 2013. A pastoralist manifesto: breaking stereotypes and re-conceptualizing pastoralism in the Near Eastern Neolithic. Levant, 45: 2, 159–174.

Malby, *Waterlogged Wealth*. Malby, E., 1986. Waterlogged Wealth. London.

Málek, *Egyptian Art*. Málek, J., 1999. Egyptian Art. London.

Málek, *Old Kingdom*. Málek, J., 2003. The Old Kingdom c2686–2160 BC. In Shaw, I. (ed.), The Oxford History of Ancient Egypt. Oxford and New York.

Malleson, *Legume Intercropping*. Malleson, C., 2016. Informal intercropping of legumes with cereals? A re-assessment of clover abundance in ancient Egyptian cereal processing by-product assemblages: Archaeobotanical investigations at Khentkawes town, Giza 2300--2100 BC. Vegetation History and Archaeobotany 25: 5, 431–442.

Maltby & Acreman, *Ecosystem Services*. Maltby, E. and M. C. Acreman, 2011. Ecosystem services of wetlands: pathfinder for a new paradigm, Hydrological Sciences Journal, 56: 8, 1341–1359.

Manassa, *El-Mo'alla to El-Deir*. Manassa, C., 2011. El-Moalla to El-Deir. In Wendrich, W. (ed.), UCLA Encyclopedia of Egyptology. https://escholarship.org/uc/item/4pc0w4hg

Manlius & Gautier*, lé Sanglier*. Manlius, N and A. Gautier., 1999. Le Sanglier in Egypte. Comptes Rendus de l' Acadamie des Sciences, Serie III -Sciences de la Vie - Life Sciences 322: 7, 573–577.

Manlius, *Historical Biogeography*. Manlius, N., 2009. Historical ecology and biogeography. An example: The Barbary sheep Ammotragus lervia in Egypt. In Riemer, H., Forster, F., Herb, M. and N. Pollath (eds), Desert Animals in the Eastern Sahara; Proceedings of an Interdisciplinary ACACIA workshop, University of Cologne, December 14-15, 2007, 111–127. Köln.

Mannermaa, *Goose Domestication*. Mannermaa, K., 2014. Goose: Domestication. In Smith, C. (ed.), Encyclopedia of Global Archaeology, 3096–3098. New York.

Manning, Water, *Irrigation & Power.* Manning, J. G., 2012. Water, irrigation and their connection to state power in Egypt. In Conference paper presented at "Resources: Endowment or Curse, Better or Worse" Yale University, February 24-25, 2012. http://www.econ.yale.edu/~egcenter/manning2012.pdf.

Marinov et al., *Egyptian Archaeobotany*. Marinova, E., Ryan, P., Van Neer, W. and R. Friedman, 2013. Animal dung from arid environments and archaeobotanical methodologies for its analysis: An example from animal burials of the Predynastic elite cemetery HK6 at Hierakonpolis, Egypt. Environmental Archaeology, 18: 1, 58–71.

Märkle & Rösch, *Carbonization Effects*. Märkle, T. and M. Rösch, 2008. Experiments on the effects of carbonization on some cultivated plant seeds. Vegetation History and Archaeobotany 17: 1, 257–263.

Marks et al*., Phragmites Australis*. Marks M., Lapin B. and J. Randall, 1993. Element Stewardship Abstract for Phragmites australis. The Nature Conservancy.

Marriner et al., *Nile Delta Hydro-geomorphology*. Marriner, N., Flaux, C., Kaniewski, D., Morhange, C., Leduc, G., Moron, V., Chen, Z., Gasse, F., Empereur, J. Y. and J. D. Stanley, 2012. ITCZ and ENSO-like pacing of Nile delta hydro-geomorphology during the Holocene. Quaternary Science Reviews 45: 73–84.

Marriner, et al*., Nile Delta's Sinking Past*. Marriner, N., Flaux, C., Morhange, C. and D. Kaniewski, 2012. Nile Delta's sinking past: Quantifiable links with Holocene compaction and climate-driven changes in sediment supply. Geology, 401: 2, 1083–1086.

Marro & Kuzucuoğlu, *3rd Millennium Crisis?* Marro, C. and C. Kuzucuoğlu, 2007 Northern Syria and Upper Mesopotamia at the end of the third millennium BC; did a crisis take place? In: Kuzucuoğlu, C. and C. Marro (eds), Sociétés humaines et changement climatique à la fin du Troisième Millénaire: une crise a-t-elle eu lieu en Haute Mésopotamie? Varia Anatolica XIX, Istanbul, 583–590. Paris.

Marshall & Hildebrand, *Cattle before Crops*. Marshall, F., and E. Hildebrand, 2002. Cattle before crops: the beginnings of food production in Africa. Journal of World Prehistory, 16: 2, 99–143.

Marston, *Modeling Resilience*. Marston, J. M., 2015. Modeling Resilience and Sustainability in Ancient Agricultural Systems. Journal of Ethnobiology, 35: 3, 585–605.

Martínez-Jauregui, et al., *People & Predators*. Martínez-Jauregui, M., Linares, O., Carranza, J. and M. Soliño, 2017. Dealing with conflicts between people and colonizing native predator species. Biological Conservation, 20: 9, 239–244.

Mascher et al*., Barley Genomics*. Mascher, M., Schuenemann, V.J., Davidovich, U., Marom, N., Himmelbach, A., Hübner, S., Korol, A., David, M., Reiter, E., Riehl, S. and M. Schreiber, 2016. Genomic analysis of 6,000-year-old cultivated grain illuminates the domestication history of barley. Nature genetics, 48: 9, 1089–1093.

Mashaly et al., *Vegetation Analysis*. Mashaly, I. A., el-Halawany, E. F. and G. Omar, 2001. Vegetation Analysis Along Irrigation and Drain Canals in Damietta Province, Egypt. Online Journal of Biological Sciences 1: 12, 1180–1189.

Matthews & Roemer, *Ancient Perspectives*. Matthews, R. and C. Roemer, 2003. Ancient Perspectives on Egypt. http://www.eblib.com.

Mattson, *Acid Lakes & Rivers*. Mattson, M. D., 1999. Acid lakes and rivers. In Alexander, D.E. and R. W. Fairbridge (eds), Encyclopaedia of Environmental Geology, 6–9. Dordrecht.

Mays, *Egyptian Water Technologies*. Mays, L. W., 2010. Water Technology in Ancient Egypt. In mays, l. W (ed.), Ancient Water Technologies, 53–65. Dordrecht.

McCarthty et al., *Hippo Impact*. McCarthy, T. S., Ellery, W. N. and A. Bloem, 1998. Some observations on the geomorphological impact of hippopotamus Hippopotamus amphibius L. in the Okavango Delta, Botswana. African Journal of Ecology, 36: 1, 44–56.

McCorriston, *Barley*. McCorriston, J., 2000. Barley. In Kiple, K. and K. Ornelas (eds), The Cambridge World History of Food, 81–89. Cambridge. doi:10.1017/CHOL9780521402149.012

McDowell &Woodward, *Animal Adaptation*. Dowell, R. E., and A. Woodward, 1982. Concepts in animal adaptation. In Adegbola, T. A. and I. Mecha (eds), Proceedings of the Third International Conference on Goat Production and Disease, Jan. 10-15, 1982, Tucson, Arizona, 387–391. Scottsdale.

McFarlane, *Irukaptah*. McFarlane, A., 2000. The Unis Cemetery at Saqqara. Vol. 1; The Tomb of Irukaptah. Warminster.

McFarlane, *Saqqara Mastabas*. McFarlane, A., 2003. Mastabas at Saqqaara: Kaiemheset, Kaipunesut, Kaiemsenu, Sehetepu and Others. Oxford.

McGregor, *Goats Notes*. McGregor, B., 2001. Goat notes C1: What do goats really like to eat? 83–85. http://hdl.handle.net/10536/DRO/DU:30065878

McIlvaine, *Implications.* McIlvaine, B. K., 2015. Implications of reappraising the iron-deficiency anemia hypothesis. International Journal of Osteoarchaeology 25: 6, 997–1000.

McIntosh, *Ecology*. McIntosh, R. P., 1986. The background of ecology: concept and theory. Cambridge.

McNabb & Batterson*, Phragmites Occurrence*. McNabb, C. D., and T. R. Batterson, 1991. Occurrence of the common reed, Phragmites australis, along roadsides in Lower Michigan. Michigan Academician 23: 211–220.

McNaughton, *Grazers Nutrient Cycling*. McNaughton, S. J., 1997. Promotion of the cycling of diet-enhancing nutrients by African grazers. Science 27: 8, 1798–1800.

McNaughton, *Typha Ecotype Function*. McNaughton, S. J., 1966. Ecotype function in the Typha community-type. Ecological Monographs 36: 4, 297–325.

Meadows & Saltonstall, *Phragmites Distribution.* Meadows, R. E. and K. Saltonstall, 2007. Distribution of native and introduced Phragmites australis in freshwater and oligohaline tidal marshes of the Delmarva Peninsula and southern New Jersey. Journal of the Torrey Botanical Society 134: 1, 99–107.

Megahed & Vymazalová, *Djedkare Temple Circumcision*. Megahed, M. and H. Vymazalová, 2011. Ancient Egyptian royal circumcision from the pyramid complex of Djedkare. Anthropologie 49: 2, 155–164.

Mekonnen & Melesse, *Soil Erosion Mapping*. Mekonnen. M. and A. M. Melesse, 2011. Soil Erosion Mapping and Hotspot Area Identification Using GIS. In Melesse, A. M. (ed.), Nile River Basin Hydrology, Climate and Water Use, 207–224. Dordrecht.

Mellado, *Dietary Selection*. Mellado, M., 2016. Dietary selection by goats and the implications for range management in the Chihuahuan Desert: a review. The Rangeland Journal, 38: 4, 331–341.

Menon et al., *Species Diversity*. Menon, M., Devi, P., Nandagopalan,V. and R. Mohanraj, 2015. Species Diversity and Functional Assemblages of Bird Fauna Along the Riverine Habitats of Tiruchirappalli, India. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj (eds), Environmental Management of River Basin Ecosystems, 729–748. Dordrecht.

Mercuri, *Wild Cereals*. Mercuri, A., Fornaciari, R., Gallinaro, M., Vanin, S., and S. Di Lernia, 2018. Plant behaviour from human imprints and the cultivation of wild cereals in Holocene Sahara. Nature Plants 4: 2, 71-81.

Messerli et al. *Environmental Changes*. Messerli, B., Grosjean, M., Hofer, T., Nunez, L., and C. Pfister, 2000. From nature-dominated to human-dominated environmental changes. Quaternary Science Reviews 19: 1, 459–479.

Mexicano et al., *Ecological Engineering*. Mexicano, L., Nagler, P. L., Zamora-Arrroyo, F. and E. P. Glenn, 2013. Vegetation dynamics in response to water inflow rates and fire in a brackish Typha domingensis Pers. marsh in the delta of the Colorado River, Mexico. Ecological engineering 5: 9, 167–175.

Meybeck, *African Rivers.* Meybeck, M., 2009. Fluvial export. In Likens, G. E. (ed.), Biogeochemistry of Inland Waters, 118–130. San Diego.

Michalowski & Guterman, *Art of Ancient Egypt*. Michalowski, K. and N. Guterman, 1969. Art of Ancient Egypt. New York.

Midant-Reynes, *Egyptian Prehistory*. Midant-Reynes, B., 2000. The prehistory of Egypt: From the first Egyptians to the first Pharaohs. London.

Middleton, *Nothing Lasts Forever*. Middleton, G. D., 2012. Nothing lasts forever: Environmental discourses on the collapse of past societies. Journal of Archaeological Research, 20: 3, 257–307.

Miller et al., *Predynastic Schistosomiasis*. Miller, R. L., De Jonge, N., Krijger, F. W., and A. M. Deelder, 1993. Predynastic schistosomiasis. In Davies, W. V. and R. Walker (eds), Biological anthropology and the study of ancient Egypt, 54–60. London.

Miller, *Hogs & Hygiene*. Miller, R., 1990. Hogs and Hygiene. The Journal of Egyptian Archaeology, 76: 1, 125–140.

Miller, *Skulls & Dentition*. Miller, J., 2008. An appraisal of the skulls and dentition of ancient Egyptians, highlighting the pathology and speculating on the influence of diet and environment. Oxford.

Mills, *SNA in Archaeology*. Mills, B., 2017. Social Network Analysis in Archaeology. Annual Review of Anthropology, 4: 6, 379–397.

Milotić & Hoffmann, *Dung & Competition*. Milotić, T. and M. Hoffmann, 2017. The impact of dung on inter- and intraspecific competition of temperate grassland seeds. Journal of Vegetation Science, 28: 4, 774–786.

Milotić & Hoffmann, *Reduced Germination Success*. Milotić, T. and M. Hoffmann, 2016. Reduced germination success of temperate grassland seeds sown in dung: Consequences for post-dispersal seed fate. Plant Biology, 18: 6, 1038–1047.

Minchinton & Bertness, *Phragmites Spread*. Minchinton, T. E. and M. D. Bertness, 2003. Disturbance-mediated competition and the spread of Phragmites australis in a coastal marsh. Ecological Applications 13: 5, 1400–1416.

Miranda-De La Lama, et al., *Livestock Transport*. Miranda-De La Lama, G.C., Villarroel, M. and G. A. María, 2014. Livestock transport from the perspective of the pre-slaughter logistic chain: a review. Meat Science, 981, 9–20.

Mitchell, *People & Wetlands*. Mitchell, P., 2012. People and Wetlands in Africa. In Menotti, F. and A. O'Sullivan (eds), The Oxford Handbook of Wetland Archaeology, 107–120. Oxford.

Mitsch & Gosselink, *Wetlands*. Mitsch, W. J. and J. G. Gosselink, 2000. Wetlands. New York.

Moeller & Marouard, *Edfu & Dendera Development*. Marouard, G. and N. Moeller, 2018. The Development of Two Early Urban Centres in Upper Egypt During the 3rd Millennium BC. The Examples of Edfu and Dendara. In Budka, J. and J. Auenmüller (eds.), From Microcosm to Macrocosm. Individual Households and Cities in Ancient Egypt and Nubia, 29–58. Leiden.

Moeller, *FIP Famine?* Moeller, N., 2006. The First Intermediate Period: A time of Famine and Climate Change? Ägypten und Levante: Internationale Zeitschrift für ägyptische archäologie und deren nachbargebeite, 16: 153–168.

Moens & Wetterstrom, *OK Plant Remains*. Moens, M. F and W. Wetterstrom, 1988. The Agricultural Economy of an Old Kingdom Town in Egypt's West Delta: Insights from the Plant Remains. Journal of Near Eastern Studies 47: 3, 159–173.

Moers, *Geography of Otherness*. Moers, G., 2010. The World and the Geography of Otherness in Pharaonic Egypt. In Raaflaub, K. A. and R. J. Talbert (eds), Geography and ethnography: Perceptions of the world in pre-modern societies, 169–181. Chichester and Malden.

Moghaddam et al., *Salinity & Flax*. Moghaddam, M., Babaei, K. and E. Saeedi Pooya, 2018. Germination and growth response of flax *Linum usitatissimum* to salinity stress by different salt types and concentrations. Journal of Plant Nutrition, 41: 5, 563–573.

Mohamed & Serag, *Anatomy of Lotus.* Mohamed, Z. A. and M. S. Serag, 2003. Ecology and Anatomy of Nymphaea Lotus L. in the Nile Delta. Journal of Environmental Sciences, 26: 2, 1–20.

Mohamed, *Nile Zooplankton & Phytoplankton*. Mohamed, S. E. M., 2003. Environmental studies on zooplankton and phytoplankton in some polluted areas of the River Nile and their relation with the feeding habit of fish. PhD, Zagazig University, Egypt.

Mohammed et al., *Crayfish Development*. Mohammad, A. A., Awaad, A. M., Samir, A. Z., Khalid, A. and M. H. Ghanem, 2015. Egg incubation and post-embryonic development in the red swamp crayfish *Procambarus clarkii* from the River Nile, Egypt. International Journal, 3: 8, 281–289.

Mohr, *Hetep-her-akhti*. Mohr, H.T., 1943. The Mastaba of Hetep-her-akhti: Study on an Egyptian Tomb Chapel in the Museum of Antiquities. Leiden.

Mona et al, *Catfish Supplementary Feed*. Mona M., Alamdeen A., Elgayar E., Heneish A. and M. El-Feky Mohamed, 2015. Evaluation on the effect of local and imported yeast as supplementary feed on African catfish *clarias gariepinus burchell,* in Egypt. International Journal of Aquaculture 5: 25, 1–8.

Montet, *Les Scenes*. Montet, P., 1923 Les scenes de la vie privee dans les tombeaux egyptiens de l'Ancien Empire. Strasbourg and Paris.

Moore, *Form & Function*. Moore, J. A., 1988. Understanding Nature: Form and Function. American Zoologist 28: 2, 449–584.

Moore, *Pollen Travel*. Moore, P. D., 1976. How far does pollen travel? Nature, 260; 388–389.

Morenó García, *Ancient Egyptian Administration*. Morenó García, J. C., 2013. The Territorial Administration of the Kingdom in the 3rd Millennium. Ancient Egyptian Administration, 85.

Morenó García, *J'ai rempli les pâturages*. Morenó García, J. C., 1999. J'ai rempli les pâturages de vaches tachetées… bétail, économie royale et idéologie en Égypte, de l'Ancien au Moyen Empire, in: Revue d'Égyptologie 50: 241–257.

Morenó García, *Microhistory*. Morenó García, J. C., 2018, Microhistory. In Grajetzki, W. and W. Wendrich (eds), UCLA Encyclopedia of Egyptology. http://digital2.library.ucla.edu/viewItem.do?ark=21198/zz002kczsg

Morenó García, *Old Kingdom Warfare*. Morenó García, J. C., 2010. War in Old Kingdom Egypt 2686-2125 BCE. In Vidal, J. (ed.), Studies on War in the Ancient Near East. Collected Essays on Military History AOAT, 372, 5–41. Münster.

Morenó García, *Patronage*. Morenó García, J. C., 2013. The 'Other'Administration: Patronage, Factions, and Informal Networks of Power in Ancient Egypt. In Morenó García, J. C. (ed.), Ancient Egyptian Administration, 1029–1065. Leiden and Boston.

Morenó García, *Pharaonic Administration Limits*. Morenó García, J. C., 2013. The Limits of Pharaonic Administration: Patronage, Informal Authorities, Mobile Populations and "Invisible" Social Sectors. Diachronic Trends. In Bárta, M. and H. Küllmer (eds), Ancient Egyptian History: Studies Dedicated to the Memory of Eva Pardey, 88–101. Prague.

Morenó García, *Pharaonic Landscapes*. Morenó García, J. C., 2007. The state and the organisation of the rural landscape in 3rd millennium BC pharaonic Egypt. In Bollig, M., Bubenzer, O., Vogelsang, R., and H.-P. Wotzka (eds), Aridity, Change and Conflict in Africa; Proceedings of an International ACACIA Conference held at Königswinter, Germany October 1-3, 2003, 313–330. Cologne.

Morenó García, *Réinterprétation du Motif de la Famine*. Morenó García, J.C., 1997. Idéologie politique, culture palatine et mutation historique à la Première Période Intermédiaire: Une réinterprétation du motif de la famine. Études sur l'administration, de l'Ancien au Moyen Empire, Aegyptiaca Leodiensia 4: 1–92. Liège.

Morenó García, *Social & Economic History*. Morenó García, J. C., 2014. Recent Developments in the Social and Economic History of Ancient Egypt. Journal of Ancient Near Eastern History, 12, 231–261.

Morenó García, *Sociopolitocal Transformation?* Morenó García, J. C., 2015. Climatic change or sociopolitical transformation? Reassessing late 3rd millennium Egypt. In Meller, H., Arz, H. W., Jung, R. and R. Risch (eds), 2200 BC—A Climatic Breakdown as A Cause for the Collapse of the Old World? 79–94. Halle.

Morenó García, *Territory, Elite & Power*. Morenó García, J. C., 2013. Building the Pharaonic state: Territory, elite, and power in ancient Egypt in the 3rd millennium BCE. In Hill, J. A., Jones, P., and A. J. Morales (eds), Experiencing Power, Generating Authority: Cosmos, Politics, and the Ideology of Kingship in Ancient Egypt and Mesopotamia, 185–217. Pennsylvania.

Morenó-García, *Production Alimentaire.* Morenó García, J. C., 2003. Production alimentaire et ideologie: Les limites de l'iconographie pour l'Otude des pratiques agricoles et alimentaires des Γgyptiens du IIIe millOnaire avant J.-C. Dialogues d'Histoire Ancienne 29: 2, 73–95.

Morris, *Was It Safe to Drink?* Morris, J., 2005. A river full of water: but was it safe to drink? Ancient Egypt Life and the Hereafter 6: 1, 36–39.

Mortensen, *Settlement Pattern Change*. Mortensen, B., 1991. Change in the settlement pattern and population in the beginning of the historical period. Ägypten und Levante/Egypt and the Levant, 11–37.

Mourad, *OK Siege Scenes*. Mourad, A. L. 2011. Siege Scenes of the Old Kingdom. In Binder, S. (ed.), Bulletin of the Australian Centre for Egyptology, 22: 135–158.

Mousa et al, *Heavy Metal Catfish*. Mousa, M., Ibrahim, H. A., Shahawy, E. L. and A. Nader, 2014. Some Studies on Heavy Metal Affecting Wild Catfish in Different Regions in Egypt. Alexandria Journal for Veterinary Sciences 43: 104–113.

Moussa & Altenmüller, *Nianchchnum und Chnumhotep*. Moussa, A., Altenmüller, H., Johannes, D. and W. Rühm, 1977. Das Grab des Nianchchnum und Chnumhotep. Old Kingdom tombs at the causeway of King Unas at Saqqara. Mainz am Rhein.

Mowlem, *Goats*. Mowlem, A., 2011. Goats. In Webster, J. (ed.), Management and Welfare of Farm Animals: The UFAW Farm Handbook, 366–389. Chicago.

Mufarrege etal., *Typha Adaptibility*. Mufarrege, M. M., Di Luca, G. A., Hadad, H. R. and M. A. Maine, 2011. Adaptability of Typha domingensis to high pH and salinity. Ecotoxicology 20: 2, 457–465.

Mugisha et al., *Wetland Vegetation & Nutrient Retention*. Mugisha, P., Kansiime, F., Mucunguzi, P. and E. Kateyo, 2007. Wetland vegetation and nutrient retention in Nakivubo and Kirinya wetlands in the Lake Victoria basin of Uganda. Physics and Chemistry of the Earth, Parts A/B/C, 32: 15-18, 1359–1365.

Mulamoottil et al., *Wetlands Guidelines*. Mulamoottil, G, Warner, B. G. and E. A. McBean, 1996. Wetlands: Environmental Guidelines, Boundaries and Buffers. Boca Raton.

Müller-Wollermann, *Crime & Punishment*. Müller-Wollermann, R., 2015. Crime and punishment in pharaonic Egypt. Near Eastern Archaeology 78: 4, 228–235.

Müller, *Discourse about Art*. Müller, M., 2012. Discourses about Works of Art in Ancient and Modern Times. In Kóthay, K. (ed.), Art and Society. Ancient and Modern Contexts of Egyptian Art, 13–22. Budapest.

Mumford & Parcak, *el-Markha*. Mumford, G. D. and S. Parcak, 2003. Pharaonic Ventures into South Sinai: el-Markha Plain Site 346. The Journal of Egyptian Archaeology 89: 83–116.

Mumford, *Ras Budran*. Mumford, G. D., 2006. Tell Ras Budran site 345: defining Egypt's Eastern Frontier and Mining Operations in South Sinai during the Late Old Kingdom Early EBIV/ MBI. Bulletin of the American Schools of Oriental Research 342: 1, 13–67.

Murray, *Cereal Production.* Murray, M. A., 2000. Cereal production and processing. In Nicholson, P. T. and I. Shaw (eds), Ancient Egyptian materials and technology, 506–536. Cambridge.

Murray, *Egyptian Climate*. Murray, G. W., 1951. The Egyptian Climate: An Historical Outline. The Geographical Journal 117: 4, 422–434.

Murray, *Fruits etc.* Murray, M. A., 2000. Fruits, Vegetables, Pulses and Condiments. In Nicholson, P. T. and I. Shaw (eds), Ancient Egyptian materials and technology, 609–655. Cambridge.

Muthuri & Jones, *Nutrient Distribution*. Muthuri, F. M. and M. B. Jones, 1997. Nutrient distribution in a papyrus swamp: Lake Naivasha, Kenya. Aquatic Botany 56: 1, 35-50.

Muthuri & Jones, *Papyrus Productivity*. Muthuri, F. M., Jones, M. B., S. K. Imbamba, 1989. Primary productivity of papyrus Cyperus papyrus in a tropical swamp; Lake Naivasha, Kenya. Biomass 18: 1, 1–14.

Muthuri & Kinyamario, *Papyrus Nutritive Value*. Muthuri, F. M. and J. J. Kinyamario, 1989. Nutritive Value of Papyrus (Cyperus Papyrus, Cyperaceae), a Tropical Emergent Macrophyte. Economic Botany 43: 1, 23–30.

Muzzolini, *Saharan Food Economy*. Muzzolini, A., 1993. The emergence of a food-producing economy in the Sahara. In Shaw, T., Sinclair, P., Andah, B. and A. Okpoko (eds), The Archaeology of Africa: Food, Metals and Towns, 227–239. London.

Myśliwiec, et al., *Saqqara Geoarchaeology & Paleoclimate*. Myśliwiec, K., Welc, F. and J. Trzciński, 2012. Geoarchaeological and Paleoclimatic Research by the Polish Archaeological Mission in Saqqara: An Updated Overview. Études et Travaux 25: 276–296.

Nag et al, *Flax Genetic Diversity*. Nag, S., Jiban, M. and P. G. Karmakar, 2015. An overview on flax *Linum usitatissimum L.* and its genetic diversity. International Journal of Agriculture, Environment and Biotechnology 8: 4, 805–817.

Nana-Sinkam, *Degradation*. Nana-Sinkam, S. C., 1995. Land and Environmental Degradation and Desertification in Africa: Issues and Options for Sustainable Economic Development with Transformation. UNECA FAO Report.

Näser, *Nomads at the Nile*. Näser, C., 2012. Nomads at the Nile: towards an archaelogy of interaction. In Barnard, H. and K. Duistermaat (eds), The history of the peoples of the Eastern Desert, 81–92. Los Angeles.

Nash, *Aquatic Animals*. Nash, C., 2012. Aquatic Animals. In Kiple, K. and K. C. Ornelas (eds), The Cambridge World History of Food, 456–467. Cambridge.

Negus, *A Great African Drought?* Negus, A. L., 1998. The fall of the Old Kingdom: a great African drought? PhD, University of California.

Neubauer, *Ecosystem Responses*. Neubauer, S. C., 2013. Ecosystem responses of a tidal freshwater marsh experiencing saltwater intrusion and altered hydrology. Estuaries and Coasts, 36: 3, 491–507.

Neuberger & Thornes, *Art & Climate.* Neuberger, H. and J. E. Thornes, 2005. Art and Climate. In Oliver, J. E., Fairbridge, R. W. and M. Rampino (eds), Encyclopedia of World Climatology, 94–102. Dordrecht.

Newberry, *Beni Hasan* I. Newberry, P.E., 1893. Beni Hasan, Part I. London.

Newberry, *Beni Hasan* II. Newberry, P.E., 1894. Beni Hasan, Part II. London.

Nicholl, *Climate as Civilizing Factor.* Nicoll, K., 2012. Geoarchaeological perspectives on holocene climate change as a civilizing factor in the Egyptian Sahara. In Giosan, L., Fuller, D. Q., Nicoll, K., Flad, R. K., and P. D. Clift (eds), Climates, Landscapes, and Civilizations, AGU Geophysical Monograph Series, 198: 157–162. Chicago.

Nikita et.al., *Saharan Dentition*. Nikita, E., Mattingly, D., and M. M Lahr, 2014. Dental indicators of adaptation in the Sahara Desert during the Late Holocene. HOMO-Journal of Comparative Human Biology, 65: 5, 381–399.

Njiru et al., *Lake Victoria Fisheries*. Njiru, M., Kazungu, J., Ngugi, C. C., Gichuki, J. and L. Muhoozi, 2008. An overview of the current status of Lake Victoria fishery: Opportunities, challenges and management strategies. Lakes & Reservoirs: Research & Management, 13: 1, 1–12.

Njiru et al., *Lake Victoria Perch & Tilapia*. Njiru, M., Nzungi, P., Getabu, A., Wakwabi, E., Othina, A., Jembe, T. and S. Wekesa, 2007. Are fisheries management, measures in Lake Victoria successful? The case of Nile perch and Nile tilapia fishery. African Journal of Ecology, 45: 3, 315–323.

Norfolk et al., *Arid South Sinai*. Norfolk, O., Eichhorn, M. P. and F. Gilbert, 2013. Traditional agricultural gardens conserve wild plants and functional richness in arid South Sinai. Basic and Applied Ecology 14: 8, 659–669.

Nuzzolo, *Divine Legitimization*. Nuzzolo, M., 2015. Royal Authority, Divine Legitimization. Topography as an element of acquisition, confirmation and renewal of power in the Fifth Dynasty. In Coppens, F., Janák, J. and H. Vymazalová (eds), 7th Symposium on Egyptian Royal Ideology. Royal versus Divine Authority. Acquisition, Legitimization and Renewal of Power. Königtum, Staat und Gesellschaft früher Hochkulturen 4, 4, 289–304. Wiesbaden.

O'Brien, *Boredom with Apocalypse*. O'Brien, S., 2017. Boredom with the Apocalypse: Resilience, Regeneration, and their Consequences for Archaeological Interpretation. In Cunningham, T. and J. Driessen (eds), Crisis to Collapse: The Archaeology of Social Breakdown, 295–302. Louvain.

O'Connor, *Enclosures Early Dynastic Abydos*. O'Connor, D., 1989. New Funerary Enclosures of the Early Dynastic Period at Abydos. Journal of the American Research Center in Egypt 26: 51–86.

O'Connor, *Society & Individual*. O'Connor, D., 2000. Society and Individual in Ancient Egypt. In Richards, J. and M. van Buren (eds), Order, Legitimacy and Wealth in Ancient States 21–35. Cambridge.

O'Keefe et al*., Exercise like a Hunter-gatherer*. O'Keefe, J. H., Vogel, R., Lavie, C. J. and L. Cordain, 2011. Exercise like a hunter-gatherer: a prescription for organic physical fitness. Progress in cardiovascular diseases, 53: 6, 471–479.

Oczkowski & Nixon, *Coastal Fishery Fall*. Oczkowski, A. and S. Nixon, 2008. Increasing nutrient concentrations and the rise and fall of a coastal fishery; a review of data from the Nile Delta, Egypt. Estuarine, Coastal and Shelf Science, 77: 3, 309–319.

Odlera, et al, *Abusir Molluscs*. Odlera, M., Dulíkováa, V. and L. Juřičkováb, 2013. Molluscs from the Stone and Mud-brick Tombs in Abusir Egypt and the Provenance of so-called "Nile-mud". Interdisciplinaria Archaeologica. Natural Sciences in Archaeology, 1: 9–22.

Okuku et al., *Plankton Response to Damming*. Okuku, E. O., Tole, M., Kiteresi, L. I. and S. Bouillon, 2016. The response of phytoplankton and zooplankton to river damming in three cascading reservoirs of the Tana River, Kenya. Lakes & Reservoirs: Research & Management, 21: 2; 114–132.

Olea-Popelka, et al., *Mycobacterium bovis & Human Tuberculosis*. Olea-Popelka, F., Dean, A. S., Muwonge, A., Perera, A., Raviglione, M. and P. I. Fujiwara, 2018. Mycobacterium bovis as the Causal Agent of Human Tuberculosis: Public Health Implications. In Chambers, M., Gordon, S., Olea-Popelka, F. and P. Barrow, (eds), Bovine Tuberculosis, 16–30. Wallingford.

Orozco Obando, *Sacred Lotus*. Orozco Obando, W.S., 2012, Evaluation of Sacred Lotus *Nelumbo nucifera Gaertn*. as an Alternative Crop for Phyto-remediation. PhD, Auburn University, Alabama.

Osman & Kloas. *Catfish Water Quality*. Osman, A. G. and W. Kloas, 2010. Water quality and heavy metal monitoring in water, sediments, and tissues of the African catfish *Clarias gariepinus Burchell*, from the river Nile, Egypt. Journal of Environmental Protection 1: 4, 389–400.

Osman et al., *Origin & Diversity*. Osman, S. A. M., Yonezawa, T. and M. Nishibori, 2016. Origin and genetic diversity of Egyptian native chickens based on complete sequence of mitochondrial DNA D-loop region, Poultry Science 95: 6, 1248–1256.

Östborn & Gerding, *Archaeological Data Network Analysis*. Östborn, P. and H. Gerding, 2014. Network analysis of archaeological data: a systematic approach. Journal of Archaeological Science, 4: 6, 75–88.

Oťaheľová et al., *Distribution Patterns of Aquatic Plants*. Oťaheľová, H., Valachovic, M. and R. Hrivnák, 2007. The impact of environmental factors on the distribution pattern of aquatic plants along the Danube River corridor Slovakia. Limnologica-Ecology and Management of Inland Waters, 37: 4; 290–302.

Othman & Soliman, *Schistosomiasis in Egypt*. Othman, A.A. and R. H. Soliman, 2015. Schistosomiasis in Egypt: A never-ending story? Acta Tropica, 148: 179–190.

Otify & Iskaros, *Water Quality Evaluation*. El-Otify, A. M. and I. A. Iskaros, 2015. Water quality and potamoplankton evaluation of the Nile River in Upper Egypt. Acta Limnologica Brasiliensia, 27: 2; 171–190.

Oxenham & Cavill, *Porotic Hyperostosis Response*. Oxenham, M. F. and I. Cavill, 2010. Porotic hyperostosis and cribra orbitalia: the erythropoietic response to iron-deficiency anaemia. Anthropological Science, 118: 3, 199–200.

Özkurt, *Egyptian Mongoose*. Özkurt, S. Ö., 2015. Karyological and some morphological characteristics of the Egyptian mongoose, Herpestes ichneumon Mammalia: Carnivora, along with current distribution range in Turkey. Turkish Journal of Zoology 39: 3, 482–487.

Palmer et al., *Plant Archaeogenetics*. Palmer, S.A., Smith, O. and R.G. Allaby, 2012. The blossoming of plant archaeogenetics. Annals of Anatomy 194: 1, 146–156.

Papachristou et al., *Goat Foraging*. Papachristou, T. G., Dziba, L. E. and F. D. Provenza, 2005. Foraging ecology of goats and sheep on wooded rangelands. Small Ruminant Research, 59: 2, 141–156.

Papyrus Data Sheet. CABI, 2016. Cyperus Papyrus. In: Invasive Species Compendium. Wallingford, UK: CAB International. http://www.cabi.org/isc/datasheet/17503.

Parcak, *Egypt's Old Kingdom Empire*? Parcak, S., 2004. Egypt's Old Kingdom 'Empire'? A Case Study Focusing on South Sinai. In Knoppers, G. N. and A. Hirsch 9eds), Egypt, Israel, and the Ancient Mediterranean World: Studies in Honor of Donald B. Redford, 41–60. Leiden.

Park, *Class Stratification*. Park, T. K., 1992. Early Trends toward Class Stratification: Chaos, Common Property, and Flood Recession Agriculture. American Anthropologist, 94: 1, 90–117.

Partridge, *Fighting Pharaohs*. Partridge, R. B., 2002. Fighting Pharaohs. London.

Patch et al., *Dawn of Egyptian Art*. Patch, D., Eaton-Krauss, M. and S. Allen, 1947 and the Metropolitan Museum of Art New York, 2011. Dawn of Egyptian art. Metropolitan Museum of Art. New York.

Paterson & Chapman, *Nile Perch Change*. Paterson, J. A. and L. J. Chapman, 2009. Fishing down and fishing hard: ecological change in the Nile perch of Lake Nabugabo, Uganda. Ecology of Freshwater Fish, 18: 3, 380–394.

Patin & Quintana-Murci, *Demeter's Legacy*. Patin, E., and L. Quintana-Murci, 2008. Demeter's legacy: rapid changes to our genome imposed by diet. Trends in Ecology and Evolution, 23: 2, 56–59.

Payne, *Moprhological Distinctions*. Payne, S., 1985. Morphological distinctions between the mandibular teeth of young sheep Ovis, and goats, Capra. Journal of Archaeological Science: 12: 139–147.

Pearce, *Hunter-Gatherer Networks*. Pearce, E., 2014. Modelling mechanisms of social network maintenance in hunter-gatherers. Journal of Archaeological Science, 50: 403–413.

Peeples & Roberts, *To binarize or Not*. Peeples, M. A. and J. M. Roberts Jr, 2013. To binarize or not to binarize: relational data and the construction of archaeological networks. Journal of Archaeological Science, 40: 7, 3001–3010.

Perbangkhem & Polprasert, *Papyrus Biomass*. Perbangkhem, T. and C. Polprasert, 2010. Biomass production of papyrus *Cyperus papyrus* in constructed wetland treating low-strength domestic wastewater. Bioresource technology, 101:2, 833–835.

Pérez Largacha, *Hydraulic Relation*. Perez Largacha, A., 1995. Chiefs and Protodynastic Egypt: A hydraulic relation? Archaeo-Nil, Mai, 79–85.

Pernthaler & Posch, *Microbial Food Webs*. Pernthaler, J. and T. Posch, 2015. Microbial Food Webs. In Likens, G. (ed.), The Encyclopedia of Inland Waters, 244–251. Amsterdam.

Pethick, *Saltmarsh Geomorphology*. Pethick, J. S., 1992. Saltmarsh Geomorphology. In Allen, J. R. L. and K. Pye (eds), Saltmarshes: Morphodynamic, Conservation and Engineering Significance, 41–62. Cambridge.

Petrie et al., *Dendereh*. Petrie, W. M. F., Griffith, F. L., Gladstone, J. H. and O. Thomas, 1900. Dendereh, 1898. London.

Pezeshki, *Cattail Photosynthetic Response.* Pezeshki, S. R., DeLaune, R. D., Kludze, H. K. and H. S. Choi, 1996. Photosynthetic and growth responses of cattail *Typha domingensis* and sawgrass *Cladium jamaicense* to soil redox conditions. Aquatic Botany, 54: 1, 25–35.

Pfeiffer & Sealy, *Foragers Body Size*. Pfeiffer, S. and J. Sealy, 2006. Body size among Holocene foragers of the Cape ecozone, southern Africa. American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists, 129: 1, 1–11.

Phillips et al., *Mid-Holocene Egypt*. Phillipps, R., Holdaway, S., Wendrich, W. and R. Cappers, 2012. Mid-Holocene occupation of Egypt and global climatic change. Quaternary International, 251: 64–76.

Phragmites Data Sheet. CABI, 2015. Phragmites Australis. In: Invasive Species Compendium. Wallingford, UK: CAB International. http://www.cabi.org/isc/datasheet/40514.

Pierssené, *Explaining Our World*. Pierssené, A., 1999. Explaining our world: An approach to the art of environmental interpretation. London.

Pitman & Läuchli, *Salinity & Agriculture*. Pitman, M. G. and A. Läuchli, 2002. Global impact of salinity and agricultural ecosystems. In Läuchli, A. and U. Lüttge, (eds), Salinity: environment-plants-molecules, 3–20. Dordrecht.

Platt & Jassby, *Photosynthesis, Light & Plankton*. Platt, T., and A. D. Jassby, 1976. The relationship between photosynthesis and light for natural assemblages of coastal marine phytoplankton. Journal of Phycology 12; 421–430.

PM III^2. Porter, B. and R. L. B. Moss; revised by J. Malek, 1974. Topographical Bibliography of Ancient Texts, Reliefs and Paintings, Volume III: Memphis. Oxford.

Poff & Zimmerman, *Altered Flow Regimes*. Poff, N. L. and J. K. Zimmerman, 2010. Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows. Freshwater Biology, 55: 1, 194–205.

Pollath, *Prehistoric Gamebag*. Pöllath, N., 2009. The Prehistoric Gamebag: The Archaeozoological Record from Sites in the Western Desert of Egypt. In Riemer, H., Forster, F., Herb, M. and N. Pollath (eds), Desert Animals in the Eastern Sahara; Proceedings of an Interdisciplinary ACACIA workshop, University of Cologne, December 14-15, 2007, 79–109. Köln.

Porter, *Mobile Pastoralism*. Porter, A., 2012. Mobile Pastoralism and the Formation of Near Eastern Civilizations. Weaving together Society. Cambridge.

Porter, *Wild Goats*. Porter, R., 1996. The Cretan wild goat *Capra aegagrus cretica* and the Theran “antelopes.” In Reese, D. S. (ed.), Pleistocene and Holocene Fauna of Crete and Its First Settlers, 295–315. Madison.

Powel, *Sumerian Agriculture*. Powell, M. A., 1999. The Sumerian Agriculture Group: A Brief History. In Klengel, H. and J. Renger (eds), Landwirtschaft im Alten Orient, 291–299. Berlin.

Qin, *Saqqara Landscape Change*. Qin, Y., 2009. Landscape change in the Saqqara/Memphis area of Egypt from 3000 BC to the present. MSci. dissertation, Earth Sciences, University of Cambridge.

Quintana, et al., *Predation, Competition & Size*. Quintana, X. D., Arim, M., Badosa, A., Blanco, J. M., Boix, D., Brucet, S., Compte, J., Egozcue, J. J., de Eyto, E., Gaedke, U. and S. Gascón, 2015. Predation and competition effects on the size diversity of aquatic communities. Aquatic Sciences, 77: 1, 45–57.

Ramachandra et al., *Ecohydrology*. Ramachandra, T. V., Chandran, M. S., Joshi, N. V., Karthick, B. and V. D. Mukri, 2015. Ecohydrology of Lotic Systems in Uttara Kannada, Central Western Ghats, India. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj (eds), Environmental Management of River Basin Ecosystems, 621–625. Dordrecht.

Ramdani et al, *Environmental Influences*. Ramdani, M. N., Elkhiati, R. J., Flower, J. R., Thompson, L., Chouba, M. M., Kraiem, F., Ayache and M. H. Ahmed, 2009. Environmental influences on the qualitative and quantitative composition of phytoplankton and zooplankton in North African coastal lagoons. Hydrobiologia 622: 1; 113–131.

Ramkumar et al., *Land Use Dynamics*. Ramkumar, M., Kumaraswamy, K. and R. Mohanraj, 2015. Land use dynamics and environmental management of River Basins with emphasis on deltaic ecosystems: Need for integrated study-based development and nourishment programs and institutionalizing the management strategies. In Ramkumar, M., Kumaraswamy, K., and R. Mohanraj, eds., Environmental Management of River Basin Ecosystems, 1–20. Dordrecht.

Ramsar www.ramsar.org/pdf/ris/key_ris_e.pdf 'Information Sheet Ramsar Wetlands.'

Ranciaro et al., *Lactase Persistence* . Ranciaro, A., Campbell, M. C., Hirbo, J. B., Ko, W. Y., Froment, A., Anagnostou, P., Kotze, M. J., Ibrahim, M., Nyambo, T., Omar, S. A. and S. A. Tishkoff, 2014. Genetic origins of lactase persistence and the spread of pastoralism in Africa. The American Journal of Human Genetics, 94: 4, 496–510.

Rao & Rao, *Weather & Insect Pests.* Rao, B. V. R. and M. S. Rao, 1996.Weather effects on Insect Pests. In Abrol, Y. P., Gadgil, S. and G. B. Pant (eds), Climate Variability and Agriculture, 281–305. New Delhi.

Rateutschak-Pluss & Guggenheim, *Dental Plaque Accumulation*. Rateutschak-Pluss, E. M. and B. Guggenheim, 1982. Effects of a carbohydrate-free diet and sugar substitutes on dental plaque accumulation. J Clin Periodontol, 9: 239–244.

Raxter, *Egyptian Body Size*. Raxter, M. H., 2011. Egyptian body size: a regional and worldwide comparison. PhD, University of South Florida.

Read, *Influence of Habitats*. Read, J. L., 1992 Influence of habitats, climate, grazing and mining on terrestrial vertebrates at Olympic Dam, South Australia. The Rangeland Journal 14: 143–156 .

Redding *Pyramids & Protein.* Redding R., 2007. Pyramids and protein of cattle, sheep, goats, and pigs, http://www.aeraweb.org/spec_zoo.asp.

Redding, *Animal Use Patterns*. Redding R. W., 1992. Egyptian Old Kingdom Patterns of Animal Use and the Value of Faunal Data in Modeling Socioeconomic Systems. Paléorient, 18: 2, 99–107.

Redding, *Faunal Evidence*. Redding, R., 2002. The study of human subsistence behavior using faunal evidence from archaeological sites. Archaeology: Original readings in method and practice, 92–110.

Redding, *Pig & Chicken*. Redding, R.W., 2015. The pig and the chicken in the Middle East: Modeling human subsistence behavior in the archaeological record using historical and animal husbandry data. Journal of Archaeological Research, 23: 4, 325–368.

Redding, *Pigs v Sheep/Goats*. Redding, R., 2002. Differential Consumption of Pig vs. Sheep/Goats at the Old Kingdom Site of Kom el-Hisn. Paper presented at the 53rd Annual Meeting of the American Research Center in Egypt, 2002. 39: 27–74.

Redding, *Role of the Pig*. Redding, R.W., 1991. The role of the pig in the subsistence system of ancient Egypt: A parable on the potential of faunal data. In: P. J. Crabtree and K. Ryan (eds), Animal Use and Culture Change, MASCA Research Papers in Science and Archaeology 8, 20–30. Philadelphia.

Redding, *Subsistence Change*. Redding, R. W., 1988. A general explanation of subsistence change: From hunting and gathering to food production. Journal of Anthropological Archaeology 71: 56–97.

Redford, *Ancient Egypt*. Redford, D. B., 2006. A History of Ancient Egypt. Dubuque.

Reimer, *A New Twist*. Reimer, P.J., 2001. A new twist in the radiocarbon tale. Science, 294: 5551, 2494–2495.

Reisner, *Giza* I. Reisner, G. A., 1942. A History of the Giza Necropolis, Vol. 1. Cambridge.

Reisner, *Giza* II. Reisner, G. A., 1955. A History of the Giza Necropolis Vol. 2. Cambridge.

Reisner, *Tomb Development*. Reisner, G. A., 1936. The Development of the Egyptian Tomb Down to the Accession of Cheops. Cambridge.

Renfrew & Bahn, *Archaeology*. Renfrew, C. and P. Bahn. 2004. Archaeology: Theories, Methods and Practice. London.

Renssen et al., *Holocene Climate Evolution*. Renssen, H., Brovkin, V., Fichefet, T., and H. Goosse, 2006. Simulation of the Holocene climate evolution in Northern Africa: the termination of the African Humid Period. Quaternary International, 150: 1, 95–102.

Revel et al., *African Monsoon Variability*. Revel, M., C. Colin, S. Bernasconi, N. Combourieu-Nebout, E. Ducassou, F. E. Grousset, Y. Rolland, S. Migeon, D. Bosch, P. Brunet, Y. Zhao, and J. Mascle, 2014. 21,000 years of Ethiopian African monsoon variability recorded in sediments of the western Nile deep-sea fan. Regional Environmental Change 14: 1685–1696.

Revel et al., *Nile River Dynamics*. Revel, M., Ducassou, E., Skonieczny, C., Colin, C., Bastian, L., Bosch, D., Migeon, S. and J. Mascle, 2015. 20,000 years of Nile River dynamics and environmental changes in the Nile catchment area as inferred from Nile upper continental slope sediments. Quaternary Science Reviews, 130; 200–221.

Reynolds, *Freshwater Plankton*. Reynolds, C. S., 1984. The ecology of freshwater phytoplankton. Cambridge.

Reynolds, *Phytoplankton Population Dynamics*. Reynolds, C., 2009. Phytoplankton Population Dynamics in Natural Environments. In Likens, G. (ed.), The Encyclopedia of Inland waters,197–203. Amsterdam.

Richards, *Weni*. Richards, J. 2002. Text and Context in the late Old Kingdom: The Archaeology and the Historiography of Weni the Elder. Journal of the American Research Center in Egypt 39: 75–102.

Riehl et al., *Barley Drought Stress*. Riehl, S., Pustovoytov, K. E., Weippert, H., Klett, S., and F. Hole, 2014. Drought stress variability in ancient Near Eastern agricultural systems evidenced by δ13C in barley grain. Proceedings of the National Academy of Sciences, 111: 34, 12348–12353.

Riehl, *Archaeobotanical Evidence*. Riehl, S., 2009. Archaeobotanical evidence for the interrelationship of agricultural decision-making and climate change in the ancient Near East. Quaternary International 197, 1–2, 93–114.

Ritchie, *Dakhleh Palaeobotany*. Ritchie J.C., 1999. Flora, Vegetation and Palaeobotany of the Dakhleh Oasis. In: C.S. Churcher and A.J. Millis (eds), Reports from the survey of the Dakhleh Oasis, Western Desert of Egypt 1977-1987, 74–80. Oxford.

Ritchie, *Dakhla Pollen Spectra*. Ritchie, J.C., 1985. Modern pollen spectra from Dakhla Oasis, Western Egyptian desert. Grana Uppsala, 1–6.

Robbins, *Collapse*. Robbins, M., 2001. Collapse of the Bronze Age. New York.

Roberts et al., *Climate Change Holocene Mediterranean.* Roberts, N., Eastwood, W. J., Kuzucuoğlu, C., Fiorentino, G. and V. Caracuta. 2011. Climatic, vegetation and cultural change in the eastern Mediterranean during the mid-Holocene environmental transition. The Holocene, 21: 1, 147–162.

Robins, *Art of Ancient Egypt*. Robins, G., 2008. The art of ancient Egypt. Harvard.

Robins, *Proportion & Style.* Robins, G., 2010. Proportion and style in ancient Egyptian art. Austin.

Roeten, *Cult Chapel Decorations*. Roeten, L. H., 2014. The Decoration on the Cult Chapel Walls of the Old Kingdom Tombs at Giza: A New Approach to Their Interaction. Leiden.

Rohling et al., *Holocene Climate Changes*. Rohling, E. J, Casford, J., Abu-Zied, R., Cooke, S., Mercone, D., Thomson, J., Croudace, I., Jorissen, F. J., Brinkhuis, H., Kallmeyer, J. and G. Wefer, 2002. Rapid Holocene climate changes in the Eastern Mediterranean. In Hassan F, (ed.), Drought, food, and culture: ecological change and food security in Africa's later prehistory 35–46. New York.

Roman et al., *Salt Marsh Vegetation Change*. Roman, C. T., Niering, W. A. and R. S. Warren, 1984. Salt marsh vegetation change in response to tidal restriction. Environmental Management, 82: 141–149.

Romem, *Unraveling Prolonged Stability*. Romem, I., 2009. The Unraveling of Prolonged Stability: The Fall of the Old Kingdom in Ancient Egypt. Berkeley.

Rosen & Rivera-Collazo, *Foraging Persistence*. Rosen, A. M., and I. Rivera-Collazo, 2012. Climate change, adaptive cycles, and the persistence of foraging economies during the late Pleistocene/Holocene transition in the Levant. Proceedings of the National Academy of Sciences, 109: 10, 3640–3645.

Rossel et al *Donkey Domestication*. Rossel, S., Marshall, F., Peters, J., Pilgram, T., Adams, M. D. and D. O'Connor, 2008. Domestication of the donkey: Timing, processes, and indicators', Proceedings of the National Academy of Sciences 105: 10, 3715-3720.

Rossel, *Food for the Dead*. Rossel, S., 2004. Food for the dead, the priest, and the mayor: looking for status and identity in the Middle Kingdom settlement at South Abydos, Egypt. In O'Day, S. J., Van Neer, W. and A. Ervynck (eds), Behaviour Behind Bones. The zooarchaeology of ritual, religion, status and identity. Proceedings of the 9th ICAZ Conference, Durham, 2002, 198–202. Oxford.

Rossel, *Tale of the Bones*. Rossel, S., 2006. A Tale of the Bones. Animal Use in the Temple and Town of Wah-Sut, http://www.penn.museum/documents/publications/expedition/PDFs/48-2/Rossel.pdf.

Roth, *Palace Attendants*. Roth, A. M., 1995. Giza Mastabas. Vol. 6: A cemetery of palace attendants: including G 2084-2099, G 2230+2231, and G 2240 Boston.

Roth, Royal *Cemetery Organisation*. Roth, A. M., 1988. The Organization of Royal Cemeteries at Saqqara in the Old Kingdom. Journal of the American Research Center in Egypt 25: 201–214.

Rothschild, *Porotic Hyperostosis*. Rothschild, B., 2002. Porotic hyperostosis as a marker of health and nutritional conditions. American Journal of Human Biology 14: 417–420.

Rothschild, *Shift to Maize*. Rothschild, B., 2012. Extrapolation of the mythology that porotic hyperostosis is caused by iron deficiency secondary to dietary shift to maize. Advances in Anthropology 2: 157–160.

Rowland, *Social transformation in the delta*. Rowland, J. M., 2003. Social transformation in the delta from to the early dynastic period- predynastic a comparative study volume. PhD, University College London.

Rudolf et al., *Water Quality Index*. Rudolf, A., Ahumada, R. and C. Perez, 2002. Dissolved oxygen content as an index of water quality in San Vicente Bay, Chile. Environmental monitoring and assessment 78: 89–100.

Ruffer, *Ancient Egyptian Teeth*. Ruffer, M. A., 1920. A study of abnormalities and pathology of ancient Egyptian teeth. Am J Phys Anthropol. 3: 335–382.

Ruffer, *Bilharzia in Mummies*. Ruffer, M. A., 1910. Note on the presence of Bilharzia hematobium in Egyptians mummies of the twentieth dynasty 1250-1000 BC. British Medical Journal 2, 16.

Ruzmaikin et al., *Nile Solar Cycles*. Ruzmaikin, A., Feynman, J., and Y. Yung, 2006. Does the Nile reflect solar variability? Proceedings of the International Astronomical Union, 2 S233, 511–518. Leuvin.

Rzeuska & Soliman, *Lost Memphis?* Rzeuska, T. I. and H. M. Soliman, 2014. In Search for the Lost Memphis. The Old Kingdom Settlement at Kôm el-Fakhry? Etudes et Travaux XXVII, 324–355.

Rzóska, *Descent to Sudan*. Rzoska, J., 1976. Descent to the Sudan Plains. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 197–214. The Hague.

Rzóska, *Domesticated Animals*. Rzóska, J., 1976. Domesticated Animals. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 69–71. The Hague.

Rzóska, *Joint Nile*. Rzoska, J., 1976. The Joint Nile in the Sudan. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 263–270. The Hague.

Rzóska, *Lake Tana Headwaters*. Rzóska, J., 1976. Lake Tana Headwaters of the Blue Nile. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 233–232. The Hague.

Rzóska, *Origin & History*. Rzóska, J., 1976. Origin and History. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 2–4. The Hague.

Rzóska, *Palaeo-Ecology*. Rzóska, J., 1976. Palaeo-Ecology. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 33–46. The Hague.

Rzóska, *Upper Nile Swamps*. Rzóska, J., 1974. The Upper Nile Swamps, a Tropical Wetland Study. Freshwater Biology 4: 1–30.

Saad & Sami, *Nile Delta Deposits*. Saad, S.I. and S. Sami, 1967. Studies of pollen and spores' content of the Nile Delta deposits Berenbal Region. Pollen Spores, 9: 467–503.

Saarinen et al., *River Water Acidity*. Saarinen, T., Celebi, A. and B. Klove, 2013. Links between river water acidity, land use and hydrology. Boreal environment research, 18: 5, 359–373.

Sabri et al, *Catfish Infection*. Sabri, D. M., Eissa, I. A., Danasoury, M. A. and H. M. Khouraiba, 2010. Prevalence of Henneguya branchialis in catfish *Clarias gariepinus* in Ismailia, Egypt. Int J Agric Bio 12: 897–900.

Saeed*, Fish Condition & Quality*. Saeed, S. M., 2013. Impact of environmental parameters on fish condition and quality in Lake Edku, Egypt. Egyptian Journal of Aquatic Biology. 17: 1, 101–112.

Saffiro, *Dietary Habits*. Saffirio, L., 1972. Food and dietary habits in ancient Egypt. Journal of Human Evolution, 13, 297–305.

Sahrhage, *Fishing in Ancient Egypt*. Sahrhage, D., 2008. Fishing in Ancient Egypt. In Selin, H. (ed.), Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures, 922–927. Dordrecht.

Said, *River Nile*. Said, R., 1993. River Nile: Geology, Hydrology and Utilization. Oxford and New York.

Salinger, *Influence of Climate*. Salinger, M. J., 2007. Agriculture's influence on climate during the Holocene. Agricultural and forest meteorology, 142: 2, 96–102.

Sallam & El-Barbary, *Secondary Channels*. Sallam, G. A. and Z. M. El-Barbary, 2004. The Effect of Closing Secondary Channels on the Morphology and the Ecology of the River Nile. Proceedings of the Eight international Water Technology Conference, IWTC8, Alexandria, 489–498. Cairo.

Sampsell, *Geology of Egypt*. Sampsell, B. M., 2003. A Traveller's Guide to the Geology of Egypt. Cairo.

Samuel, *Ancient Egyptian Nutrition*. Samuel, D. W., 1997. Cereal foods and nutrition in ancient Egypt. Nutrition 13: 6, 579–580.

Santoro et al., *1000 years of Famine*. Santoro, M., Hassan, F., Wahab, M., Cerveny, R. and R. Balling, 2015. An aggregated climate teleconnection index linked to historical Egyptian famines of the last thousand years. The Holocene, 25: 5, 872–879.

Saunders et al., *Papyrus Carbon & Water Cycles*. Saunders, M. J., Jones, M. B. and F. Kanslime, 2007. Carbon and Water Cycles in Tropical Papyrus Wetlands. Wetlands Ecological Management, 15: 489–498.

Savage, *Recent Predynastic Trends*. Savage, S. H., 2001. Some recent trends in the archaeology of Predynastic Egypt. Journal of Archaeological Research, 92: 101–155.

Säve-Söderbergh, *Hamra Dom*. Säve-Söderbergh, T., 1994. The Old Kingdom Cemetery at Hamra Dom (El-Qasr wa es-Saiyad). Stokholm.

Säve-Soderbergh, *Hippopotamus Hunting*. Säve-Soderbergh, T., 1953. On Egyptian Representations of Hippopotamus Hunting as a Religious Motif. Lund.

Scanlon, *Animals*. Scanlon, B., 2000. Animals: The Hunted and the Domesticated. In Donovan, L. and K. McCorquodale (eds), Egyptian Art, Principles and Themes in Wall Scenes, 83–100. Guizeh.

Do Linh san et al., *Herpestes ichneumon*. Do Linh San, E., Maddock, A.H., Gaubert, P. and F. Palomares, 2016. Herpestes ichneumon. The IUCN Red List of Threatened Species, e.T41613A45207211. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41613A45207211.en.

Schäfer, *Principles of Egyptian Art*. Schäfer, H., Brunner-Traut, E. and J. Baines (trans.) 1986. Principles of Egyptian Art. Oxford.

Schindler, *Acid Rain & Freshwater*. Schindler, D. W., 1988. Effects of acid rain on freshwater ecosystems. Science, 239: 4836, 149–157.

Schliemann, *Viverrids.* Schliemann, H., 1990. Viverrids. In Grzimek, B., Illies, J., and W. Klausewitz (eds), Grzimek's Encyclopedia of Ecology, III, 518. New York..

Schlumbaum & Edwards, *Ancient DNA*. Schlumbaum, A. and C. J. Edwards, 2012. Ancient DNA Research on Wetland Archaeological Evidence. In Menotti, F. and A. O'Sullivan (eds), The Oxford Handbook of Wetland Archaeology, 569–584.

Schrank & Mahmoud, *Dakhla Palynology*. Schrank, E. and M. S. Mahmoud, 1998. Palynology pollen, spores and dinoflagellates and Cretaceous stratigraphy of the Dakhla Oasis, central Egypt. Journal of African Earth Sciences 26: 2; 167–193.

Schultz, *Paleohistopathology*. Schultz, M., 2001 Paleohistopathology of bone: a new approach to the study of ancient diseases. American Journal of Physical Anthropology 44: 106–147.

Schurmann, *Reliefs Ii-nefret*. Schurmann, W., 1983. Die Reliefs aus dem Grab des Pyramidenoverstehers Ii-nefret. Karlsruhe.

Schwarz, *dentaire dans l'Égypte Pharaonique*. Schwarz, J. C., 1979. La Médicine dentaire dans l'Égypte Pharaonique. Bulletin de la société d'Égyptologie 2, 37–42.

Sealy, et al., *Diet & Dental Caries*. Sealy, J. C., Patrick, M. K., Morris, A. G. and D. Alder, 1992. Diet and dental caries among later Stone Age inhabitants of the Cape Province, South Africa. American Journal of Physical Anthropology 88: 123–134.

Seidlmayer, *Beni Hassan People*. Seidlmayer, S., 2007. People at Beni Hassan: Contributions to a Model of Ancient Egyptian Rural Society. In Hawass. Z. and J. Richards (eds), The Archaeology and Art of Ancient Egypt. Essays in Honor of David B. O'Connor II, 351–368. Cairo.

Seidlmayer, *OK Elephantine*. Seidlmayer, S. J., 1996. Town and State in the Early Old Kingdom: A View from Elephantine. In Spencer, J. (ed.), Aspects of Early Egypt, 108–127. London.

Seidlylmeyer, *First Intermediate Period*. Seidlylmeyer, S., 2000. Ch.6; The First Intermediate Period. In Shaw, I. (ed.), The Oxford History of Ancient Egypt, 108–136. Oxford.

Shaaba, et al., *Chlorophyll & Phytoplankton*. Shaaba, A. M., Mansour, H. A. and A. A. S. Sabera, 2013. Relationship between total chlorophyll and phytoplankton individuals of the Rosetta branch of river Nile, Egypt. Ecology 18; 1–7.

Shafik, *Disloyalty & Punishmnet*. Shafik, S., 2010. Disloyalty and punishment: the case of Ishfu at Saqqara. In Woods, A., McFarlane, A., and S. Binder (eds), Egyptian Culture and Society. Studies in Honour of Naguib Kanawati, II, 181–191. Cairo.

Shahin, *Water Resources.* Shahin, M., 2002 Hydrology and Water Resources of Africa. London.

Shaker, *Salt Tolerant Goats*. Shaker, Y. M., Ibrahim, N. H., Younis, F. E., and H. M. El Shaer, 2014. Effect of feeding some salt tolerant fodder shrubs mixture on physiological performance of Shami goats in Southern Sinai, Egypt. Journal of American Science, 10: 2s, 66–77.

Shalomi-Hen, *Rise of Osiris*. Shalomi-Hen, R., 2015. The 1Dawn of Osiris and the Dusk of the Sun-Temples: Religious History at the End of the Fifth Dynasty. In Der Manuelian, P. and T. Schneider (eds), Towards a new history for the Egyptian Old Kingdom: Perspectives on the pyramid age, I, 456–469. Harvard.

Shaltout & Azzazi, *Nile Delta Climate Change*. Shaltout, M. and M. Azzazi, 2014. Climate Change in the Nile Delta from Prehistoric to the Modern Era and Their Impact on Soil and Vegetation in Some Archaeological Sites. Journal of Earth Science and Engineering, 4, 632–642.

Shaltout & El-Sheikh, *Vegetation Environment Relations*. Shaltout, K.H. and M. A. El-Sheikh, 1993. Vegetation-environment relations along water courses in the Nile Delta region. Journal of Vegetation Science, 4: 4; 567–570.

Shaltout et al*., Hydrophyte Nutrient Status*. Shaltout, K. H., Galal, T. M. and T. M. El-Komi, 2009. Evaluation of the nutrient status of some hydrophytes in the water courses of Nile Delta, Egypt. Journal of Botany 1–11.

Shaw & Nicholson, *Dictionary*. Shaw, I. and P. Nicholson, 2003. The British Museum Dictionary of Ancient Egypt. London.

Shaw, *Egypt and the Outside*. Shaw, I., 2000. Chapter 11: Egypt And the Outside World. In Shaw, I (ed.), The Oxford History of Ancient Egypt, 308–323. Oxford.

Shaw, *Warfare & Weapons*. Shaw, I., 1991. Egyptian Warfare and Weapons. London.

Shen-Miller et al., *Long-living Lotus*. Shen-Miller, J., Schopf, J. W., Harbottle, G., Cao, R.I. Ouyang, S. Zhou, K.S. Southon, J.R. and G.H. Liu, 2002. Long-living lotus: Germination and soil γ-irradiation of centuries old fruits, and cultivation, growth and phenotypic abnormalities of offspring. Amer. J. Bot. 92: 236–247.

Sherratt, *Water, Soil & Seasonality*. Sherratt, A., 1980. Water, soil and seasonality in early cereal cultivation. World Archaeology, 11: 3, 313–330.

Shimazu et al. *Dietary Patterns & Mortality*. Shimazu, T., Kuriyama, S., Hozawa, A., Ohmori, K., Sato, Y., Nakaya, N., Nishino, Y., Tsubono, Y. and I. Tsuji, 2007. Dietary patterns and cardiovascular disease mortality in Japan: A prospective cohort study. Int. J. Epidemiol. 36, 600–609.

Shirai, *Egypt's First Farmer Herders*. Shirai, N., 2010. The archaeology of the first farmer-herders in Egypt: New insights into the Fayum Epipalaeolithic and Neolithic. Leiden.

Shirai, *Ideal & Reality*. Shirai, Y., 2006. Ideal and Reality in Old Kingdom Private Funerary Cults. In Bárta, M. (ed.), The old kingdom art and archaeology: proceedings of the conference held in Prague, May 31-June 4, 2004, 325–333. Prague.

Siebels, *Agricultural Scenes*. Siebels, R., 2000. Agricultural Scenes. In Donovan, L. and K. McCorquodale (eds), Egyptian Art, Principles and Themes in Wall Scenes, 55–64. Guizeh.

Silanikove & Koluman, *Adaptation in Dairy Goats*. Silanikove, N. and N. Koluman, 2015. Impact of climate change on the dairy industry in temperate zones: predications on the overall negative impact and on the positive role of dairy goats in adaptation to earth warming. Small Ruminant Research, 123: 1, 27–34.

Silanikove, *Adaptation in Goats*. Silanikove, N., 2000. The physiological basis of adaptation in goats to harsh environments. Small Ruminant Research, 35: 3, 181–193.

Silliman et al., *Livestock as Control Agents*. Silliman, B. R., Mozdzer, T., Angelini, C., Brundage, J. E., Esselink, P., Bakker, J. P., Gedan, K. B., van de Koppel, J. and A. H. Baldwin, 2014. Livestock as a potential biological control agent for an invasive wetland plant. PeerJ, 2: 10, 1–19.

Sillman et al. *Grazing as Phragmites Control*. Silliman, B. R., Mozdzer, T., Angelini, C., Brundage, J. E., Esselink, P., Bakker, J. P. and A. Baldwin, 2014. Livestock as a potential biological control agent for an invasive wetland plant. PeerJ, 2: 10, 567–586.

Silverman, *Anthropology & Circumcision*. Silverman, E. K., 2004. Anthropology and circumcision. Annual Review of Anthropology, 33: 1, 419–445.

Simpson, *Qar & Idu*. Simpson, W. K., 1976. Giza Mastabas. Volume 2; The Mastabas of Qar and Idu. New Haven.

Skonieczny, et al., *Western Sahara River System*. Skonieczny, C., Paillou, P., Bory, A., Bayon, G., Biscara, L., Crosta, X., Eynaud, F., Malaizé, B., Revel, M., Aleman, N., Barusseau, J., Vernet, R., Lopez, S. and F. Grousset, 2015. African Humid periods triggered the reactivation of a large river system in Western Sahara. Nat. Commun. 6: 8751, 1–6.

Smith & Simpson, *Art & Architecture*. Smith, W. S. and W. K. Simpson, 1998. The Art and Architecture of Ancient Egypt. New Haven.

Smith et al., *Optical Characteristics*. Smith, D. G., Davies-Colley, R. J., Knoef, J. and G. W. Slot, 1997. Optical characteristics of New Zealand rivers in relation to flow. Journal of the American Water Resources Association 33: 301–312.

Smith-Guzmán, *Nile Valley Malaria*. Smith-Guzmán, N. E., 2015. Cribra orbitalia in the ancient Nile Valley and its connection to malaria. International journal of paleopathology, 10, 1–12.

Smith, *Egyptian Imperialism.* Smith, S. T., 1991. A Model for Egyptian Imperialism in Nubia. GM 122: 77–102.

Smith, *HESPOK*. Smith, W.S., 1978. A History of Egyptian Sculpture and Painting in the Old Kingdom. London.

Smith, *Identifying Cess-pits*. Smith, D., 2013. Defining an 'indicator package' to allow identification of 'cess pits' in the archaeological record. Journal of Archaeological Science 40: 526–543.

Smith, *Origins Unidentified Reliefs*. Smith, W. S., 1942. The origin of some unidentified Old Kingdom reliefs. American Journal of Archaeology, 464: 509–531.

Smith, *Pastoral Emergence*. Smith, A. B., 2005. African herders: emergence of pastoral traditions. Altamira.

Smith, *People and Their Environments*. Smith, A., 2013 People and their environments: do cultural and natural values intersect in the cultural landscapes on the World Heritage List? In Frankel, D., Webb, J. M. and S. Lawrence (eds), Archaeology in environment and technology: intersections and transformations, 181–203. Abingdon.

Sofaer, *Osteoarchaeology*. Sofaer, J. R., 2006. The body as material culture: a theoretical osteoarchaeology Vol. 4. Cambridge.

Soliman, et al., *Plant Species Nile Islands*. Soliman, A.T., Amer, W. and W. Hassan, 2015. Factors affecting the spatial distribution of plant species in Nile islands of mid Egypt. Current Life Sciences, 12: 70–92.

Soria-Trastoy, *Fishing Tackle Analysis*. Soria-Trastoy, M. T., 2012. Iconographic and Archaeological analysis of the fishing tack1e in the tomb of Niankhkhnum and Khnumhotep. Journal of Oriental and Ancient History, 1: 13–58.

Soroush & Mordechai, *Short-Term Cataclysms*. Soroush, M. and L. Mordechai, 2018. Adaptation to Short-Term Cataclysmic Events: Flooding in Pre-modern Riverine Societies. Human Ecology, 46: 3, 349–361.

Sowada, *Late 3rd Millenium Weather*. Sowada, K., 2013. Evidence for late third millennium weather events from a Sixth Dynasty tomb at Saqqara. Studia Quaternaria, 302: 69–74.

Sowada, *OK Eastern Mediterranean*. Sowada, K., 2009. Egypt in the Eastern Mediterranean during the Old Kingdom: An Archaeological Perspective. Fribourg.

Spalinger, *War*. Spalinger, A. J., 2005. War in Ancient Egypt. Malden.

Speight & Blackith, *the Animals.* Speight, M. C. D. and R. E. Blackith, 1983. The Animals. In Gore, A. J. P. (ed.), Ecosystems of the World 4A: Mires, Swamps, Bog, Fen and Moor, 349–365. Amsterdam.

Spiegelman, *Emergency Surgery*? Spiegelman, M., 1997. The Circumcision scene in the tomb of Ankhmahor: the first record of emergency surgery? In Binder, S. (ed.), The Bulleting of the Australian Centre for Egyptology 8: 91–100. Sydney.

Stanley et al., *Nile Flow Failure.* Stanley, J. D., Krom, M. D., Cliff, R. and J. C. Woodward, 2003 Short contribution: Nile flow failure at the end of the Old Kingdom, Egypt: strontium isotopic and petrologic evidence. Geoarchaeology 18: 3, 395–402.

Stanton, *White Nile Marshes*. Stanton, E. A., 1903. The Great Marshes of the White Nile. Journal of the Royal African Society, 28, 375–379.

Staring, *Fixed Rules, Personal Choices*. Staring, N. T. B., 2015. Contextualizing Old Kingdom Elite Tomb Decoration: Fixed Rules Versus Personal Choice. In Strudwick, N. and H. Strudwick (eds), Old Kingdom: New

Perspectives. Egyptian Art and Archaeology 2750-2150 BC. Proceedings of a Conference at the Fitzwilliam Museum Cambridge, May 2009, 256–269. Oxford.

Starling & Stock, *Dental Indicators*. Starling, A. P., and J. T. Stock, 2007. Dental indicators of health and stress in early Egyptian and Nubian agriculturalists: a difficult transition and gradual recovery. American journal of physical anthropology, 1344: 520–528.

Staubwassser et al., *Climate Change*. Staubwasser, M., Sirocko, F., Grootes, P. M., and M. Segl, 2003. Climate change at the 4.2 ka BP termination of the Indus valley civilization and Holocene south Asian monsoon variability. Geophys. Res. Lett., 308: 1–4.

Steckel et al., *Skeletal. Health*. Steckel, R. H., Rose, J. C., Spencer Larsen, C., and P. L. Walker, 2002. Skeletal health in the Western Hemisphere from 4000 BC to the present. Evolutionary Anthropology: Issues, News, and Reviews, 114: 142–155.

Steckel, *Standard of Living*. Steckel, R. H., 2008. Biological measures of the standard of living. The Journal of Economic Perspectives, 129–152.

Steenhuis et al., *Erosion & Discharge*. Steenhuis, T. S., Tilahun, S. A., Tesemma, Z. K., Tebebu, T. Y., Moges, M., Zimale, F. A., Worqlul, A. W., Alemu, M. L., Ayana, E. K. and Y. A. Mohamed, 2014. Soil erosion and discharge in the Blue Nile Basin: trends and challenges. In Melesse, A., Abtew, W. and S. G. Setegn, (eds), Nile River basin: ecohydrological challenges, climate change and hydropolitics, 133–147. Dordrecht.

Steindorf, *Ti*. Steindorf, G., 1913. Das Grab des Ti. Leipzig.

Sterelny, *Social & Human intelligence*. Sterelny, K., 2007. Social intelligence, human intelligence and niche construction. Philosophical Transactions of the Royal Society B: Biological Sciences, 362: 1480, 719–730.

Sterner, *Herbivores Effect on Algae*. Sterner R. W., 1986 Herbivores' direct and indirect effects on algal populations. Science 231: 605–607.

Sterner, *Role of Zooplankton.* Sterner, R. W. 2015. Role of Zooplankton in Aquatic Ecosystems. In Likens, G. (ed.), The Encyclopedia of Inland Waters, 678–688. Amsterdam.

Stevenson, *Algae of Rivers*. Stevenson, R. J., 2015. Algae of River Ecosystems. In Likens, G. (ed.), The Encyclopedia of Inland Waters, 114–122. Amsterdam.

Stevenson, *Egyptian Archaeology*. Stevenson, A., 2014. Egyptian Archaeology and the Museum. Oxford.

Steward et al, *River Runs Dry*. Steward, A. L., von Schiller, D., Tockner, K., Marshall, J. C. and S. E. Bunn, 2012. When the river runs dry: human and ecological values of dry riverbeds. Frontiers in Ecology and the Environment, 104: 202–209.

Stewart et al, *Tracing Ancient Tracks.* Stewart, C., Lemmens, K. and M. Sala. 2015. Satellite Radar in Support to Archaeological Research in Egypt: Tracing Ancient Tracks Between Egypt and Southern Levant Across North Sinai. In G. Capriotti Vittozzi (ed.), Egyptian Curses 2. A Research on Ancient Catastrophes. Archaeological Heritage & Multidisciplinary Egyptological Studies 2: 197–221.

Stewart, *Fossil Fish*. Stewart, K. M., 2009. Fossil fish from the Nile River and its southern basins. In Dumont, H. (ed.), The Nile, 677–704. Dordrecht.

Stika & Heiss, *Plant Cultivation*. Stika, H.P. and A. Heiss, 2013. Plant cultivation in the Bronze Age. The Oxford handbook of the European bronze age, 348–369. Oxford.

Stock & Gifford-Gonzalez, *Genetics & Cattle Domestication.* Stock, F. and Gifford-Gonzalez, D., 2013. Genetics and African cattle domestication. African Archaeological Review, 301: 51–72.

Stock et al., *Skeletal. Biomechanics.* Stock, J. T., O'Neill, M. C., Ruff, C. B., Zabecki, M., Shackelfrod, L. and J. C. Rose, 2011. Body Size, Skeletal Biomechanics, Mobility and Habitual Activity from the Late Palaeolithic to the Mid-Dynastic Nile Valley. In Pinhasi, R., and J. T. Stock, (eds), Human bioarchaeology of the transition to agriculture. Chichester.

Stocker et al., *Climate Change 2013.* Stocker, T. F., Qin, D., Plattner, G. K., Alexander, L. V., Allen, S. K., Bindoff, N. L., Bréon, F. M., Church, J. A., Cubasch, U., Emori, S. and P. Forster, 2013. Technical summary. In Climate change 2013: the physical science basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 33–115. Cambridge.

Stommel et al., *Reduced Water Availability.* Stommel, C., Hofer, H. and M. L. East, 2016. The effect of reduced water availability in the Great Ruaha River on the vulnerable common hippopotamus in the Ruaha National Park, Tanzania. PloS one, 116, 1–18. e0157145.

Strudwick, *OK Administration*. Strudwick, N. C., 1985. The Administration of Egypt in the Old Kingdom; The Highest Titles and their Holders. London.

Strudwick, *Pyramid Age Texts*. Strudwick, N. C., 2005. Texts from the Pyramid Age. Atlanta.

Stuart-Macadam, *Porotic hyperostosis*. Stuart-Macadam P., 1992 Porotic hyperostosis: a new perspective. American Journal of Physical Anthropology. 87: 1, 39–47.

Stuart, *Paleoethnobotany*. Stuart, G. S. L., 2014. Paleoethnobotany. In Smith, C. (ed.), The Encyclopedia of Global Archaeology, Springer, 5755–5760

Suberkropp, *Temperature & Seasonal Occurrence*. Suberkropp K., 1984 Effect of temperature on seasonal occurrence of aquatic hyphomycetes.Transactions of the British Mycological Society 82: 53–62.

Sukhanovski et al., *Rainfall Erosivity Index* Sukhanovski, Y.P., Ollesch, G., Khan, K.Y. and R. Meiβner, 2002. A new index for rainfall erosivity on a physical basis. Journal of Plant Nutritionand Soil Science 165: 51–57.

Sullivan, *Divine & Rational*. Sullivan, R., 1997. Divine and Rational: The Reproductive Health of Women in Ancient Egypt. Obstetrical & Gynecological Survey, 5210, 635–642.

Sutcliffe, *Nile Basin Hydrology.* Sutcliffe, J. V., 2009. The hydrology of the Nile Basin. In Dumont, H. (ed.) The Nile, 335–364. Dordrecht.

Sutton & Hudson, *Arthropod Succession in Papyrus*. Sutton, L. S. L. and P. J. Hudson, 1981. Arthropod Succession and Diversity in Umbels of Cyperus papyrus. Biotropica, 13: 2, 117–120.

Swanson & Morrow-Tesch, *Cattle Transport*. Swanson, J. C. and J. Morrow-Tesch, 2001. Cattle transport: Historical, research, and future perspectives. Journal of Animal Science, 79E-Suppl, 102–109.

Swinton, *Dating Tombs*. Swinton, J., 2014. Dating the tombs of the Egyptian Old Kingdom. Oxford.

Swinton, *Old Kingdom Resources*. Swinton, J., 2012. The Management of Estates and their Resources in the Egyptian Old Kingdom. Oxford.

Tackholm, *Landscape, Flora & Agriculture*. Tackholm, V., 1976. Ancient Egypt, Landscape, Flora and Agriculture. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 51–72. The Hague.

Taher & Abdel-Motelib, *Microbial Sedimentary Structures*. Taher, A.G. and A. Abdel-Motelib, 2015. New insights into microbially induced sedimentary structures in alkaline hypersaline El Beida Lake, Wadi El Natrun, Egypt. Geo-Marine Letters, 35: 5, 341–353.

Tal, *Grazing Regulations*. Tal, A., 2009. The logic and logistics of grazing regulations. Land degradation & development, 204: 455–467.

Talenti et al., *EgyptianGoat Genome*. Talenti, A., Bertolini, F., Frattini, S., Elbeltagy, A., Pagnacco, G., Coizet, B., Aboul-Naga, A.M., Reecy, J.M., Moaeen-ud-Din, M., Rothschild, M.F. and P. Crepaldi, 2016. Initial genomic characterization of Italian, Egyptian and Pakistani goat breeds. International Journal of Health, Animal Science and Food Safety, 129: 3, 194–200.

Talling, *History of Nile Research*. Talling, J. F., 2009. The Nile: History of Scientific Research. In Dumont, H. (ed.), The Nile, 23–34. Dordrecht.

Talling, *Nile Water Characteristics*. Talling, J. F., 2009. Physical and chemical water characteristics. In Dumont, H. (ed.), The Nile, 367–394. Dordrecht.

Tansley, *Vegetational Concepts*. Tansley, A., 1935. The Use and Abuse of Vegetational Concepts and Terms. Ecology, 163: 284–307.

Tata, *Egyptian Textiles*. Tata, G., 1986. The development of the Egyptian textile industry. PhD, University of Utah.

Taylor, *Third Intermediate Period*. Taylor, J., 2000. The Third Intermediate Period. In Shaw, I. (ed.), Oxford History of Ancient Egypt. Oxford.

Terrell, *SNA & History*. Terrell J. E., 2013. Social network analysis and the practice of history. In Knappett, C. (ed.), Network Analysis in Archaeology: New Approaches to Regional Interaction, 17–42. Oxford.

Thienemann, *Grundprinzip*. Thienemann, A., 1954. Ein drittes biozonotisches Grundprinzip. Archives für Hydrobiologie 49: 421–422.

Thirukumaran & Ramkumar, *Remote Sensing*. V. Thirukumaran, V. and Mu. Ramkumar, 2015. Remote Sensing—A Fast and Reliable Tool to Map the Morphodynamics of the River Systems for Environmental Management. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj, (eds), Environmental Management of River Basin Ecosystems, 161–176. Dordrecht.

Thompson & Hamilton, *Peatlands*. Thompson, K. and A. C. Hamilton, 1983. Peatlands and swamps of the African continent. Ecosystems of the World. In Gore, A. J. P. (ed.), Mires: swamp, bog, fen and moor, B: regional studies, 331–373 Amsterdam.

Thompson et al., *Isotopic Palaeodiet.* Thompson, A. H., Richards, M. P., Shortland, A., and S. R. Zakrzewski, 2005. Isotopic palaeodiet studies of ancient Egyptian fauna and humans. Journal of Archaeological Science, 323: 451–463.

Thompson et.al., *Ancient Kerma Diet*. Thompson, A. H., Chaix, L. and M. P. Richards, 2008. Stable isotopes and diet at ancient Kerma, Upper Nubia Sudan. Journal of Archaeological Science, 352: 376–387.

Thompson, *Swamp Development*. Thompson, K., 1976. Swamp Development in the head waters of the White Nile. In Rzóska, J. (ed.) The Nile: Biology of an Ancient River, 177–196. The Hague.

Thompson, *Tehna* I. Thompson, E., 2014. The Old Kingdom cemetery at Tehna: volume I: the tombs of Nikaiankh I, Nikaiankh II and Kaihep. Oxford.

Thompson, *Tehna Report 2007.* Thompson, E. M., 2012. Report for the Supreme Council of Antiquities of the Expedition of the Australian Centre for Egyptology Macquarie University at the Early Old Kingdom Cemetery at Tehna in Middle Egypt Inspectorate of Minya: November–December 2007 Season. http://www.egyptology.mq.edu.au/08miniconf/Tehna%20Report%20for%20the%20SCA%20Nov%20Dec%202007.htm

Thopmson et al, *Ancient Egyptian Palaeodiet.* Thompson, A. H., Richards, M. P., Shortland, A. and S. R. Zakrzewski, 2005. Isotopic palaeodiet studies of ancient Egyptian fauna and humans. Journal of Archaeological Science, 323: 451–463.

Tiner, *Wetland Indicators*. Tiner, R. W., 1999. Wetland Indicators: A Guide to Wetland Identification, Delineation, Classification and Mapping. Boca Raton.

Tiradritti, *Art, architecture and history*. Tiradritti, F., 2002. Ancient Egypt: art, architecture and history. London.

Tirok & Schaler, *Water Depth & Turbidity*. Tirok, K. and U. M. Scharler, 2014. Influence of variable water depth and turbidity on microalgae production in a shallow estuarine lake system—A modelling study. Estuarine, Coastal and Shelf Science, 146: 111–127.

Tolia-Kelly, *Visual Culture*. Tolia-Kelly, D. P., 2012. The geographies of cultural geography II Visual culture. Progress in Human Geography, 361: 135–142.

Touzeau et al., *Ancient Egyptian Diet*. Touzeau, A., Amiot, R., Blichert-Toft, J., Flandrois, J. P., Fourel, F., Grossi, V., Martineau, F., Richardin, P. and C. Lécuyer, 2014. Diet of ancient Egyptians inferred from stable isotope systematics. Journal of Archaeological Science, 46: 114–124.

Touzeau et al., *Nile Valley Aridity*. Touzeau, A., Blichert-Toft, J., Amiot, R., Fourel, F., Martineau, F., Cockitt, J., Keith Hall, K., Flandrois, J. and C. Lécuyer, 2013. Egyptian mummies record increasing aridity in the Nile valley from 5500 to 1500yr before present. Earth and Planetary Science Letters, 375: 92–100.

Triambelas, *Caries Prevalence*. Triambelas, K., 2014. Caries Prevalence in Ancient Egyptian and Nubians. PhD, University of Alaska Fairbanks.

Trigger, *Kerma*. Trigger, B., 1976. Kerma: The Rise of an African Civilisation. The International Journal of Historical Studies. 91: 1–21.

Trigger, *Rise of Egyptian Civilization*. Trigger, B., 1982. The rise of civilization in Egypt. In J. Clark (ed.), The Cambridge History of Africa, 478–547. Cambridge. doi:10.1017/CHOL9780521222150.008

Tristant, *L'habitat Pre-Dynastique.* Tristant, Y. 2004. L'Habitat Pre-Dynastique de la Vallee du Nil: Vivre sur le rives du Nil aux V et IV Millenaires, Oxford.

Trøjelsgaard & Olesen, *Ecological Networks in Motion*. Trøjelsgaard, K. and J. M. Olesen, 2016. Ecological networks in motion: micro-and macroscopic variability across scales. Functional Ecology, 3012: 1926–1935.

Trzciñski, et al, *West Saqqara Geoarchaeology.* Trzciñski, J., Kuraszkiewicz, K.O. and F. Welc, 2010. Preliminary report on geoarchaeological research in West Saqqara, Polish Archaeology in the Mediterranean 19, 194–208.

Tulbure & Johnston, *Phragmites Invasion*. Tulbure, M. and C. Johnston, 2010. Environmental conditions promoting non-native Phragmites australis expansion in Great Lakes coastal wetlands. Wetlands, 303: 577–587.

Turner, *Grazing Effects*. Turner, M. G., 1987. Effects of grazing by feral horses, clipping, trampling, and burning on a Georgia salt-marsh. Estuaries 10: 54–60.

Turner, *Landscape Ecology*. Turner M. G., 1998 Landscape ecology, living in a mosaic. In Dodson, S. I., Allen, T. F. H, Carpenter, S. R., Ives, A. R., Jeanne, R. J., Kitchell, J. F., Langston, N. E. and M. G. Turner, (eds), Ecology, 78–122. New York.

Uchytil, *Phragmites australis*. Uchytil, R. J., 1992. Phragmites australis. US Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory, Fire Effects Information System. http://www. fs. fed. us/database/feis/plants/gramin oid/phraus/all. html.

Uprety et al., *Climate Change & Agriculture*. Uprety, D.C., Reddy, V.R. and J. D. Mura, 2019. Historical Analysis of Climate Change and Agriculture. In Climate Change and Agriculture, 7–29. Singapore.

Ussishkin, *Philistine Canaan*. Ussishkin, D., 2007. Lachish and the date of the Philistine settlement in Canaan. In Bietak, M. and E. Czerny, (eds), The Synchronisation of Civilisations in the Eastern Mediterranean in the Second Millennium BC: III, 601–608. Vienna.

Uzabaci et al., *Goat Pregnancy Factors*. Uzabaci, E., Çubukçu, K. and S. Dikmen, 2014. Determination of factors affecting pregnancy rate in Turkish Saanen goats. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 61: 303–307.

Vachala, *Ptahshepses*. Vachala, B., 2004. Abusir VIII. Die Relieffragmente aus der Mastaba des Ptahshepses in Abusir. Prague.

Våge et al., *Microbial Food Webs*. Våge, S., Bratbak, G., Egge, J., Heldal, M., Larsen, A., Norland, S., Lund Paulsen, M., Pree, B., Sandaa, R. A., Skjoldal, E. F. and T. M. Tsagaraki, 2018. Simple models combining competition, defence and resource availability have broad implications in pelagic microbial food webs. Ecology letters, 21: 9, 1440–1452.

van Dam et al., *Papyrus Wetlands*. van Dam, A., Kipkemboi, J., Zaal, F., and J. B. Okeyo-Owuor, 2011. The ecology of livelihoods in East African papyrus wetlands ECOLIVE. Reviews in Environmental Science and Biotechnology, 104: 291–300.

van De Mieroop, *Ancient Near East.* van De Mieroop, M., 2007. A History of the Ancient Near East. Oxford.

van den Brink, *Settlement Patterns*. van den Brink, E. C. M., 1993. Settlement Patterns in the Northeastern Nile Delta in the 4th-2nd Millenium B.C. In Krzyzaniak, L., Kobusiewicz, M. and J. Alexander, (eds), Environmental Change and Human Culture in the Nile Basin and Northern Africa until the Second Millenium B.C., 301–302. Poznan.

van der Leeuw, *Archaeology, Networks & Beyond*. van der Leeuw, S., 2013. Archaeology, networks, information processing, and beyond. In Knappett, C. (ed.), Network Analysis in Archaeology: New Approaches to Regional Interaction, 335–349. Oxford.

Van der Veen *Carbonised Plant Remains*. Van der Veen, M., 2007. Formation processes of desiccated and carbonized plant remains–the identification of routine practice. Journal of archaeological science, 346: 968–990.

van Deursen & Drost, *Cattle Defoliation*. van Deursen, E. J. M. and H. J. Drost, 1990. Defoliation and Treading by Cattle of Reed Phragmites Australis. Journal of Applied Ecology 27: 284–297.

Van Elsbergen, *Fischerei*. Van Elsbergen, M. J., 1997. Fischerei Im Alien Agypten: Untersitclnmgen zu den Fischfangdarstellungen in den Grabern der 4. bis 6. Dynastie. Berlin.

van Ham et al., *Ecosystems in Papyrus Marshes*. van Dam, A. A., Kipkemboi , J., Rahman, M. M. and G. M. Gettel, 2013. Linking hydrology, ecosystem function, and livelihood outcomes in African papyrus wetlands using a Bayesian Network model. Wetlands 33: 381–397.

van Ham et al., *Papyrus Management*. van Dam, A. A., Kipkemboi, J., Mazvimavi, D. and K. Irvine, 2014. A synthesis of past, current and future research for protection and management of papyrus Cyperus papyrus L. wetlands in Africa. Wetlands ecology and management, 222: 99–114.

Van Lepp, Artificial Irrigation? Van Lepp, J., 1995. Evidence for artificial irrigation in Amratian art. Journal of the American Research Center in Egypt, 32, pp.197-209.

van Neer, *Fishing Evolution*. van Neer, W., 2004. Evolution of Prehistoric Fishing in the Nile Valley. Journal of African Archaeology, 2: 251–269.

van Neer, *Prehistoric Fishing.* van Neer, W., 1989. Fishing along the prehistoric Nile. In Krzyzaniak, L. and M. Kobusiewicz (eds), Late Prehistory of the Nile Basin and the Sahara, 49–56. Poznan.

van Walsam, *Iconography*. van Walsam, R., 2005. The Iconography of Old Kingdom Elite Tombs. Leiden.

van Walsam, *Sense & Sensibility*. van Walsam, R., 2007. Sense and Sensibility. On the Analysis and Interpretation of the Iconography Programmes of Four Old Kingdom Elite Tombs. Internet Beitrage zur Agyptologie und Sudanarchaologie. Dekorierte Grabanlangen in Alten Reich Methodik und Interpretation, 277–331.

Vandier, *La Famine.* Vandier, J., 1936. La Famine dans l'Egypte Ancienne. Cairo.

Vandier, *Mo'alla*. Vandier, J., 1950. La tomhe d'Ankhtifi et la tombe de Sebekhotep. Cairo.

Vassilika & Bourriau, *Egyptian Art*. Vassilika, E. and J. Bourriau, 1995. Egyptian Art at the Fitzwilliam Museum. Cambridge.

Veiga, *Prevalent Pathologies*. da Silva Veiga, P A., 2012. Some prevalent pathologies in ancient Egypt. Institut Oriental: Centro de Estudios Arqueológicos: des Universités de Genève et Porto, 63–83. Porto.

Venkatachalapathy & Karthikeyan, *Water Quality Index*. Venkatachalapathy, R. and P. Karthikeyan, 2015. Diatom Indices and Water Quality Index of the Cauvery River, India: Implications on the Suitability of Bio-Indicators for Environmental Impact Assessment. In E Ramkumar, M., Kumaraswamy, K., and R. Mohanraj, (eds), Environmental Management of River Basin Ecosystems,707–727. Dordrecht.

Venkatesan et al., *Fluvial System Analysis*. Venkatesan, A., Jothibasu, A. and S. Anbazhagan, 2015. GIS Based Quantitative Geomorphic Analysis of Fluvial System and Implications on the Effectiveness of River Basin Environmental Management. In Ramkumar, M., Kumaraswamy, K. and R. Mohanraj, (eds), Environmental Management of River Basin Ecosystems, 161–176. Dordrecht.

Vereecken et al., *Dayr al-Barsha Pottery*. Vereecken, S., De Meyer, M., Dupras, T., and L. Williams, 2009. An Old Kingdom Funerary Assemblage at Dayr al-Barsha. In Rzeuska, T. I. and A. Wodzińska (eds), Studies on Old Kingdom Pottery. Proceedings of the Old Kingdom Pottery Workshop, Warsaw, 20–21 August ,2007, 187–207. Warsaw.

Verner & Callendar, *Djedkare's Family*. Verner, M. and G. Callendar, 2002. Abusir VI: Djedkare's Family Cemetery. Prague.

Verner et al., *Abusir's Second Renaissance*. Verner, M., Bárta, M. and Z Sůvová, 2010. The Second Renaissance of Abusir. In Woods, A., McFarlane, A. and S. Binder (eds), Egyptian Culture and Society: Studies in Honour of Naguib Kanawati, Vol. 2: 267–275. Cairo.

Verner, *Dating in the Old Kingdom*. Verner, M., 2008. The System of Dating in the Old Kingdom. In Bárta, M and H, Vymazalová, (eds), Chronology and Archaeology in Ancient Egypt, 23–43. Prague.

Verner, *Forgotten Pyramids*. Verner, M., 1994., Forgotten Pyramids: The Lost Pyramids of Abusir. Prague.

Verner, *Ptahshepses Reliefs*. Verner, M., 1987. Abusir I. The Mastaba of Ptahshepses I: Reliefs. Prague.

Verner, *Ptahshepses Texts*. Verner, M., 1986. Abusir I. The Mastaba of Ptahshepses I: Texts. Prague.

Verner, *Raneferef*. Verner, M., 2006. Abusir IX: The Pyramid Complex of Raneferef. Prague.

Verner, *Sons of the Sun*. Verner, M., 2014. Sons of the Sun. Rise and Decline of the Fifth Dynasty. Prague.

Verner, *Who was Shepseskara?* Verner, M., 2000. Who was Shepseskara, and when did he reign? In Bárta, M. and J. Krejčí (eds), Abusir and Saqqara in the Year 2000, 581–602. Prague.

Vernus & Yoyotte, *Bestiaire*. Vernus, P. and J. Yoyotte, 2005. Bestiaire des pharaons. Paris.

Verreth et al., *Catfish Digestive System*. Verreth, J. A., Torreele, E., Spazier, E., Sluiszen, A., Rombout, J. H., Booms, R. and H. Segner, 1992. The development of a functional digestive system in the African catfish Clarias gariepinus Burchell. Journal of the World Aquaculture Society, 234: 286–298.

Verreth, et al., *Feeding Practices*. Verreth, J., E. H. Eding, G. R. M. Rao, F. Huskens, and H. Segner, 1993. A review of feeding practices, growth and nutritional physiology in larvae of the catfishes Clarias gariepinus and Clarias batrachus. Journal of the World Aquaculture Society 24: 2, 135–144.

Viega, *Health & Medicine*. da Silva Veiga, P. A., 2009. Health and medicine in ancient Egypt: magic and science. Oxford.

Viles & Goudie, *Climatic Variability & Geomorphology*. Viles, H. A. and A. S. Goudie, 2003. Interannual, decadal and multidecadal scale climatic variability and geomorphology. Earth-Science Reviews, 611: 105–131.

Vincent, *Cyanobacteria*. Vincent, W. F., 2015. Cyanobacteria. In Likens, G. (ed.), The Encyclopaedia of inland waters, 226–232. Amsterdam.

Virgós & Casanovas, *Genet Habitat Selection*. Virgós E. and J. G. Casanovas, 1997. Habitat selection of genet Genetta genetta in the mountains of central Spain. Acta Theriol. 42: 169–177.

Vischak, *Agency*. Vischak, D., 2007. Agency in Old Kingdom Elite Tomb Programs: traditions, Locations, and Variable Meanings. Internet Beitrage zur Agyptologie und Sudanarchaologie. Vol. 6. Dekorierte Grabanlangen in Alten Reich Methodik und Interpretation: 255–276.

Vischak, *Ankhmahor*. Vischak, D., 2005. Common Ground between the Pyramid Texts and Old Kingdom Tomb Design: The Case of Ankhmahor. Journal of the American Research Center in Egypt. 40: 133–158.

Vischak, *Elephantine Identity*. Vischak, D., 2007. Identity in/of Elephantine: the Old Kingdom Tombs at Qubbet el Hawa. In Hawass, Z. and J. Richards (eds), The Archaeology and Art of Ancient Egypt: Essays in Honor of David B. O'Connor II, 443–457. Cairo.

Vivian et al., *Wetland Plant Growth*. Vivian, L. M., Godfree, R. C., Colloff, M. J., Mayence, C. E. and D. J. Marshall, 2014. Wetland plant growth under contrasting water regimes associated with river regulation and drought: implications for environmental water management. Plant Ecology, 215: 9, 997–1011.

Vogelsang-Eastwood, *Textiles*. Vogelsang-Eastwood, G., 2000. Textiles. In Nicholson, P. T. and I. Shaw (eds), Ancient Egyptian Materials and Technology, 268–298.

von Achthoven etal., *Productivity & Environment.* von Achthoven, T., Z., Merabet, Z., Shalaby, K. and F. Van Steenbergen, 2004. Balancing Productivity and Environmental Pressure in Egypt. Agriculture and Rural Development Working Paper. International Bank for Reconstruction and Development. 13: 1-83.

von den Driesch & Peters, *Störche über Elephantine*. on den Driesch, A. and J. Peters, 2008. Störche über Elephantine. In Engel, E. M., Müller, V. and U. Hartung, (eds), Zeichen aus dem Sand. Streiflichter aus Ägyptens Geschichte zu Ehren von Günter Dreyer, 661–679. Wiesbaden.

von den Driesch, *Fish Archaeozoology*. von den Driesch, A., 1983. Some archaeozoological remarks on fishes in Ancient Egypt. Animals and Archaeology, 2: 87–110.

von der Way, *Early Nile Delta Investigations.* von der Way, T., 1988. Investigations Concerning the Early Periods in the Northern Delta of Egypt. In van den Brink, E. C. M., (ed.), The Archaeology of the Nile Delta, Egypt: Problems and Priorities. Proceedings of the Seminar held in Cairo, 19-22 October 1986, on the occasion of the fifteenth anniversary of the Netherlands Institute of Archaeology and Arabic Studies in Cairo, 245–249. Cairo.

Vymazalová & Arias Kytnarova, *Sheretnebty*, Vymazalová, H. and K. Arias Kytnarová, 2017. The development of tomb AS 68c in Abusir South: Burial place of the king's daughter Sheretnebty and her family. In Bárta. M., Coppens, F. and J. Krejčí (eds), Abusir and Saqqara in the Year 2015, 435–450. Prague.

Vymazalova & Barta, *Chronology & Archaeology*. Vymazalová, H. and M. Bárta, Eds. 2008. Chronology and Archaeology in Ancient Egypt. Prague.

Walker et al., *Anemia Hypothesis Reappraisal*. Walker, P. L., Bathurst, R. R., Richman, R., Gjerdrum, T. and V. A. Andrushko, 2009. The causes of porotic hyperostosis and cribra orbitalia: A reappraisal of the iron-deficiency-anemia hypothesis. American Journal of Physical Anthropology, 1392: 109–125.

Walker et al., *Dryland River Ecosystems*. Walker, K. F., Sheldon, F. and J. T. Puckridge, 1995. A perspective on dryland river ecosystems. Regulated Rivers: Research & Management, 111: 85–104.

Wapler et al., *Sudanese Cranial Pathology*. Wapler, U., Crubézy, E., and M. Schultz, Is cribra orbitalia synonymous with anemia? Analysis and interpretation of cranial pathology in Sudan. American Journal of Physical Anthropology 123: 333–339.

Warburton, *Economic Thinking*. Warburton, D., 1998. Economic Thinking in Egyptology. Studien zur Altagyptischen kultur 26: 143–170.

Ward et al., *Floodplain Biodiversity*. Ward, J. V., Tockner, K., and F. Schiemer, 1999. Biodiversity of floodplain river ecosystems: ecotones and connectivity. Regulated rivers: research and management, 151: 125–139.

Ward et al., *Riverine Landscape Diversity.* Ward, J. V., Tochner, K., Arscott, D. B. and C. Claret, 2002. Riverine landscape diversity. Freshwater Biology 47: 517–539.

Warden, *Old Kingdom Economy.* Warden, L. A., 2014. Pottery and Economy in Old Kingdom Egypt. Leiden.

Watkins, *Hydrology, Nutrients & Salinity*. Watkins, L., 2005. The effects of hydrology, nutrients, and salinity on ten common wetland plants in Louisiana: a mesocosm study. PhD, Southern Louisiana University.

Weins, *Riverine Landscapes*. Weins J. A., 2002 Riverine landscapes: taking landscape ecology into the water. Freshwater Biology 47: 501–515

Weinstein, *Egyptian Palestine Empire*. Weinstein, J. M., 1981. The Egyptian Empire in Palestine: A Reassessment. Bulletin of the American Schools of Oriental Research 241: 1–28.

Weiskel, *Ecological Lessons.* Weiskel, T. C. 1989. The Ecological Lessons of the Past: An Anthropology of Environmental Decline. The Ecologist 193: 98–103.

Weiss et al., *Northern Mesopotamian Collapse*. Weiss, H., Courty, M.-A., Wetterstrom, W., Guichard, F., Senior, L., Meadow, R., and A. Curnow, 1993. The genesis and collapse of third millennium North Mesopotamian civilization. Science 261: 5124, 995–1004.

Weiss, *Collapse as Adaptation*. Weiss, H., 2000. Beyond the Younger Dryas: Collapse as adaptation to abrupt climate change in ancient West Asia and the Eastern Mediterranean. In Bawden, G. and R. M. Reycraft, (eds), Environmental Disaster and the Archaeology of Human Response. Maxwell Museum of Anthropology, Anthropological Papers, No. 7. Confronting Natural Disaster: Engaging the Past to Understand the Future, 75–98. Albuquerque.

Welc & Marks, *Geoarchaeological Evidence.* Welc, F. and L. Marks, 2014. Climate change at the end of the Old Kingdom in Egypt around 4200 BP: New geoarchaeological evidence. Quaternary International, 324, 124–133.

Welc & Marks, *Old Kingdom Fall*. Welc, F. and L. Marks, 2012. Late Mid Holocene climate variability and fall of the Old Kingdom in Egypt ca. 2200 BC, a new geoarchaeological perspective. In Geomorphic Processes and Geoarchaeology, from Landscape Archaeology to Archaeotourism. Proceedings of the International Conference, August 20-24, 286–289. Moscow.

Welc & Marks, *Old Kingdom Climate Change*. Welc, F. and L. Marks, 2013. Climate change at the end of the Old Kingdom in Egypt around 4200 BP: New geoarchaeological evidence. Quaternary International, XXX: 1–10.

Welc & Mieszkowski, *Unknown Ancient Structures*. Welc, F., and R. Mieszkowski, 2015. Unknown Ancient Funerary Structures Discovered in West Saqqara Egypt Using Ground-Penetrating Radar GPR. Études et Travaux [du Centre d'Archéologie Méditerranéenne de l'Académie Polonaise des Sciences], 28: 201–215.

Weldeab et al., *East African Monsoon Holocene*. Weldeab, S., V. Menke, and G. Schmiedl, 2014, The pace of East African monsoon evolution during the Holocene. Geophysical Research Letters; 41: 1724–1731.

Wells, *Changes in Nutritional Diseases*. Wells, C., 1975. Prehistoric and historical changes in nutritional diseases and associated conditions. Progress in Food & Nutrition Science 1: 11–12.

Wemmer, *Comparative Ethology*. Wemmer, C. M., 1977. Comparative ethology of the large-spotted genet Genetta tigrina and some related viverrids. Washington.

Wendorf, *Jebel Sabaha*. Wendorf, F., 1968. Site 117: A Nubian Final Palaeolithic Graveyard near Jebel Sahaba, Sudan In Wendorf, F. (ed.), The Prehistory of Nubia, 954–995. Dallas.

Wendrich et al, *Fayum Neolithic*. Wendrich, W., Taylor, R.E. and J. Southon, 2010. Dating stratified settlement sites at Kom K and Kom W: fifth millennium BCE radiocarbon ages for the Fayum Neolithic. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 2687: 999–1002.

Wengrow et al., *Nile Valley Neolithic*. Wengrow, D., Dee, M., Foster, S., Stevenson, A. and C. B. Ramsey, 2014. Cultural convergence in the Neolithic of the Nile Valley: a prehistoric perspective on Egypt's place in Africa. Antiquity, 88339: 95–111.

Wengrow, *Cattle Cults*. Wengrow, D., 2001. Rethinking 'cattle cults' in early Egypt: towards a prehistoric perspective on the Narmer Palette. Cambridge Archaeological Journal, 1101: 91–104.

Wengrow, *Social Transformations*. Wengrow D., 2006. The Archaeology of early Egypt. Social Transformations in North-East Africa 10,000 to 2650 BC, Cambridge.

Wenke et al., *Kom el-Hsin*. Wenke, R. J., Buck, P.E., Hamroush, H.A., Kobusiewicz, M., Kroeper, K. and R. W. Redding, 1988. Kom el-Hsin: Excavation of an Old Kingdom Settlement in the Egyptian Delta. Journal of American Research Center in Egypt 25: 5–34.

Wenke, *Egyptian Civilisation Evolution*. Wenke, R. J. 1991. The evolution of early Egyptian civilization: Issues and evidence. Journal of World Prehistory, 53: 279–329.

Wenke, *OK Western Delta*. Wenke. R. J., 1986. Old kingdom community organization in the Western Egyptian Delta. Norwegian Archaeological Review 19: 1, 15–33.

Wenke, *Origins.* Wenke, R. J., 2009. The Ancient Egyptian State. The Origins of Egyptian Culture c.8000–2000 BC

Wenke, *Origins of Complex Societies*. Wenke, R. J., 1989. Egypt: Origins of complex societies. Annual Review of Anthropology, 129–155.

Westlake, *Light Climate for Plants*. Westlake, D. F., 1966, The light climate for plants in rivers. In Bainbridge, R., Evans, G. C. and O. Rackham (eds), Light as an Ecological Factor, 99–119. Oxford.

Wetterstrom, *Foraging & Farming*. Wetterstrom, W., 1993. Foraging and farming in Egypt: the transition from hunting and gathering to horticulture in the Nile Valley. In Shaw, T., Sinclair, P., Andah, B. and A. Okpoko (eds), The Archaeology of Africa. Food, metals and towns, 165–226. London.

White & Mattingly, *Ancient Saharan Lakes*. White, K. and J. D. Mattingly, 2006. Ancient lakes of the Sahara. American scientist, 941: 58–65.

White et al., *Seasonal Diet Variation.* White, C. D., Longstaffe, F. J. and K. R. Law, 1999. Seasonal stability and variation in diet as reflected in human mummy tissues from the Kharga Oasis and the Nile Valley. Palaeogeography, Palaeoclimatology, Palaeoecology, 1473: 209–222.

White, *Aswan Environmental Effects*. White, G. F., 1988. The environmental effects of the high dam at Aswan. Environment: Science and Policy for Sustainable Development, 307: 4–40.

WHO, *Dietary References.* World Health Organisation, 2007. WHO. Dietary Reference Intakes for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids Macronutrients; WHO Technical Report Series 935. Geneva.

Wicker, *Road to Punt*. Wicker, F. D. P., 1998. The Road to Punt. The Geographical Journal 1642: 155–167.

Wild, *Ti* II. Wild, H. 1953. Le tombeau de Ti, Fasc II: La chapelle première partie. Mémoires publiés par les Membres de l'Institut Français d'Archéologie Orientale du Caire, Le Caire.

Wild, *Ti* III. Wild, H., 1966. Le tombeau de Ti, Fasc III: La chapelle deuxième partie. Mémoires publiés par les Membres de l'Institut Français d'Archéologie Orientale du Caire, Le Caire.

Wilkinson & Stevens, *Enviromental Archaeology*. Wilkinson, K. and C. Stevens, 2010. Environmental Archaeology: Approaches, Techniques and Applications. Stroud.

Wilkinson, *Complete Temples*. Wilkinson, R. H., 2000. The Complete Temples of Ancient Egypt. London.

Wilkinson, *Gods & Goddesses*. Wilkinson, R. H., 2003. The Complete Gods and Goddesses of Ancient Egypt. London.

Wilkinson, *Marshes in the Middle East*. Wilkinson, T. J., 2012. Wetland Archaeology and the Role of Marshes in the Ancient Middle East. In Menotti, F. and A. O'Sullivan, (eds), The Oxford Handbook of Wetland Archaeology, 121–140.

Wilkinson, *Political Unification*. Wilkinson, T., 2000. Political unification: Towards a reconstruction. Mitteilungen des Deutschen Archäologischen Instituts, Abteilung 56: 377–395, Kairo.

Wilkinson, *Reading Egyptian Art*. Wilkinson, R. H., 1994. Reading Egyptian art: a hieroglyphic guide to ancient Egyptian painting and sculpture. London.

Wilkinson, *Symbolism & Design*. Wilkinson, A., 1994. Symbolism and design in ancient Egyptian gardens. Garden History: 1–17.

Willcocks, *Irrigation*. Willcocks, C. A., 1913. Egyptian Irrigation. London.

Willems et al., *Wadi Zabayada*. Willems, H., Vereecken, S., Kuijper, L., Vanthuyne, B., Marinova, E., Linseele, V., Verstraeten, G., Hendrickx, S., Eyckerman, M., Van den Broeck, A., Van Neer, W., Bourriau, J., French, P., Peeters, C., De Laet, V., Mortier, S. and Z. De Kooning, 2009. An industrial site at Al-Shaykh Sacıd/Wadı Zabayda. Ägypten und Levante/Egypt and the Levant 19: 293–331.

Williams & Hill, *Meat & Evolution*. Williams, A. C., and L. J. Hill, 2017. Meat and nicotinamide: a causal role in human evolution, history, and demographics. International Journal of Tryptophan Research, 10: 1, 1–23.

Williams & Nottage, *Extreme Rainfall Impacts*. Williams, M., and J. Nottage, 2006. Impact of extreme rainfall in the central Sudan during 1999 as a partial analogue for reconstructing early Holocene prehistoric environments. Quaternary international, 1501: 82–94.

Williams et al., *Late Quaternary Floods & Drought*. Williams, M. A. J., Williams, F. M., Duller, G. A. T., Munro, R. N., El Tom, O. A. M., Barrows, T. T., Macklin, M., Woodward, J., Talbot, M. R., Haberlah, D and J. Fluin, 2010. Late Quaternary floods and droughts in the Nile valley, Sudan: new evidence from optically stimulated luminescence and AMS radiocarbon dating. Quaternary Science Reviews, 299, 1116–1137.

Williams, *Ancient Nile Environments*. Williams, M. A., 2009. Late Pleistocene and Holocene environments in the Nile basin. Global and Planetary Change, 691: 1–15.

Williams, *Human Impact Nile Basin*. Williams, M.A., 2009. Human Impact on the Nile Basin: Past, Present, Future. In Dumont H. J. (ed.), The Nile, 771–779. Dordrecht.

Williamson & Payne, *Animal Husbandry*. Williamson, G. and W. J. Payne., 1978. Animal Husbandry in the Tropics. London.

Wilson, *Mendes.* Wilson, K. L., 1982. Cities of the Delta Volume II: Mendes. Malibu.

Winckler & Wilfing, *Anthropologische un den Skelettresten*. Winkler, E. and H. Wilfling. 1991 Tell el-Dab'a VI: Anthropologische Untersuchungen an der Skelettresten der Kampagnen 1966–1969, 1975–1980, 1985. VI. Vol. 10. Austrian Academy of Sciences.

Wing, *Animals as Food*. Wing, E., 2000. Animals Used for Food in the Past: As Seen by Their Remains Excavated from Archaeological Sites. In Kiple, K. and K. Ornelas (eds), The Cambridge World History of Food, 51–58. Cambridge.

Winlaw, *D5 Giza Mastabas*. Winlaw, S., 2007. Fifth Dynasty Mastabas at Giza: Typologies, Chronologies and the Use of the Cemetery. PhD, Macquarie University, Sydney.

Wiskens & Rzóska, *Vegetation*. Wickens, G. E. and J. Rzóska, 1976. Vegetation of the Nile Basin. In Rzóska, J. (ed.), The Nile: Biology of an Ancient River, 79–86. The Hague.

Wittfogel, *Oriental Despotism*. Wittfogel, K., 1957 Oriental Despotism: A Comparative Study of Total Power. New York.

Woldering, *Art of the Pharaohs*. Woldering, I., 1963. Egypt: The Art of the Pharaohs. London.

Wood, *Egyptian Amphorae*. Wood, B. G., 1987. BA Guide to Artifacts: Egyptian Amphorae of the New Kingdom and Ramesside Periods. The Biblical Archaeologist 502: 75–83.

Woods, *Five Significant Features*. Woods, A., 2015. Five significant features in Old Kingdom spear-fishing and fowling scenes. In Kousoulis, P. and N. Lazaridis (eds), Proceedings of the Tenth International Congress of Egyptologists, University of the Aegean, Rhodes, 22-29 May 2008, 1897–1910. Leuven.

Woods, *Marshes I*. Woods, A., 2007. A Day in the Marshes. Vol. I. PhD, Macquarie University, Sydney.

Woods, *Marshes II*. Woods, A., 2007. A Day in the Marshes. Vol. II Prospography, Texts, Plates. PhD, Macquarie University, Sydney

Woods, *Seneb at Giza*. Woods, A., 2009. A Date for the Tomb of Seneb at Giza: Revisited. In Woods, A., McFarlane, A. and S. Binder (eds) Egyptian Culture and Society: Studies in Honour of Naguib Kanawati, 302–331. Cairo.

Woodward et al., *Nile Evolution.* Woodward, J. C., Macklin, M. G., Krom, M. D., and M. A. Williams 2007. The Nile: evolution, Quaternary river environments and material fluxes. Large Rivers, Geomorphology and Management, 261–289.

Woodward et al., *Strontium Isotope Record*. Woodward, J., Macklin, M., Fielding, L., Millar, I., Spencer, N., Welsby, D. and M. Williams, 2015. Shifting sediment sources in the world's longest river: A strontium isotope record for the Holocene Nile. Quaternary Science Reviews, 130: 124–140.

Wörster, *Rivers of Empire*. Wörster, D., 1985. Rivers of Empire: Water Aridity and the Growth of the American West. New York.

Wright, *Humans as Agents*. Wright, D. K., 2017. Humans as Agents in the Termination of the African Humid Period. Frontiers in Earth Science. 5: 4, 1–14. doi:10.3389/feart.2017.00004. ISSN 2296-6463.

Yadin, *Biblical Warfare.* Yadin, Y., 1963. The Art of Warfare in Biblical Lands. London.

Yang et.al, *Phragmites Stress*. Yang, Z., Xie, T. and Q. Liu, 2014. Physiological responses of Phragmites australis to the combined effects of water and salinity stress. Ecohydrology, 72: 420–426.

Yekutieli, *Desert Egyptian Colony*. Yekutieli, Y., 2004. The Desert, the Sown and the Egyptian Colony. Ägypten und Levante/Egypt and the Levant, 163–171.

Yilmaz, et al., *Domesticated Donkey*. Yılmaz, O., Saim, B., and E. Mehmet, 2012. The domesticated donkey: I– species characteristics. Can J App Sci, 42: 339–353.

Yitayew & Melesse, *Water Resource Issues*. Yitayew, M. and A. M. Melesse, 2011. Critical Water Resources Issues in the Nile River Basin. In Melesse, A. M. (ed.) Nile River Basin Hydrology, Climate and Water Use, 401–416. Dordrecht.

Zaharieva et al., *Cultivated emmer wheat.* Zaharieva, M., Ayana, N.G., Hakimi, A.A., Misra, S.C., and P. Monneveux, 2010. Cultivated emmer wheat Triticum dicoccon Schrank, an old crop with promising future: a review. Genetic Resources and Crop Evolution, 57: 937–962.

Zahran & Willis, *River Nile Plant Life*. Zahran, M. A. and A. J. Willis, 2003. Plant life in the River Nile in Egypt. Riyadh.

Zahran & Willis, *Vegetation of Egypt*. Zahran, M. A. and A. J. Willis, 2008. The Vegetation of Egypt Vol. 2. Dordrecht.

Zakrzewski, *Life Expectancy*. Zakrzewski, S., 2015. Life Expectancy. UCLA Encyclopedia of Egyptology, 11. http://escholarship.org/uc/item/7zb2f62c.

Zakrzewski, *Population continuity or change*. Zakrzewski, S. R., 2007. Population continuity or population change: formation of the ancient Egyptian state. American Journal of Physical Anthropology 132: 501–509.

Zakrzewski, *Variation in Ancient Egyptians*. Zakrzewski, S., 2003. Variation in ancient Egyptian stature and body proportions. American Journal of Physical Anthropology, 1213: 219–229.

Zanchetta etal., *Mediterranean Holocene.* Zanchetta, G., Sulpizio, R., Roberts, N., Cioni, R., Eastwood, W. J., Siani, G., Caron, B., Paterne, M. and R. Santacroce, 2011. Tephrostratigraphy, chronology and climatic events of the Mediterranean basin during the Holocene: an overview. The Holocene, 211: 33–52.

Zeder, *Origins of Agriculture*. Zeder, M.A., 2011. The origins of agriculture in the Near East. Curr. Anthropol. 52: 221–235.

Zeuner, *Domesticated Animals.* Zeuner F. E., 1963. A history of domesticated animals. London.

Zhao et al., *Nutrient Accumulation*. Zhao, Y., Xia, X. and Z. Yang, 2013. Growth and nutrient accumulation of Phragmites australis in relation to water level variation and nutrient loadings in a shallow lake. Journal of Environmental Sciences, 25: 1, 16–25.

Ziada et al., *Economic Potentialities*. Ziada, M. A., Mashaly, I. A., El-Monem, M. A. and M. Torky, 2008. Economic potentialities of some aquatic plants growing in north east Nile delta, Egypt. Journal of Applied Sciences, 8: 8, 1395–1405.

Zink et al., *Ancient Egyptian Tuberculosis*. Zink, A., Haas, C. J., Reischl, U. D. O., Szeimies, U. and A. G. Nerlich, 2001. Molecular analysis of skeletal tuberculosis in an ancient Egyptian population. Journal of Medical Microbiology 50: 355–366.

Zohary & Hopf, *Old world Plant Origins*. Zohary, D. and M. Hopf, 2000. Domestication of plants in the old world: the origin and spread of cultivated plants in West Asia, Europe and the Nile Valley. Oxford.

Zohary et al., *Old World Plant Domestication*. Zohary, D., Hopf, M. and E. Weiss, 2012. Domestication of plants in the Old World. Oxford.

Zorn & Komac, *Erosivity*. Zorn M. and B. Komac, 2013 Erosivity. In Bobrowsky P.T., (ed.), Encyclopedia of Natural Hazards. Encyclopedia of Earth Sciences Series. Dordrecht.

Zwart et al., *Ecosystem Function*. Zwart, J. A., Solomon, C. T. and S. E. Jones, 2015. Phytoplankton traits predict ecosystem function in a global set of lakes. Ecology, 96: 8, 2257–2264.