Changes in Suid and Caprine Husbandry Practices Throughout Dynastic Egypt Using Linear Enamel Hypoplasia (LEH)

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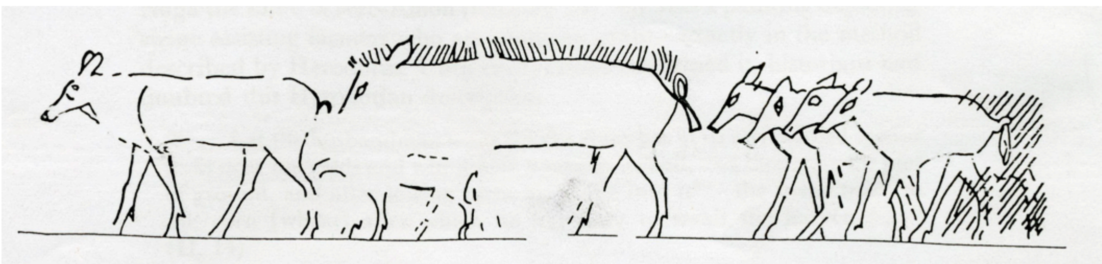
By

Louise C. Bertini



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Abstract

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Title: Changes in suid and caprine husbandry practice throughout dynastic Egypt using linear enamel hypoplasia (LEH).

Linear enamel hypoplasia (LEH) is the most commonly identified form of enamel defect in teeth. Defined as a deficiency in enamel thickness encountered during dental development, LEH can occur as horizontal lines or depressions of irregular enamel, or clusters of pitting on the enamel surface. These defects are caused by physiological stresses such as disease or poor nutrition, causing a disruption of enamel secretion.

Studies on LEH have been used as a way to understand the health status and husbandry practices of both ancient and modern animal populations. As there are no data that describe the prevalence of LEH in either ancient or modern Egyptian animal material, this thesis aims to establish the frequency of LEH in the archaeological remains of pigs and caprines (sheep and goat) from thirteen different ancient Egyptian sites, investigating the links between LEH, possible changes in husbandry practices, geographic, as well as site contexts, and compare it to modern Egyptian pig and caprine data from similar geographic contexts.

Results indicate that enamel hypoplasia is common throughout the thirteen different sites throughout Egypt discussed in this thesis. These defects are related to key events in the animal's life such as weaning, nutritional stresses associated with winter, along with environmental stresses and diachronic changes including the annual flood of the Nile (which is known to change over time) and management choices (i.e. sites with free-ranging versus penned animals).

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Declaration: No material contained within this thesis has been previously submitted for a degree in this or any other institution

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1 Introduction

1.1 General introduction to the study

Linear enamel hypoplasia (LEH) is the most commonly identified form of enamel defect in teeth. Recent zooarchaeological studies on European, Near Eastern, and East Asian material (Dobney & Ervynck 1998, 2000; Dobney *et al.* 2002, 2004; Ervynck & Dobney 1999, 2002; Ervynck *et al*. 2001; Arbuckle 2004) have shown how mammal teeth can provide information on husbandry practices, environment, health status, and the diet of an individual through the recording of the developmental defect, LEH. The resultant deductions about husbandry practices and the environment can relate to penning, seasonal food supply, possible scavenging, and seasonal environmental factors. However, research on this particular dental defect has never been done in Egypt before. Through this research, I want to establish a baseline model for agricultural production in ancient Egypt through the study of LEH.

Animals were very important to the ancient Egyptians because they were a basic part of their economy and subsistence. Although there have been many studies on the general husbandry of animals in Egypt (Brewer, Redford and Redford 1994; Germond 2001; Houlihan 1996) and meat production (Ikram 1995), with particular reference to the highly valued cattle (Ghoneim 1977), little to no work has been done on the herd structure, and possible changes in the husbandry regime of pig (*Sus scrofa*), sheep (*Ovis aries*), and goat (*Capra hircus*). This is partly due, perhaps, to the emphasis on funerary archaeology in Egypt and to an absence of full publications of animal bones from settlement sites in the last thirty years. The situation in Egypt is changing, however, with good recording of animal material from sites now included in most published reports, but the following research at a wider level is still rather limited.

LEH is defined as a deficiency in enamel thickness that occurs during tooth crown formation. This defect is caused by physiological stresses such as disease or poor nutrition. This causes a disruption in enamel secretion (Goodman and Rose 1990), and manifests itself in a variety of ways on the tooth's surface, such as lines, depressions, or pits. Thus, it serves as a means to study the health status of both ancient and modern human and non-human animal populations.

This thesis aims to look at the husbandry regime of pig, sheep, and goat, and its possible changes by documenting the frequency of LEH in the archaeological remains of these three animals' teeth from thirteen ancient Egyptian sites. Since there are no data sets that describe the prevalence of LEH in either ancient or modern Egyptian animal material, this study will provide a baseline for future work, and will also investigate the links between LEH and possible changes in husbandry regimes within the different geographic zones of Egypt. In order to separate out the geography variable, the frequency and height distribution of LEH for each individual site will be compared to other sites of a similar geographical context in order to look for both similarities and anomalies. This will also be related to sites with similar time periods to see if patterns may or may not exist. Previous work (Ervynck and Dobney 1999: 1-2; Dobney *et al.* 2002: 36; Dobney *et al.* 2004: 198) has demonstrated that that variations in husbandry practices can be interpreted through analysis of enamel hypoplasia frequency patterns. Although other factors can affect the presence of LEH, this thesis will use the collected data to see if there are changes in pig and caprine (*Ovis aries* and *Capra hircus*) husbandry regimes throughout dynastic Egypt. Furthermore, it will look at how this data relates to the general health status of the domesticated pig, sheep, and goat population and its relationship to what is known about ancient Egyptian husbandry practices from the ancient textual and pictorial record, and modern practices.

Although the majority of past LEH studies have focused on humans and primates (Goodman & Rose 1990, 1991; Guatelli-Steinberg 2000, 2001, 2003; Hilson 1986; Larson & Hutchinson 1992; Lukacs 1999, 2001; Molner & Ward 1975; Reid & Dean 2000; Rose 1977, Rose *et al.* 1978; Whittington 1992), recently the recording of LEH has been applied to other species, notably pig (Dobney & Ervynck 1998, 2000; Dobney *et al.* 2002; Ervynck & Dobney 1999, 2002; Ervynck *et al.* 2001) and more recently, caprines (Arbuckle 2004; Upex 2010). These previous publications clearly demonstrate that LEH is related to key physiological events such as birth, weaning, seasonality, diet, and environmental/climatic change, domestication, and animal management. Animal management, in particular, is the central theme of this dissertation.

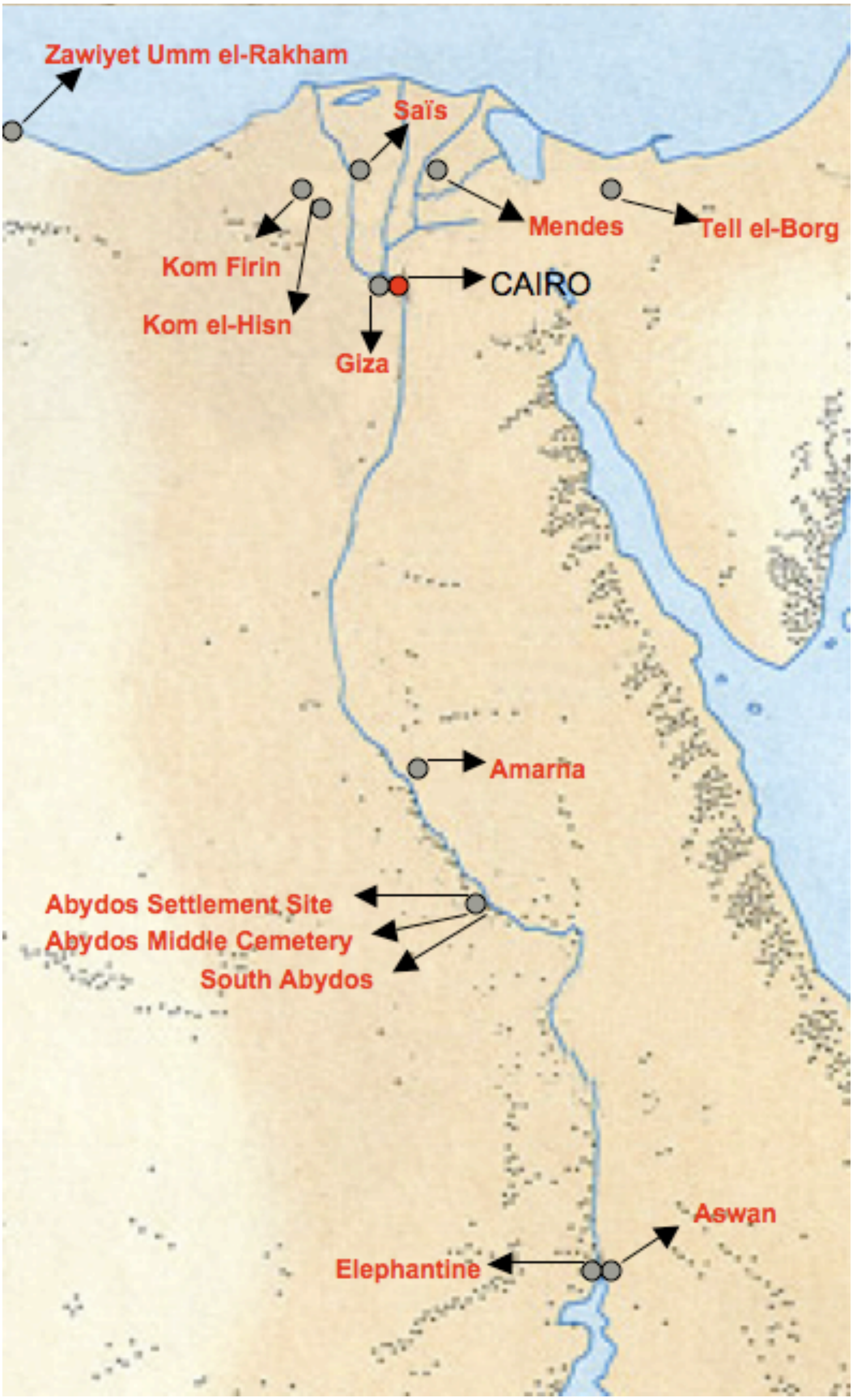

Figure 1.1: The location of each of the thirteen archaeological sites where samples have been collected.

1.2 Key research questions

Three key research questions are posed with respect to how changes in pig and caprine management practices throughout dynastic Egypt can be studied through the presence of enamel hypoplasia.

1) What is the frequency of LEH in pig and caprines and do coherent patterns exist in the archaeological material that might reflect husbandry regimes and/or ecological setting?
2) Was there any variability with diachronic change?
3) How similar is the archaeological material to the modern material?

1.2.1 The frequency of LEH in pig and caprines

As discussed in section 1.1, there are no data sets that record the prevalence of enamel hypoplasia in either modern or ancient Egyptian archaeological material. Thus, the first goal of this dissertation is to establish what, if any, frequency of enamel hypoplasia exists in the tooth remains of pigs and caprines from the thirteen archaeological sites. Using the enamel hypoplasia patterns that can be found, this dissertation will try to establish whether they reflect changes in husbandry practices and/or ecological setting.

1.2.2 Is there variability with diachronic change?

As the data came from thirteen sites which span the entire period of dynastic Egyptian history (for full ancient Egyptian chronology see Appendix 1) from the Old Kingdom (c.2686-2125 BC) through the Ptolemaic-Roman period (c. 332 BC- AD 395), it is possible to look at changes in LEH over a wide time span. Using the established enamel hypoplasia patterns for each of the sites, possible diachronic change can be analyzed, taking into consideration environmental and cultural changes. Data has also been collected on the age and size (using tooth width) of the both the pigs and caprines, which provides another way to investigate diachronic changes as a cross check.

1.2.3 How similar is the archaeological material to the modern material?

In order to understand the patterns in the archaeological data, the need for an established control group with a known age of birth, death and husbandry regime is necessary to provide a basis for comparison. Thus a modern pig and caprine assemblage was collected in Egypt. Recording the same data from the modern assemblage as is done for the archaeological assemblage will help to understand how similar or different the archaeological assemblages are in both age of death, size and enamel hypoplasia patterns. This also provides the foundation for a basic standard of mortality profiles, biometry, and LEH in Egyptian pig and caprine teeth that can be used in subsequent future zooarchaeological studies.

1.3 Primary source and site selection

The primary source for this work is the teeth themselves as sources of information on LEH. The selection of sites is based on availability of materials and the generosity of excavation directors[1] and permission from the Egyptian authorities in the form of the Supreme Council for Antiquities[2] As is often the case with past excavations in Egypt, animal bones were either not collected or not properly curated and recorded. Therefore, the selection of teeth in this study comes from sites that had animal bone material available for study, and have been excavated within the last thirty years, which rather restricts the sample.

Since one of the goals of this thesis is to analyze the changes in ancient Egyptian husbandry practices through the presence of LEH, sites were selected which had a known domestic context. These include: Elephantine, Giza (Workmen's Village), Kom el-Hisn, Mendes, Abydos Settlement Site, South Abydos town of *Wah-Sut*, Amarna, Kom Firin, Saïs, Zawiyet Umm el-Rakham, Tell el-Borg, and Aswan. Temple and funerary contexts are not included as pigs are rarely present, and ovicaprids are not the normal meat source in these situations. However, the Abydos Middle Cemetery is included in this study only as a basis of comparison of funerary sites to domestic ones, and includes only caprine remains, as these animals are part of funerary assemblages.

Sites were also selected on the basis of their geographic location, in order to get as wide of a range as possible of sites throughout Egypt. This allows one to investigate whether environment and geographical location had an effect on the presence of LEH, and also how the animals were managed, for example, were they penned or allowed to roam free range. Sites were also chosen on the basis of their occupational period, in order to have material representing all of dynastic Egyptian history. As a result, sites represent the time span of the Old Kingdom through the Ptolemaic-Roman period, approximately c. 2686 BC- AD 395.

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[1] A special thanks is in order to the following excavation directors for access to samples: Matthew D. Adams, Matthew J. Adams, James Hoffmeier, Barry Kemp, Mark Lehner, Cornelius von Pilgrim, Dietrich Raue, Richard Redding, Donald Redford, Janet Richards, Steven Snape, Neal Spencer, Josef Wegner and Penelope Wilson.

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Archaeological evidence will complement the analysis of the teeth. Thus, the pig-pens at Amarna (Shaw 1984, Kemp 1991: 256) will be used for the interpretation of how animals were managed. This evidence, however, is somewhat limited in that Amarna is the only known site in Egypt for which pig-pens have been excavated.

Egyptological sources in the form of ancient texts and artistic sources will also be used to provide further context for the discussions on animal husbandry. Typically temple and particularly tomb decorations can provide a wealth of information on animals, albeit within very specific contexts. However, in the case of pigs there are very few representations, and none showing any specifics of slaughtering (Ikram 1995: 41). The collection of contemporary material from Egypt in the form of modern pig, sheep, and goat teeth with known life histories and ethnographic information about husbandry practices will also be used to shed light on the presence of enamel hypoplasia in teeth. All modern samples were collected in Egypt.

Through the physical remains of pig and caprine teeth and their presence (or absence) of LEH, large amounts of information on their rearing regime and the environment in which they lived can be learned. This will help to fill in the gaps of artistic and textual evidence, and for the first time in zooarchaeological studies on ancient Egypt provide a correlation between archaeological and representational and textual evidence.

1.4 Animal husbandry in ancient Egypt

As previously stated, animals were very important to the ancient Egyptians as they, along with cultivated plants, formed the bases of their economy, since the majority of the Egyptian population consisted of agriculturalists in rural settings (Ikram 2010: 190).

There are a plethora of animals that were in utilized in ancient Egypt, many of which are seen on the numerous tomb and temple reliefs, including both wild and domestic creatures, fish, and fowl. A full account on animal behavior in Egyptian art is provided in both Evans's 2010 publication and Houlihan (1996) on animal behavior in Egyptian art. However, the most economically important animals that the majority of the Egyptian population would encounter are the domestic herd animals. The ancient Egyptians classified herd animals into two groups: large and small cattle. Large cattle included bulls, cows, and oxen. Small cattle included sheep, goats, and in some instances pigs (Brewer, Redford, and Redford 1994: 77).

Cattle were the most valuable of these, and had the highest status of all domestic animals. This was to such an extent that there was an entire state regulated bureaucracy of cattle rearing, supported both by artistic and textual evidence (Germond 2001: 57). However, there is very little artistic evidence for sheep and goat herding, and even fewer for pigs. Furthermore, there is no textual evidence, aside from the inclusion of sheep, goats, and pigs in possession lists, a topic that will be further discussed in sections 4.2.2 and 7.2.3.

It is known that domestic herd animals (both large and small cattle) were kept primarily for subsistence. They were slaughtered for meat consumption, or in some special instances as food offerings (Janssen and Janssen 1989: 7). Some specially selected domestic herd animals, notably cattle and sheep are also known to have been cherished and respected to the point of being divine, and were worshipped and mummified upon their death (Ikram 2005:1).

As cattle provide eight to ten times the meat of a sheep or goat (Dahl and Hjort 1976), in theory beef should be more important in the diet. In spite of this, because of their high status, cattle were largely consumed by the elite (Ikram 1995: 10). Aside from fish, small cattle (sheep, goats, and pigs) provided the majority of the meat consumption for the non-elite Egyptian population and were useful in trampling the grain into the fields (Ikram 2010: 215). Goats were kept primarily for their meat, skin, and perhaps milk, though less importantly for their hair. However, goat hair is known to have been processed at the Workmen's Village at Amarna (Janssen and Janssen 1989: 33; Hall 1986: 10), although, there is no mention of this in the Amarna Reports (Kemp 1984-1989). Sheep were used to trample seeds into the fields as seen in the numerous Old Kingdom tomb images (such as in Figure 1.2), and a primary source of meat and milk. Wool was also probably used by ancient Egyptians, although there is some misconception surrounding its use, largely due to several comments made by classical authors such as Herodotus and Plutarch (Vogelsang-Eastwood 2000: 269; Hall 1986: 10). Herodotus' comment (II: 82) discusses how it was contrary to religious usage to either be buried in a woolen garment or wear one into a temple. If this belief did exist, it seems to have only been applied to priests, as Herodotus does further state that young men did wear linen garments. Furthermore, various woollen garments have been excavated at numerous sites from the Predynastic period onwards (Vogelsang-Eastwood 2000: 269; Hall 1986: 10).

Figure 1.2: Sheep trampling seeds from the tomb of Urarna at Sheikh Saïd- Tomb #25) (Vogelsang-Eastwood 2000: Figure 11.2)

Pigs were kept primarily for their meat (Janssen and Janssen 1989: 34), although ancient Egyptian medical texts state that pig fat is used in various medical recipes, an issue that will be discussed further in section 4.2.4.

There is very little knowledge on the use of small cattle in ancient Egypt. There is even less knowledge on how they were herded, and how they fit into the economic system of ancient Egypt. Since there is a greater knowledge on cattle herding in ancient Egypt, an analysis will first be provided on their herding system in order to provide a possible model in which to compare small cattle herding.

As cattle were considered to be the most valuable of all the domestic herd animals, its rearing was a strictly regulated, state controlled activity, reliant on a highly developed and well staffed bureaucracy. On each cattle estate, there was an overseer of all the cattle herders whose honory title was: 'superintendent of the herds of the Kings/Gods' (Ghoneim 1977: 244). This position, however, was not related to the actual supervision of the livestock (Brewer, Redford, and Redford 1994: 21). The overseer was in charge of compiling records including periodic examinations of cattle prior to their presentation to the owner of the estate (Brewer, Redford, and Redford 1994: 21), and counting the cattle every two years in a census that was used as a measure of the wealth of the estate's owner (Ikram 2010: 215; Montet 1958: 75).

The breeding process, however, was both directed and controlled by the herdsmen underneath the overseer, who would take care of and ensure that the appropriate bull served each cow and that calves were weaned under the best possible conditions (Germond 2001:57; Ghoneim 1977: 245). This is even recorded in the ancient Egyptian text *The Tale of Two Brothers*, which describes not only the care that was taken in their diet and reproduction, but how herdsmen would even sleep with their cattle in order to provide optimum care.

"…Then he drank and ate and [went to sleep in] his stable among his cattle… Then he took bread for himself for the fields, and he drove his cattle to let them eat in the fields. He walked behind his cattle, and they would say to him: 'The grass is good in such-and-such a place,' And he heard all they said and took them to the place of good grass they desired. Thus the cattle he tended became exceedingly fine, and they increased their offspring very much. Now at plowing time his [elder] brother said to him: 'have a team [of oxen] made for us for plowing, for the soil has emerged and is right for plowing…." (Lichtheim 1976: 204).

In fact, herdsman are known to have taken such great care of their cattle that they were provided with proper food, medicine, or whatever else they required. Herdsmen are also known to have named their cattle as if they were their own pets (Brewer, Redford, and Redford 1994: 21). Veterinarians are also known to have tended to sick animals, including priests of the goddess Sekhmet. In fact, a papyrus from Kahun discusses diseases that were specific to cattle (Ikram 2010: 217; Nunn 1996: 119-120).

Cattle herdsman are also said to have branded their herds in order to prevent theft (Janssen and Janssen 1989: 30). Furthermore, cattle provided a number of secondary products that could be sold and taxed as well, including dairy products such as milk, cream, butter, and cheese. Horns, bones, and hides were also used as they provide raw materials for many artifacts from weapons to clothes (Ikram 1995: 8). Fat was also burned for fuel for lamps and hooves were reduced to make gelatin and glue (Lucas 1962: 3), and even the manure can be used for fuel, fertilizer, and building material (Clutton-Brock 1987: 62).

Cattle were typically kept in one of two ways: either they were confined to pens/stables for fattening and slaughter or they herds would roam freely in the pastures. Between these two methods a balance did seem to exist between pen raising and herding (Brewer, Redford, and Redford 1994: 78; Janssen and Janssen 1989:27) and were also both previously described in the quote from the *The Tale of Two Brothers* (Lichtheim 1976: 204). Sacred bulls such as the Apis, however, were often chosen or identified at birth and kept in special stalls or enclosures such as the Area of the Apis at Memphis (the capital of Egypt during the Old Kingdom) for the duration of its life (Ikram 1995: 5-6).

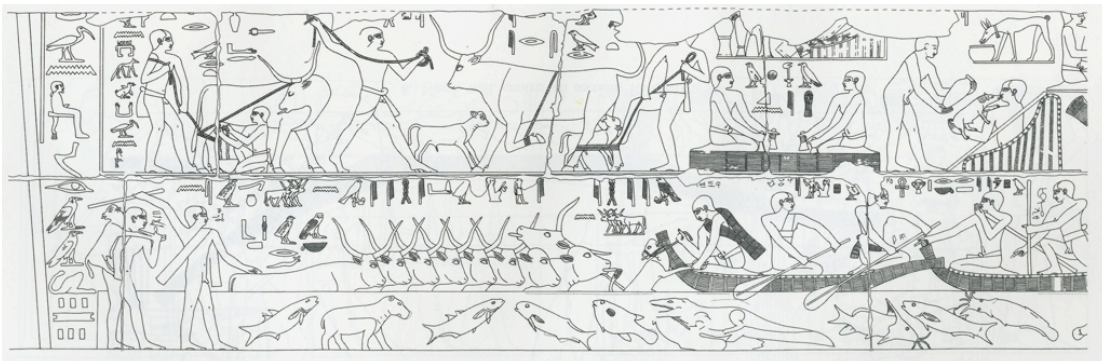

Figure 1.3: Cattle crossing water from tomb of Kagemni, Saqqara (Harpur and Scremin 2006: Figure 1, Context Drawings)

Putting the sacred bulls aside, cattle would typically be kept on whatever estate they belonged to. There have been some suggestions that during the summer cattle kept in the Nile valley in Upper Egypt may be herded to the cooler areas of the Delta marshes in Lower Egypt, sometimes for long periods of time (Janssen and Janssen 1989: 27; Brewer, Redford, and Redford 1994: 21). These cattle drives and Delta pasturing would coincide with the hot, summer dry season when availability of forage was limited in Upper Egypt (Brewer, Redford, and Redford 1994: 21). Although this suggestion has been presented, the likely hood of cattle traveling from upper Egypt into the delta poses many problems. First these drives would have taken place during the hot summer months, when the heat would pose a problem to both the cattle and herder. Second, based on modern estimates from cattle drives in the United States (Malone 1971: 52), to move the cattle back and forth over Egypt would have taken at least four months a year. Furthermore, a huge herd of cattle would be required to account for ones who die off in addition to the massive amount of food resourced that would be needed. They would also be traveling through farmed land that would create a lot of chaos unless they were herded along the west bank of the Nile on the desert edge, which would prove problematic for both food and water. However, possible Old Kingdom evidence for these annual drives is seen in the many representations of cattle in water crossing scenes (Figure 1.3), and are also known to have been ferried in cargo ships on the Nile to grazing grounds (Houlihan 1996: 13). One advantage to annual drives is the weight gain, calving rate, and calf survival is better among migratory herds than among sedentary ones (Brewer, Redford, and Redford 1994:78). Most likely there may have been short-range drives.

The possibility of an annual cattle drive is also supported in a Second Intermediate Period treaty between the Hyksos and the vassal of Thebaid of Upper Egypt, which documents the safety of the herds:

"We are at ease in our part of Egypt, Elephantine is strong, and Middle Egypt is with [us] as far as Kusae. The untenanted plots of their land are worked for us, and our cattle are pastured in the Delta fields, while emmer is sent down for our pigs. Our cattle have not been seized…" (Brewer, Redford and Redford 1994: 21)

Referring back to the fact that not much is known about the herding of small cattle, this treaty provides very important information on different herding strategies for both large and small cattle. While it does confirm the annual drive of large cattle, it also confirms that small cattle, namely pigs were kept on site throughout the year. Furthermore, it indicates that there were links between cattle estates in both the Delta (Lower Egypt) and Upper Egypt. This would provide better food for the cattle during the summer months in the cool marshlands of the Delta, while food supplies from the area were sent down to the smaller cattle that were left behind in Upper Egypt. The most likely reason for the cattle alone being driven to the Delta during the summer months is simply because of their higher status, where as the lower status small cattle left behind, did not merit the special treatment to better grazing grounds. However, another possibility is simply due to the fact that cattle, sheep/goats, and pigs thrive differently under various environmental conditions.

Considering that cattle had to possibly undergo an annual drive every year, large herds of cattle would be beneficial for both reproduction and availability of food. Furthermore, diversified herds incorporating sheep and goat are known (Brewer, Redford, and Redford 1994: 79), offering an additional food resource to the herdsman and are seen in modern day Egypt. However, there are no known ancient Egyptian pictorial examples of cattle being herded together with sheep or goat, as they are always shown separately. There is, however, a unique representation from the tomb of Nefer and Ka-Hay at Saqqara (Figure 1.4) that shows both cattle and sheep trampling seeds, but no evidence of them being herded together. If only cattle were being driven north annually, then they would be a great comparison to sheep, goats, and pigs in terms of the presence of Linear Enamel Hypoplasia in their teeth. However, they are not included in this dissertation due to the methodological differences in recording their teeth as discussed by Kierdorf *et al*. (2006). So how then, does this all fit into the ancient Egyptian economy?

Figure 1.4: Cattle and sheep trampling seeds from tomb of Nefer and Ka-Hay (Moussa and Altenmüller 1971: Plate 1). Note cattle and sheep on the bottom register.

In the late Palaeolithic (c. 8,000 BC) the inhabitants of the Nile Valley lived in an economy based on hunting and gathering, which was on the whole destructive to their surroundings. Although at the time, this posed no significant threat to the environment, there were very few hunter and gathers to support the growing population, making the domestication of animals a profitable alternative (Germond 2001: 48-49).

Although it is not the aim of this dissertation to focus on the domestication/introduction of species into Egypt, a brief discussion is provided in sections 4.1.3 and 7.1.2 on both the pig and sheep/goat. Putting aside this discussion, it can be confirmed that by c. 6000 BC, domesticated animals are in use in Egypt, but are by no means the dominant species present in faunal assembalges (Germond 2001: 49). Neolithic (c. 5100-4500 BC) sites such as Merimde Benisalame and the Fayum A reveal a mixed economy based on the utilization of both domesticated and hunted/fished animals (Midant-Reynes 1992: 110-111; Germond 2001: 50; Veerle Linseele, Personal Communication). However, by c. 4500 BC, domesticated animals begin to dominate the faunal assemblages (Midant-Reynes 1992: 113; Germond 2001: 50) although there are still some wild species present (Richard Redding, Personal Communication).

This is also partly supported in the artistic record as well, albeit at a slightly later date than what the faunal record reveals. During the early Predynastic period (c. 4500-4000 BC), wild animals such as crocodiles, elephants, giraffes, wild bulls, and mouflons are the main animals present, with domestic ones being rarely depicted. However, by the middle/late Predynastic period (c. 3800-3200 BC) the reverse is true. This shift in economy begins the foundations of the 'Redistributive Economy' (Warburton 2003: 155; Kemp 1991: 233) that became the main economic system for the rest of dynastic Egyptian history.

In a 'Redistributive Economy', a widespread, centralized collection of produce takes place that is subsequently distributed throughout the population, but is not necessarily returned to their producers (Warburton 2003: 155; Kemp 1991: 233). For this type of economic system to be successful, the centralized authority must be sensitive on its prediction of personal demands, and flexible in its response with the supply of goods and services to make all the people content (Kemp 1991: 233). So what was provided by the central authority to the people?

The economic system was based upon exchange, whereby most people had to barter in order to buy and sell commodities. However, the central authority did provide basic rations to its people, which were considered to be a basic wage. The standard basic wage consisted of ten loaves of bread and a measure of beer that could fluctuate between a third of a jug to one, or even two whole jugs. As one moved up the ranks, the distributions would increase in multiples of the basic ration (Kemp 1991: 125-126). However, these rations are only known to have been provided to workmen residing in Workmen's Villages such as those at Deir el-Medina, Amarna, and Giza (Kemp 1991: 255). As one can clearly see, this is not enough to survive on, which is when small-scale economic transactions would take place. Acquiring and disposing of goods was done by barter, and everything had a value, expressed in various units which coincided with quantities of certain commodities such as weights of silver or copper/bronze, and units of capacity of grain and sesame-oil (Kemp 1991: 248; Janssen 1975: 10).

As protein is an essential part of an individuals diet, meat would have been its most important source at the time. As herders would have had regular access to pork and/or mutton, others would have had to barter in order to obtain it. The cost of a pig ranges between three to five deben of copper (about 270-450 grams) (Janssen 1975: 177-8). The cost of a goat ranged between one to three deben of copper (about 90-270 grams) (Janssen 1975: 166), indicating that goat was actually cheaper, and most likely less valued than the pig. Although not likely affordable by residents of the Workmen's Villages, cattle were the most expensive with costs as high as 141 deben of copper (about 12,690 grams) (Janssen 1975: 173). Thus the animals that were most actively reared and consumed by most of the Egyptian population would have been small cattle.

Based on the presence of the commodity prices from various texts from Deir el-Medina, it is clear that small cattle were present in the village. However, it is difficult to conclude whether small cattle were being raised at the Workmen's Villages. As for pigs, it is known that the residents of the Workmen's Village at Amarna were actively involved in the raising of pigs, attested by not only the numerous volume of pig remains uncovered (Hecker 1984) but more importantly by the presence of pig-pens that were excavated in the early 1980's (Kemp 1991: 256; Shaw 1984). As it is also known that pigs were raised free-range as well (Miller 1990: 126) and is also observed in modern day Egypt in villages such as El-Bayadiya (and will be returned to in section 4.1.1), one can conclude that there are some similarities to cattle rearing in that pigs also have the same two methods of rearing: penning and free-range, and, as evidenced by the pens at the Workmen's Village at Amarna, were kept onsite.

Sheep and goat rearing methods in ancient Egypt have even less information available, largely due to the animals' better adaptability to the environment and preference for browsing (goats) and grazing (sheep). Goats likely roamed about on the outskirts of settlements, where as sheep were likely herded relatively close to the sites, sometimes in the same areas as cattle (Redding 1992: 103). Nevertheless, there is still a negligible amount of information on the herding and rearing regimes of small cattle, which is where this dissertation hopes to fill in some of the gaps through the analysis of the physical remains of the teeth of these two species using a methodology that has never been applied before to any material from Egypt.

1.5 Outline of the study

After the introduction in Chapter 1, Chapter 2 will outline the definition and development of the methodology used in this study. It will also discuss the various problems faced when recording enamel hypoplasia on suid and caprine teeth. Chapter 3 will provide an introduction to Egypt, its various environmental factors, seasonality, site selection, and the individual sites from which tooth data has been collected. Information on the location/ site history and excavation history of each site will also be presented.

The following chapters, 4, 5, and 6 will deal with the data collected from pigs. Chapter 4 will provide an introduction to the pig in ancient Egypt, discussing its natural history (appearance, domestication, reproduction, diet etc.) and appearance in ancient Egyptian sources (artistic, textual and archaeological). Chapter 5 will examine the age and biometrical data (namely the animal's size through tooth width) of the modern and archaeological pigs from eleven of the thirteen archaeological assemblages, since the two remaining sites of Zawiyet Umm el-Rakham and the Abydos Middle Cemetery have no pig remains present. Chapter 6 will look at the presence of enamel hypoplasia in both the modern and archaeological pigs from the same eleven assemblages. Through the analysis of enamel hypoplasia frequencies and its patterns, the issues of interpreting husbandry practices, understanding seasonality and dietary/physiological impacts, and the interpretation of defect type and severity will be addressed.

Chapters 7, 8, and 9 will follow the same format at Chapters 4, 5, and 6, but will address the caprine data. The final chapter, Chapter 10, will provide a conclusion of the research results and will also provide suggestions for future work.

2 Methodology for the Analysis of Linear Enamel Hypoplasias

In order for LEH to be recorded accurately, a standardized methodology needs to be used in order to allow the comparison of multiple sites. This chapter lays out the methodology that will be used in this thesis and the rationale behind it. It is divided into several sections including: the definition and types of enamel hypoplasia, the selection of teeth/mandibles, the methods used for recording, observation, measurements, and analysis of enamel hypoplasia. The methods in this research are primarily based on the methodology created by Dobney and Ervynck (1998) on pigs, and slightly adapted to account for the various problems associated with high crown species such as caprines, as discussed by Upex (2010). As the main goal of this research is to address possible changes in pig and caprine husbandry practices throughout dynastic Egypt, it is important to remove any potential biases from the data set. For this reason, all teeth included in this study have the entire crown complete. Teeth that have damaged or broken cusps that may hinder data recording were excluded.

2.1 Defining Linear Enamel Hypoplasia

As discussed in chapter 1, enamel hypoplasia is the most common form of enamel defect in teeth. It is defined as a deficiency in enamel thickness encountered during dental development. This deficiency can be caused by a number of physiological and/ or environmental reasons (Goodman and Rose 1990). As enamel hypoplasia is thus linked to the underlying development and structure of teeth, a brief word is needed here on the process of tooth formation and development.

Enamel is the hard, protective, mineralized outer layer of the tooth (Goodman and Rose 1990) and can vary in thickness over different parts of the tooth, being thinnest at the cervical line and hardest on the occlusal surfaces (Nanci 2008). Enamel is formed in layers produced by epithelial cells (ameloblasts), which are long, narrow, cylindrical cells that are packed closely together forming a sheet, with each cell having contact with the developing enamel front developing from the tip to the base of the crown (Hilson 2005: 155; Franz-Odendall 2004: 199; Dobney and Ervynck 2000: 602). This process by which enamel is formed is called amelogenesis and can be divided into three phases. The first phase, pre-secretory, is when the ameloblasts prepare to secrete the enamel matrix. The second phase, secretory, is when the cells produce the organic enamel matrix and organize the entire thickness of the enamel. The final stage, maturation, is when the cells transport ions, removing the organic component and the enamel matrix is mineralized (Nanci 2008, Hilson 2005: 155).

Enamel hypoplasia typically occurs in the secretory phase of amelogenesis and is a consequence of ameloblast impairment due to stress. The type of stress and its duration can produce several different types of enamel defects (discussed in the next section) and are all caused by the amelobalst cells either slowing down the enamel secretion or stopping secretion entirely (Witzel *et al.* 2006: 94; Upex 2010: 35).

2.2 Types of Enamel Hypoplasia

Hypoplastic defects can be divided into several different types. The four most common that have been identified in the Egyptian material are discussed below.

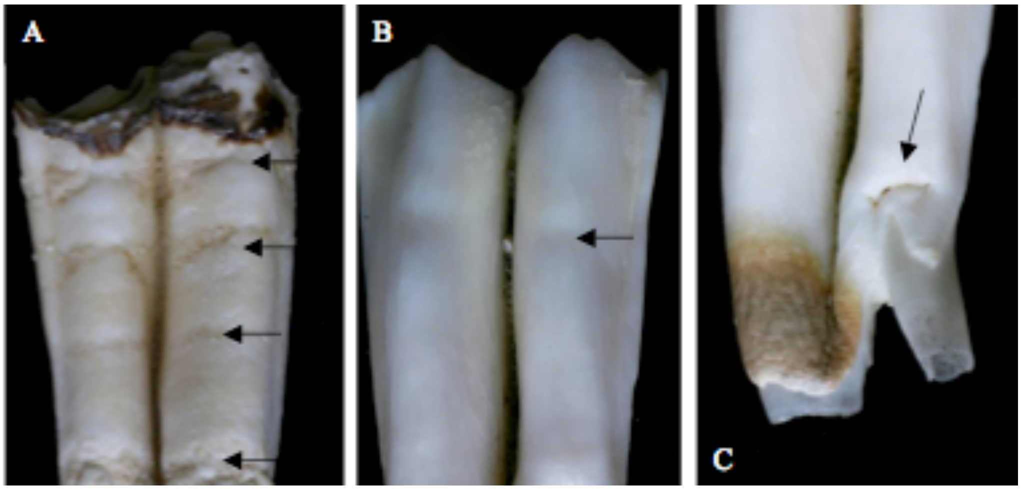

Figure 2.1: The different types of hypoplastic defects recorded as indicated by the arrows- A=line; B=depression; C=pit (Photo courtesy of Upex 2010: Figure 4.11)

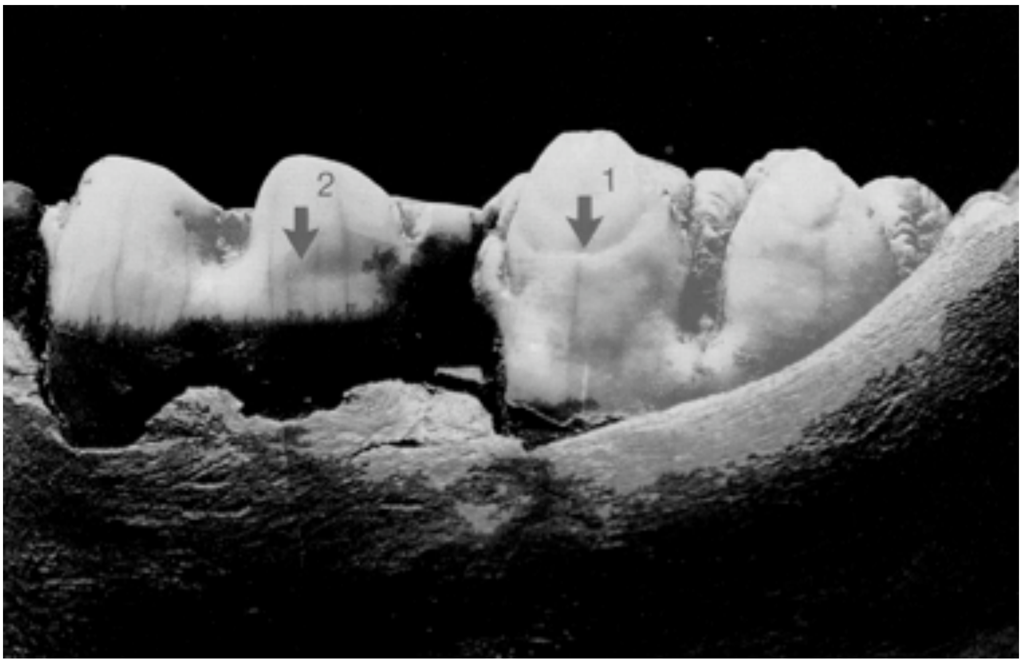

Figure 2.2: Enamel hypoplasia on the second and third molar of a medieval domestic pig from Ename (Belgium) 1=line; 2= depression (Photo courtesy of Dobney, Ervynck, and La Ferla 2002: Figure 1)

2.2.1 Line-type

Line-type defects are the most commonly occurring form of enamel hypoplasia. These defects consist of narrow, clearly defined, horizontal bands running across the tooth surface (Figure 2.1, 2.2). It has been suggested that this type of defect is caused by a severe stress impact that lasts over a short duration (Witzel *et al.* 2006: 108).

2.2.2 Depression-type

Depression-type defects in teeth (notably in pig teeth) are the result of a reduction in enamel thickness, producing a clear depression on the surface of the tooth (Figure 2.1, 2.2). From microscopic examination of this type of defect, the enamel underlying the depression appears normal, indicating that a slowing down in the rate of enamel secretion over an extended period of time is the cause for this type of defect. This suggests that depressions are caused by periods of long lasting, but low intensity periods of stress (Witzel *et al.* 2006: 108) such as a prolonged period of nutritional stress possible encountered during winter (Ervynck and Dobney 1999: 2).

2.2.3 Pit-type

Pit-type defects can vary in size and number, and can be arranged in small clusters or in bands running across the surface of the tooth (Figure 2.3), and sometimes even accompany liner-type defects (Upex 2010: 41). Single, large pits are also common and are often associated with isolated traumas, although more recent studies have suggested that isolated pit-type defects could also be sue to systematic stress (Franz-Odendaal 2004: 204). Pits are formed only when small clusters of cells cease matrix production, while the neighbouring cells are able to continue production (Witzel *et al.* 2006: 96).

Figure 2.3: Showing pit defects on the surface of a caprine first molar (Photo courtesy of Witzel, unpublished in Upex 2010: Figure 3.3)

2.2.4 Shift-type

The fourth type of defect, referred to as shifts (Figure 2.4) have also been observed in the Egyptian material. As this type of defect is only observed in a few caprine teeth, it will be discussed in further detail in chapter 9, section 9.3.4.

Figure 2.4: Shift in trajectory of crown direction- North Ronaldsay sheep first molar (Photo courtesy of Upex 2010: Figure 5.14)

2.3 Selection of Teeth/Mandibles

Based on the knowledge of what hypoplasia is and the forms in which it can occur, the mandibles and individual teeth of both pigs and caprines from each Egyptian archaeological (and modern) site were recorded, together with their context information. All permanent molars preserved in the mandibles were recorded. However, due to various taphonomic factors the faunal remains recovered are often in a poor state of preservation and so a number of isolated teeth are also often recovered. Furthermore, as there can be difficulty in differentiating the first from second molars, isolated teeth were recorded (as a separate category of m1/2), but not included in the analysis of this research. All deciduous fourth premolars were recorded as well, but are also not utilized in this thesis because of the probable marked differences between enamel formation in deciduous and permanent dentition (Dobney and Ervynck 2000 600-601). Furthermore, they are excluded because no deciduous fourth premolars showed any evidence of LEH. This coincides with preliminary studies on sheep/goats (Arbuckle 2004), concluding that deciduous teeth show very little evidence of hypoplaisa, finding LEH on 0-8.4% of all deciduous teeth. This is because the formation of deciduous teeth occurs very rapidly, with the deciduous fourth premolar fully formed at birth in sheep/goats (Payne 1973: 297) and within the first 11-20 days in pigs (Matschke 1967: 112). Thus, because the deciduous fourth premolar forms so quickly in the womb, being protected from physiological stresses, LEH usually do not form. The lack of LEH on deciduous teeth is the reason that this study will focus on the permanent molars.

2.4 Recording Enamel Hypoplasia

The following protocol is used to record all teeth: taxon, tooth type (molar number), side (right or left), and age. Ages are identified using Grant's (1982) method for pigs and Payne's (1973) method for caprines. Only mandibular teeth are included in this study. Maxillary teeth are excluded in an attempt to reduce redundancy in data collection. Eruption and wear stages in teeth were recorded following the methods developed by Grant (1982) for pigs and Payne (1973) for caprines. The methods are explained in detail below chapters 5 and 8.

Figure 2.5: Showing the large amount of tooth crown hidden inside the mandibular corpus of caprines, thus the need to drill the bone to extract teeth (Photo courtesy of Upex 2010: Figure 4.4)

When sheep and goat teeth are preserved in the mandible, they are extracted using a drill in order to allow total visibility of the tooth crown to record any LEH. This is due to the fact that a large percentage of the tooth crown is not visible (located below the surface of the bone), thus making hypoplasia observation and measurements impossible to see and record (as seen in Figure 2.5). This is usually not done for pig teeth as the entire crown is typically visible above the bone. The only exception is when the tooth has not completely erupted above the bone, and is drilled out to allow LEH visibility.

2.5 Hypoplasia Observation and Measurements

The choice of measurements taken was based on the recommendations in Payne and Bull (1988), Albarella and Payne (2005), along with the crown maximum height (seen in Figure 2.7). Based on these standards, the measurements taken are the posterior width of the first and second molar, and the anterior width of the third molar. These measurements will be used in biometrical analysis (Chapter 5 and 8) to compare differences in population sizes based on tooth width in both the pig and caprine assemblages. Crown maximum heights are also recorded on the lingual surface of the tooth from the base of the enamel in the valley separating the first and second cusps to the occlusal surface. All measurements are taken to the nearest 0.1mm with digital calipers.

In fully developed crowns, hypoplastic defects are recorded on the buccal surface of permanent molars and are easily observed by placing the tooth under a strong light to observe the hypoplasias more clearly. Hypoplasias can be seen as a line, depression, or pits, which are usually present on the enamel crown running parallel to the cemento-enamel junction (Dobney and Ervynck 1998: 265). Frequently, multiple occurrences of Linear Enamel Hypoplasia can be observed (as in Figure 2.6), sometimes seen as clusters of lines of depressions, with each occurrence noted separately. With numerous pits grouped together in a linear fashion, a measurement is recorded for the depth of the pit cluster.

The Linear Enamel Hypoplasia position on the crown is recorded by measuring the distance between the hypoplasia and the cemento-enamel junction on each cusp, along a perpendicular axis. The measurement (Figure 2.7) is taken from the midpoint of the hypoplasia line, depression etc. down to the cemento-enamel junction (Dobney and Ervynck 1998: 267) using digital calipers. This measurement technique, however, is only used when the tooth crown is complete.

Severity scores were also given to all line type of hypoplasias. This was only done for line type of hypoplasia defects as previous research has indicated that these are the most common type of defect (Upex 2010: 94). The classification of line type of defects as developed by Upex (2010: 94) has been applied for the recording of both the pig and caprine teeth and is described below (Table 2.1):

Severity Score	Classification of linear defects
1	Defect is only visible using a strong directional light source
2	Defect is just visible with out the light source
3	Defect is clearly visible without the light source
4	Defect is clearly visible, enamel is clearly missing, disrupted or very poorly mineralized and/ or defect covers a large area.

Table 2.1: The classification of the severity of linear defects as developed by Upex (2010: 94).

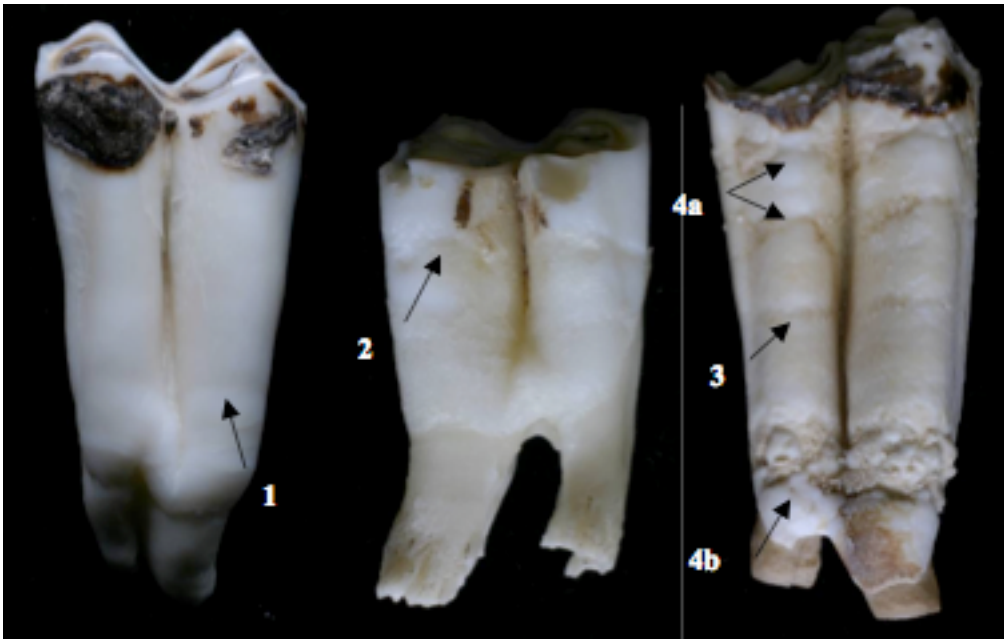

Figure 2.6: The severity scores of linear defects scored for severity. Arrows indicate the location of their defects and their severity score (Photo courtesy of Upex 2010: Figure 4.12).

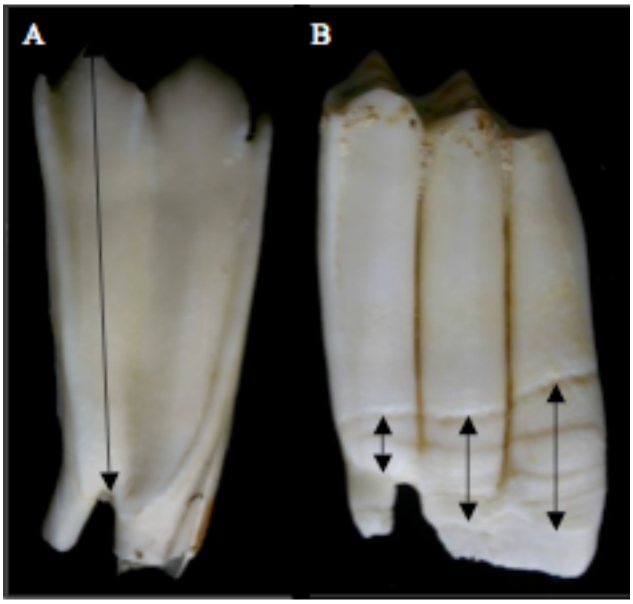

Figure 2.7: A= the measurement of the maximum height of the tooth crown; B= the measurement of hypoplastic defects on a complete tooth crown (Photo courtesy of Upex 2010: Figure 4.13)

2.6 Data Analysis

2.6.1 Developing dental chronologies

As teeth develop from the tip to the base of the crown, the age at which a defect is formed (*i.e*. the timing of a stress episode) can be estimated from its position on the crown. Assessing the timing and duration of early developmental stress events by measuring the height of the defect on the crown surface thus requires a detailed knowledge of both the timing and sequence of tooth development (Franz-Odendaal 2004: 199; Dobney and Ervynck 2000: 602). Thus, in order for enamel hypoplasia to by studied, especially in relation to physiological and seasonal events, it must be related to the age of the animal at the time of defect formation (Upex 2010: 98)

For the purposes of this dissertation, the occurrence of hypoplasia in pigs will be plotted in relation to the chronology of tooth formation as established by McCance *et al.* (1961), which provides data for both normal and undernourished populations. Like the data utilized in Dobney and Ervynck (2000: 602), it has been assumed that ancient pig populations are more comparable to those with undernourished development rates, since early domestic pigs are known to have developed more slowly than modern improved breeds. There are a few other published development rates on wild boar such as Mohr (1960), Matschke (1967), and Briedermann (1972), but they are not applicable to Egyptian samples, which consist more of domestic pigs rather than wild boar.

In caprines, there are three different development rates that have been published. Milhaud and Nezit's study (1991) was on the development rates of Pre-Alps ewes, Weinreb and Sharav (1964) on the development rates of fat-tail Israeli Awassi sheep and Upex (2010) discusses the development rates for a population of Shetland sheep from the Orkney island of Hoy in Scotland.

As Upex (2010: 103) discusses and is seen in Figure 2.8, clear differences are seen in these three published caprine dental development rates, which can partly be explained by some animals living in more optimum nutritional conditions as compared to others. This could potentially explain the faster development rates in populations such as those studied by Milhaud and Nezit (1991) as compared to the Hoy sheep (Upex 2010). Regardless of these discrepancies in development rates, for this dissertation the development rates based on the Awassi sheep (Weinreb and Sharav 1964) which are the traditional breed in the Middle East (Epstein 1985) will be used, as they are likely closest in both breed and geographical context to the Egyptian caprines.

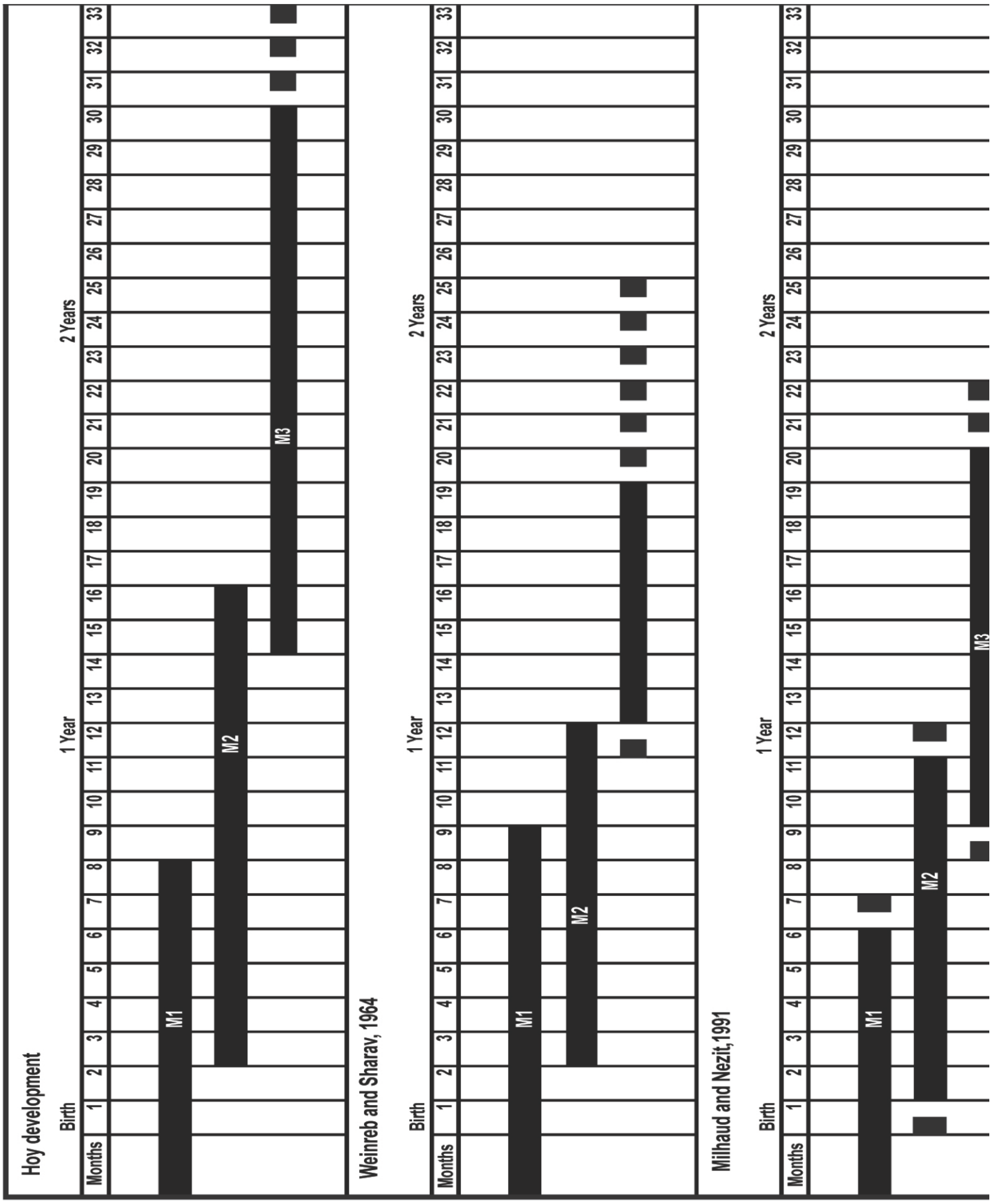

Figure 2.8: The differences in recorded developmental rates between Upex (2010), Weinreb and Sharav (1964) and Milhaud and Nezit (1991). The periods of observed dental development for each molar are shown in black; months after birth are marked along the top of each graph. M1= first molar, M2= second molar, M3= third molar. (Photo courtesy of Upex 2010: Figure 4.13).

2.6.2 Plotting enamel hypoplasia against other established dental chronologies

In order for patterns in the location of hyploplastic defects to be detected and to allow an easier comparison to other established samples, defects are plotted using histograms with ranges of 1 millimeter intervals for the pig sample and 2 millimeter intervals for the caprine sample. The use of these intervals helps to smooth the data, while removing any outliers. The results were further smoothed using running means (ongoing calculation of a statistic using progressively more of the available data values) and then converted into relative frequencies (proportion of all given values in an interval, calculated as a percentage) in order to allow the data sets to be directly compared.

As discussed in section 2.1, teeth develop in layers at regular intervals during the course of tooth crown formation (Hilson 2005: 155; Franz-Odendall 2004: 199; Dobney and Ervynck 2000: 602). Caprine teeth, however, do not develop at a regular interval. Analysis of the indivdual layers of the tooth have demonstrated that the occlusal half of the tooth develops faster, at a rate of approximately twice the speed of the cervical half of the tooth (Upex 2010: 104). This means that when plotting caprine enamel hypoplaisa patterns, the graphs have to be adjusted to reflect the irregular intervals during tooth formation. Although there is possibly a variation in the enamel development in pigs, in humans it has been argued that any variation encountered is not enough to afffect the study of enamel hypoplasia (Martin *et al.* 2008; Upex 2010: 61). However, as caprines have a comparably longer period of enamel development, following the methodology established by Upex (2010: 109), enamel defects on the occlusal half of the crown are plotted in four millimeter groups and enamel defects on the cervical hald of the crown are plotted in two millimeter groups.

2.7 Problems and conclusions

2.7.1 Problems

Recording enamel hypoplasia

Problems that can affect the recording of enamel hypoplasia include visibility of the entire tooth crown, dental wear, tooth length, and a problem that has not yet been discussed, the presence of coronal cementum.

As discussed in section 2.4, in caprines, a large majority of the tooth crown is located below the surface of the bone, thus resulting in the need to drill out and extract the tooth. Although the drilling out of the tooth provides a solution for the recording of enamel hypoplasia, it is a destructive process, so every effort was made to minimize as much destruction as possible in the caprine mandibles so that they could still be saved for possible future study. However, there were a few caprine mandibles that were impossible to drill out due to taphonomic factors and are thus not included in this study. In general, pig mandibles did not have to have any teeth drilled out, with the exception of the modern sample, which had a number of teeth that had not yet erupted, resulting in the need to extract them from the mandible.

Dental wear and tooth length also proved to be a problem, especially in high-crowned species such as caprines. This is because they have such a fast rate of attrition, which potentially removes a large part of the occlusal portion of the crown, destroying any hypoplasia occuring in this area (Upex 2010: 81). This would mean that if large numbers of worn teeth are studied, then the data may be biased towards enamel defects occurring only in the cervical half of the tooth crown. Caprine teeth in Egypt wear down faster than those of pigs because of the hot, sandy, desert environment of Egypt and caprine animals tended to be grazed on scrub lands, whereas pigs tended to live on the floodplain. Although pigs do not experience as fast a rate of wear as caprines, it is expected that pigs would experience a faster rate of attrition then pigs in a more temperate climate such as Europe or North America. The ideal way to avoid this problem is to have enough individuals from each age category and to compare individuals only in a specific category. However, since the vast majority of Egyptian archaeological samples are very small, there was no way to avoid this problem.

The presence of coronal cementum is the last problem than can be encountered when recording the presence of enamel hypoplasia. The role of cementum is to hold the tooth within the jaw, providing a firm attachment for the peridonal ligaments, which are attached to the alveolar bone surrounding the tooth (Kierdorf *et al.* 2006: 1691; Upex 2010: 75). Like the formation of enamel, cementum is deposited in layers, which can vary in thickness, resulting in the formation of a ridged surface, mimmicing hypoplasia defects (Kierdorf *et al.* 2006: 1691). Fortuantely, the covering of coronal cementum is pig and caprine teeth is considerably thinner than in larger high-crowned species such as bovids and equids, meaning that hypoplastic defects are mre commonly visible through the cementum (Upex 2010: 79). There were a few caprine teeth that did have some cementum present, but it is very easy to remove, largely due to taphonomic factors that cause it to flake off very easily.

Separating sheep and goat

Although some publications have attempted (Balasse and Ambrose 2005, Zeder and Pilaar 2010) to differentiate sheep from goat teeth, in the absence of a complete mandible, it is very difficult to differenitate between the two species. Although Zeder and Pillar's (2010) method will be applied only to the modern caprine sample, this was not published in time to apply it to the archaeological material. In any case, since most of the caprine assemblages consisted of incomplete mandibles, the method of Zeder and Pillar would have been difficult to use. It is possible, therefore, that data could be biased due to the lack of seperation of sheep and goat teeth. This issue, however will be discussed further in chapters 7-9 together with how the analysis of biometry and hypoplasia may provide some help in separating the two species in the absence of reliable morphological characterictics.

Access to sites, recovery, and preservation

The simple access to sites proved to be one of the biggest challenges when working with Egyptian material. The Egyptian Supreme Council of Antiquities required security clearance to work at any site (bones are not allowed to leave the site), thus getting permission to visit the site required time and advance planning in order to have access to any sample. Although access to more sites might help to increase the sample size and geographic varibility, a large enough of a sample size was still availible for the purposes of this dissertation.

Furthermore, once on the site, the initial recovery method for bones and their state of perservtion provides challenges. Delta sites in particular are problematic both for the recovery and preservation of bone due to the very high water table. Recovery can also pose a problem if the site has either only recently started to be excavated, thus creating a small sample size or has not had a careful enough recovery method, for example using too small a sieve or no sieving at all.

2.7.2 Conclusions: Recording defects, developmental chronologies, and data analysis

This chapter has outlined a methodology for the recording of enamel hypoplasia in pigs and caprines based on the previous methodologies developed by Dobney and Ervynck (1998) and Upex (2010). The current method records only the buccal surface of mandibular permanent molars in addition to information in the toth taxon, tooth type, side, and age. Information recorded for hypoplaisa will include the specific type (line, depression, and/or pit), in addition to its measurement from the cemento-enamel junctions up to the defect. Line-type defects are also scored for severity.

The developmental rates of pig molars are based on McCance *et al.* (1961) and Weinreb and Sharav (1964) for caprines. Data will then be plotted as relative frequencies so theat it can be more easily compared between populations. Running means are used to smooth the data, removing irrelevant information and allowing underlying trends to be clearly visible. In the caprine samples, the graphs are adjusted for non-linear growth rates by altering the width of the categories used to create the histograms of enamel hypoplasia. Four millimeter categories are used in the occlusal half of the tooth crown, while two millimeter categories are used in the cervical half of the tooth crown.

The resultant analyses will be used as the basis for discussions about animal husbandry practices in ancient Egypt when compared with other information from textual and pictorial sources.

3 Background on Egypt and the Sites Studied

This chapter will provide information on Egypt, the country from which all the data was collected and the specific sites that are the sources of data. Information on the Egyptian seasons and climate will also be discussed, as well as how and why ancient sites were chosen for data analysis. For the purposes of this chapter only, the sites are arranged according to geographical region.

3.1 Egypt

Egypt is located in the north-eastern corner of Africa, and covers an area of approximately 386,875 square miles. Modern Egypt is bordered to the north by the Mediterranean Sea, to the west by Libya, to the south by Sudan, to the east by both the Red Sea and Israel/Palestine. The boundaries of Pharaonic Egypt changed over time, but the country roughly occupied the same area as it does today. Geographic markers largely established the ancient borders of Egypt with its components including the Nile valley, the delta, and the Fayum, with the vast Sahara desert punctuated by oases to the west, as well as the Sinai peninsula to the east. The southern frontier extended to the first cataract of the Nile at the present day city of Aswan, although it moved further south during some periods into Lower Nubia. Aside from these boundaries, the line of oases running from Siwa to Kharga approximately 200 kilometers west of the Nile were also controlled by Egyptians during most of dynastic Egypt (Baines and Malek 2002: 12).

3.2 The Nile

The Nile flood was one of the main features of the Egyptian landscape and was a major component of its environment. The course of the Nile had created a deep, wide gorge in the desert plateau, and therein deposited a thick layer of rich, dark silt. It is this deep layer of silt, built up during the annual flooding of the Nile that has given the valley its amazing fertility, transforming the land into a densely populated agricultural country (Kemp 1991: 8) that has been continuously occupied since ancient times.

The waters of the Nile come from three main tributaries: the White Nile, the Blue Nile, and the Atbara (Figure 3.1). The White Nile, which rises south of Lake Victoria in Central Africa is fed by the rains of the tropical belt, providing a relatively consistent supply of water throughout the year (Baines and Malek 2002: 15; Said 1993: 12-20). The Blue Nile, along with the Atbara rises in the Ethiopian highlands and brings vast quantities of water from the summer monsoon, which is situated in the Inter-tropical Convergence Zone (ITCZ). The ITCZ produces two main wet seasons, a smaller one in October to December and the main season in March to June, which provides almost all of the flood water in the river from July to October (Davies *et al*. 1985; Baines and Malek 2002: 15; Said 1993: 21-27).

Before the construction of the Aswan high dam in the 1960's, the Nile water level was at its lowest point from April to June. The level would rise in July, with the flood proper beginning in August, covering most of the valley floor until about late September, washing out the salts from the soil and depositing a rich layer of silt. After the water levels receded, crops would be planted in October/November, and ripen between January- May (Baines and Malek 2002: 15; Said 1993: 96-97).

Despite its regularity in the yearly flood, Nile discharge, however, has not conformed to a predictable equilibrium model (Butzer, In Press). Instead, it has experienced changing flood levels, a phenomenon that dates back to dynastic times. The reconstruction of ancient Nile fluctuations has been derived from a number of sources including written observations, archaeology and geoarchaeology. These sources are also derived from multiple locations in order to construct as large of a picture as possible. The following is a brief summary of Nile fluctuations throughout dynastic history.

Figure 3.1: Map of the Nile river basin
(http://climatesecurity.org/blog/wp-content/uploads/2008/03/nilebasin.gif)

The Old Kingdom (c. 2686-2125 BC) was marked by a decrease in flood levels by the first dynasty and experienced continued low, but stable levels throughout the Old Kingdom (Butzer 1976: 33). The average height of the flood was about 2.8

meters in height with the highest Old Kingdom level during year thirty of the reign of King Den, registering at 4.25 meters (Said 1993: 134).

The First Intermediate Period experienced continued flood failure, with especially low levels between 2250-1950 BC (Butzer 1976: 28; Bell 1971: 2; Moeller 2005). This likely caused widespread famine across Egypt as attested in inscriptions such as those seen from the tomb of Ankhtifi at Mo‘alla (Bell 1971: 8-10; Vandier 1950). However, there was a dramatic increase during the Middle Kingdom with phenomenal flood levels during the late 12th dynasty (c. 1840-1770 BC) as attested in the Semna inscriptions (Seidlmayer 2001: 73-80; Said 1993: 145-6; Bell 1975: 238-245). These increased floods ushered in a new era of improved hydrological conditions and developments (Butzer 1976: 33) with particular reference to the intensive irrigation projects that took place in the Fayum during the reign of King Senusret II (c. 1877-1870 BC) (Callender 2000: 164-165). Although controversial, the flood levels seemed to remain fairly high until the time of Ramses III (Butzer In Press: 19; 1976: 55-56).

As of yet there has been no systematic study of the floods for the Late Period and Ptolemaic-Roman, and even the New Kingdom (Butzer 1976: 29), the Nile flood levels seem to have declined by 1100 BC (21st dynasty), although they slightly increased around 710 BC (Butzer In Press: 17-18; Breasted 2001: 369-370). This is confirmed by high flood inscriptions on the quay of the Karnak temple (Seidlmayer 2001: 63-73; Butzer In Press: 18; Said 1993: 152). This was followed by another hiatus until the late Roman/Coptic times- c. AD 700 (Butzer 1976: 18).

3.3 Egyptian Climate and Seasons

As this dissertation will look at the presence of linear enamel hypoplasia (LEH) in suids and caprines, it is essential to compare the data to already established data sets. Although this will be looked at in great detail in the forthcoming chapters, it is important to establish the climatic context in which these animals lived. As the vast majority of previous studies on LEH in suids and caprines come from European sites, the data obviously fits into a Europocentric view of four seasons, which is not the case in Egypt.

The seasons that Egypt experiences today are very similar to what was experienced in dynastic Egypt which revolve around the Nile. The only exception is that with the construction of the Aswan high dam in the 1960's, the annual flooding of the Nile completely ceased north of it. Nevertheless, beginning in the first dynasty (c. 3000 BC), the Egyptian calendar was divided into three seasons based on the agricultural rhythm of the Nile valley: flood season from mid July to October, winter (Growing season) from mid November to February, and summer (Harvest season) from mid March to July (Spalinger 2000: 224).

In Egypt, the essential climatic factor is the level of the Nile in the season of its annual flood. With the exception of the Mediterranean coastline, which amounts to about 150 mm per year (Hurst 1952: 34), not much rainfall occurs in Egypt (Table 3.1). Thus, for crops to grow, the flood must be sufficient in order to overflow the fields and prepare them for the sowing of the seeds. It is known, though, that on occasion warm air from the southeast from the Red Sea is sometimes blown into the eastern desert causing thunderstorms, and occasionally even violent cloudbursts which can turn dry *wadis* (desert valleys) into raging torrents for a few hours that on rare occasions feed into the Nile valley (Sutton 1949: 74; Bell 1975: 247). But because of the desert environment, overall Egypt has a very dry, hot climate during the day, although it can cool down significantly at night (Hurst 1944: 26). Although we are not sure of what the average temperatures may have been an antiquity, the following modern averages (Table 3.2) are provided as a baseline.

City/ Area	Yearly Rainfall Total	Source
Marsa Matruh	160 mm	Hurst & Black 1943: 13
Alexandria	217 mm	Hurst & Black 1943: 13
Mansura	55 mm	Hurst & Black 1943: 15
Tanta	43 mm	Hurst & Black 1943: 16
Giza	28 mm	Hurst & Black 1943: 17
Fayum	8 mm	Hurst & Black 1943: 17
Upper Egypt	4 mm	Hurst & Black 1943: 45

Table 3.1: Yearly Rainfall totals from Hurst and Black (1943) for 1937.

Month		Cairo Min/Max	Alexandria Min/Max	Luxor Min/Max	Aswan Min/Max
January	C	8.6/19.1	9.3/18.3	5.4/23	8/23.8
	F	47/66	49/65	42/74	46/75
February	C	9.3/21	9.7/19.2	6.8/25.4	9.4/26.1
	F	48/69	49/67	44/78	49/79
March	C	11.2/23.7	11.3/21	10.7/29	12.6/30.4
	F	52/75	52/70	51/84	54/86
April	C	13.9/28.2	14.5/23.6	15.7/35	17.5/36
	F	56/83	58/75	60/95	63/97
May	C	17.4/32.4	16.7/26.5	20.7/39.3	21.1/38.5
	F	63/90	62/80	69/103	71/101
June	C	19.9/34.5	20.4/28.2	22.6/41	24.2/42.1
	F	68/95	69/83	72/107	76/108
July	C	21.5/35.4	22.7/29.6	23.6/40.8	24.5/42
	F	71/96	73/86	74/106	76/108
August	C	21.6/34.8	22.9/30.4	23.5/41	24.7/41.3
	F	71/95	73/87	74/107	76/107
September	C	19.9/23.3	21.3/29.4	21.5/38.5	22.2/39.6
	F	68/89	71/85	71/101	72/103
October	C	17.8/29.8	17.9/27.7	17.8/35.1	19.3/36.6
	F	64/86	64/82	64/95	66/99
November	C	12.1/24.1	14.8/24.4	12.3/29.6	14.5/30.2
	F	54/75	59/76	54/85	58/86
December	C	10.4/20.7	14.8/24.4	7.7/24.8	9.9/20.5
	F	51/69	52/69	52/69	

Table 3.2: Average temperatures in Cairo, Alexandria, Luxor, and Aswan throughout the year (www.ask-aladdin.com/weather)

According to the ancient Egyptian calendar, each of these seasons lasted four months apiece, each containing thirty days. As this adds up to 360 days, five additional days were added at the end of each year, referred to as the epagomenals, or "days above the year" to fix the calendar to the rotation of the sun at 365 days (Spalinger 2000: 224). Inundation or flood season, referred to as *3xt* (Faulkner 2002: 4) by the ancient Egyptians, lasted from July through October. This would have been a hot and very difficult time for not only the people due to the increased water levels, but for the animals as well as there would have been a lack of food, which might force the animals to forage for food unless they were moved elsewhere, possibly to the desert edges. As moving the animals may have been difficult in the delta, they possibly moved to the settlement edges that were not affected by the flood.

Winter or *prt* (Faulkner 2002: 91) lasted from November to February. Although temperatures can significantly decrease at this time of year (particularly in lower Egypt), this is when the crops would have been planted after the receding of the flood. It is possible that during periods of increased flood levels such as those in the Middle Kingdom, soil parasites (ex. *Pythium debayianum, Rizochtonia solani*) would have set in that could affect both the crops and animals. These parasites would affect the crops by possible delaying the harvest until April when the hot *khamsin* winds would parch the crop (Wilcocks and Craig 1913: 304). The parasites could also affect animals by infecting their food, along with fording the animals to be moved to the desert margins away from the flood (Butzer 1976: 51, 1984: 105). Although it is possible that the winter months would not have had as dramatic affect on animals in Upper Egypt, particularly in the Aswan area where it is warm all year round, it is possible that a combination of the flood recession and temperature change could have created a fair amount of stress on the animals.

The harvest/summer season or *shemw* (Faulkner 2002: 267) lasted from March through June. Despite the increased heat, this would have been harvest time and, due to the increased food supply, would have been the likely birthing season. Although temperatures would increase even more so in Upper Egypt, possibly causing the reverse pattern as seen in Lower Egypt, which would have been cooler and more wet, overall this would have been a time of decreased stress to the increase in temperature and food availability.

3.4 Site Selection

Archaeological material has been selected from thirteen different sites all over Egypt representing time periods from the Old Kingdom (c. 2686 BC) through the Ptolemaic-Roman period (up through AD 400). There is some data that has been collected from the site of Saïs that dates to the Neolithic period (c. 4000 BC), however, that particular data set was too negligible to provide any useful information.

The first criterion for site selection is that the sample be of a settlement context. These are the types of sites that are not only where pigs and sheep/goats are most common, but are where these animals are subject to more varied physiological stresses, thus resulting in the occurrence of hypoplasia, the focus of this study. Twelve out of the thirteen sites are of settlement context, although there is one site of a cemetery context, the Abydos Middle Cemetery. This was analyzed simply because of the sample's availability and will be used for possible comparison to settlement sites. Otherwise cemetery and temple sites were avoided as remains from these contexts rarely include pig and sheep/goat. The selection of the sites was based on three criteria: time period of site occupation, geographic location of the site, and the availability of the site sample.

The time period of site occupation was the second criterion for site selection. As one of the purposes of this research is to look at diachronic changes in suid and caprine husbandry practices throughout dynastic Egypt relating to both geographic and site contexts, it is essential that the analyzed data sets represent the entirety of dynastic Egypt. Thus, every effort was made to represent the span of ancient Egyptian history, and as mentioned before, the collected data spans the time period of c. 4500 BC-AD 400.

Geographic location is the third of the site selection criteria. As Egypt is a large country, with fairly varied geographic regions, every attempt was made to select sites from the different regions of Egypt- i.e. Upper vs. Lower Egypt, and desert vs. the coast or wetland. Although the selected sites have varied geographic locations (as seen in Figure 1.1) the more pressing factor for site selection is that of sample availability.

As no antiquities, including animal remains, are allowed outside Egypt, examination of the pig and sheep/goat teeth resulted in having to visit every site in order to record the needed data, which was made possible by the generosity of the site directors of all the sites examined. Following these selection criteria is a brief summary of every site from which data has been collected. Each site summary provides information on the location/site history along with its excavation history.

3.5 The Sites

3.5.1 Aswan, ancient *Syene*

Location/ Site History:

The town of Aswan is located on the eastern bank of the Nile river at the first cataract. The modern name of Aswan is derived from the Greek *Syene* and ultimately from Egyptian *swnw* meaning “to trade” (Morkot 2000: 151), as it was a riverside settlement on the desert margins. Little to no rainfall would occur in the region (see above) as it is estimated that only about 4mm of rainfall could occur annually (Hurst & Black 1943: 45). Probably, though the annual flood was more intense and longer in duration in the region as compared to Lower Egypt. The region of Aswan was an important as a major source of granite, with quarries on both sides of the river (Morkot 2000: 151). It also had an important role as a defender of the southern frontier, and was the starting point for many military and trading expeditions into Nubia (Morkot 2000: 151).

Although Aswan was inhabited from at least the Old Kingdom (c. 2686 BC) onward, very little remains from the settlements or temples from most of the Pharaonic era, perhaps because they have been consumed by the modern town. Aswan seems to have been an important town site during the Graeco- Roman (c. 332 BC-AD 395) and later periods (von Pilgrim et al. 2004: 119). This is in contrast to the rich remainder of religious and secular activities found on Elephantine Island that date to the earlier periods of Pharaonic history (see below).

There are a few visible ancient monuments that have survived in present day Aswan. The two most notable surviving monuments are the temple of Isis dating to the reign of Ptolemy III (c. 246-222 BC) at the southern edge of the town (Figure 3.2) and the Byzantine town wall which incorporates blocks from earlier Roman temples (Morkot 2000: 151). This lack of preservation is due to the serious problem that Aswan (and many other ancient sites throughout Egypt for that matter) faces, which is the conflict between the needs of the modern town and the responsibility of preserving its historical roots (von Pilgrim et al. 2004: 119).

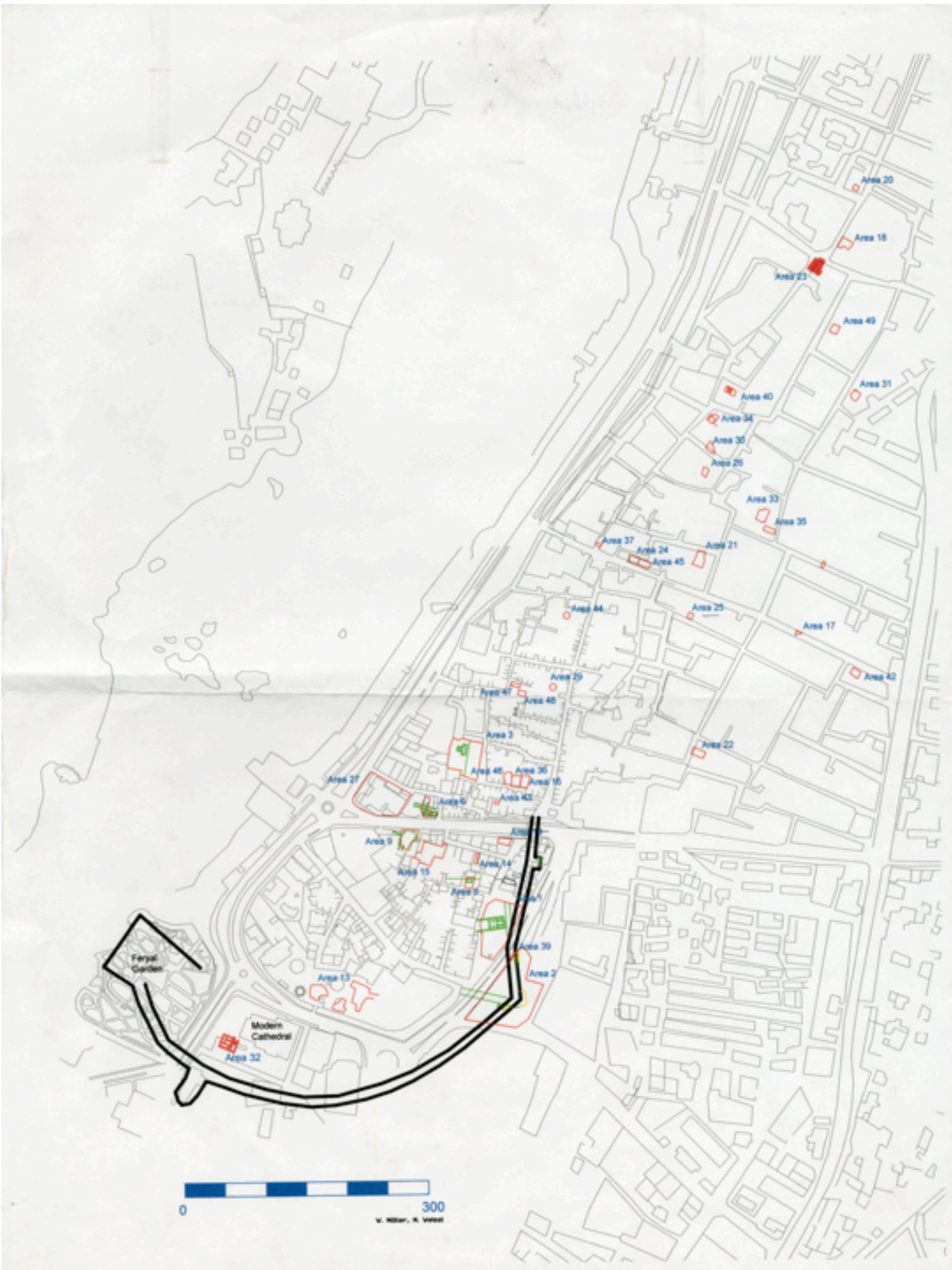

Figure 3.2: Map of excavated areas in the Aswan settlement (Photo courtesy of Cornelius von Pilgirim)

Excavation History:

Unlike the extensive work that has been done at Elephantine, no systematic excavations have ever been conducted in Aswan. The earliest reports on ancient Syene come from the first European travellers who visited the site in the eighteenth century, with the most precise descriptions coming from F.L. Nordon and Pococke who visited Aswan in 1737- 1743 (Pococke 1743: 116-118 in von Pilgrim *et al.* 2004: 122). Aside from the few monuments visible since ancient times, all further discoveries were due to the *sebakh* digging or construction activities, with the most prominent discovery being that of the Isis temple that was uncovered in 1871 (von Pilgrim *et al.* 2004: 122).

In October 2000, the Swiss Institute of Architectural and Archaeological Research on Ancient Egypt, Cairo and the Supreme Council of Antiquities commenced a joint archaeological project in the old part of Aswan, the ancient town of *Syene* (von Pilgrim *et al.* 2004:119). The first two seasons of work concentrated mainly in the area of the temple of Isis and Domitian (von Pilgrim *et al.* 2004: 124). The main focus of seasons three and four was rather on a sequence of domestic buildings south of the Isis temple (von Pilgrim *et al.* 2006: 215). Since then, work has concentrated in many areas throughout Aswan (Figure 3.2) up through the present. Thus, the dynastic material from here dates mainly to the Ptolemaic-Roman period, although there is some material from both the Middle Kingdom and Late Period, all from a settlement context.

3.5.2 Elephantine

Location/ Site History:

Elephantine is the modern name of the island located in the Nile river, opposite the city of Aswan (ancient *Syene*). Derived from the Greek rendering of the Egyptian word for Elephant (*3bw*), Elephantine is a name that seems to indicate a reshipment port for African ivory and other exotic goods (Franke 2000: 465). By the Old Kingdom, Elephantine was also the starting entrepôt for the southern trade routes from Egypt to Nubia, as during pharaonic times it was Egypt's southernmost border city (Kaiser 1999: 283). This is attested by inscriptions such as the sixth dynasty (c. 2350 BC) autobiography of Harkhuf (Lichtheim 1973: 23-7) inscribed at his tomb at Qubbet el-Hawa. The environment of the Elephantine settlement was fairly similar to that of Aswan, both being riverside settlements located across from one another. However, Elephantine is obviously different in that it is located on an island, and might have been more dramatically affected by the flood.

Elephantine island was inhabited at least from late Predynastic (c. 4000 BC) times (Baines and Malek 2002: 72), with its settlement developing around a cluster of large monoliths that formed a grotto. This later became the sanctuary of Satet, the patron goddess of Elephantine (Franke 2000: 465). Satet was later eclipsed by the ram god, Khnum, whose temple was constructed in later periods on top of her temple (Kaiser 1999: 285). The site's development as a town, however, seems to have occurred during the early Old Kingdom (Kemp 1991: 69), although more recent excavations at the site show extensive town development by the Early Dynastic (c. 3000-2680 BC) period (Raue et al. 2009: 4). The settlement continued to grow and the many excavations at the site have uncovered evidence of over 3,000 years of continuous occupation, unparalleled to date at any other ancient Egyptian settlement (Kaiser 1999: 283). Occupation at the ancient settlement probably ended around the thirteenth/ fourteenth century BC (Kaiser 1999: 288).

Excavation History:

The first excavations at the site took place between 1906 and 1908 by a German team supervised by O. Rubensohn, followed by a French team in 1906-1910, both with the goal of searching for Aramaic papyri (Kaiser 1999: 283; Franke 2000: 466). It was not until 1969 that the current program of comprehensive exploration of the entire town commenced under the German Archaeological Institute (Cairo branch) in cooperation with the Swiss Institute of Architectural and Archaeological Research on Ancient Egypt, Cairo and continues until the present (Raue 2006, 2009).

3.5.3 ABYDOS

Abydos, or ancient *3bdw* is about 413 km (256 miles) south of modern day Cairo, and about 91 km (56 miles) north of modern day Luxor. On the west bank of the Nile, the site stretches about 8 square km (5 square miles) and is composed of archaeological remains from all phases of ancient Egyptian civilization (O'Connor 2009: 23; Wegner 2000: 7). Abydos was important during antiquity as the main cult center of Osiris, ancient Egypt's primary funerary god. Many cult structures dedicated to Osiris were constructed at Abydos, notably including the well preserved New Kingdom temple of Seti I and Ramses II (O'Connor 2009: 25, Wegner 2000: 7). Abydos is also important as the burial ground for all the kings of the first dynasty (beginning c. 2950 BC) and the last two of the second dynasty (ending c. 2650 BC), subsequently followed by a transformation during the Old and Middle Kingdom into a religious centre of great importance (Dreyer 1999: 109-114; O'Connor 2009: 137, Wegner 2000: 7). Although there are many different areas of the site (Figure 3.3), the three main areas from which teeth are sampled in this study are the Abydos Settlement Site, Abydos Middle Cemetery, and the South Abydos town of *Wah-Sut* at the mortuary complex of Senwosret III.

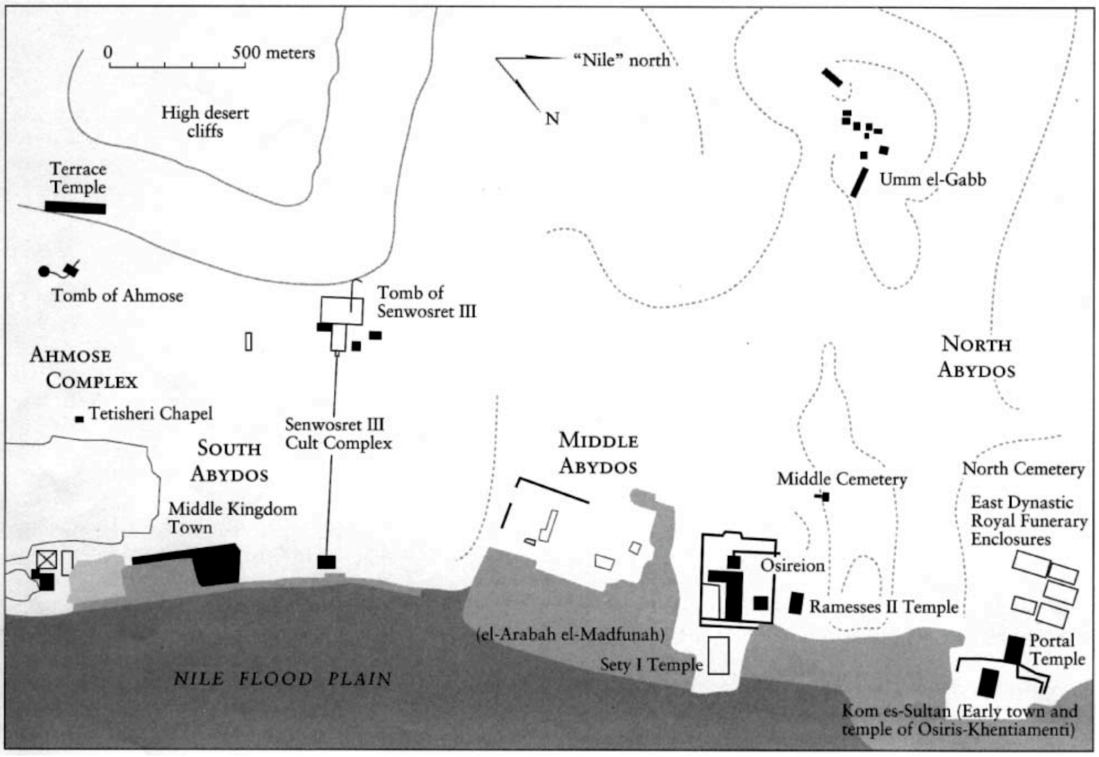

Figure 3.3: Map of the main archaeological areas at Abydos (O'Connor 2009: Figure 3)

3.5.3.1 Abydos Settlement Site

Location/Site History:

Adjacent to the modern village of Beni-Mansur, and slightly north of the early dynastic royal funerary enclosures (Figure 3.3) lies the ancient settlement at Abydos (Kom es-Sultan). As most of the known and excavated settlement sites of the Old Kingdom/ First Intermediate Period (c. 2686-2055 BCE) are restricted to 'pyramid towns' such as those at Giza (including the Workmen's Village, and the settlements at the pyramids of Queen Khent-kawes and King Menkaura), Dashur, and Abusir (Kemp 1991: 141- 149), the Old Kingdom/ First Intermediate Period Abydos Settlement Site is unique in that it rather seems to be associated with the Osiris- Khentyamentiu temple (Adams 1999: 97; O'Connor 2009: 84; Kemp 1977: 186).

The site was originally a classic '*tell*', possibly as much as twelve meters or more in height. However, the *tell* has been reduced, as most of the later levels have been removed as the result of digging for organic material (*sebakh*) used as fertilizer by the local farmers. Thus, the Old Kingdom and First Intermediate Period levels at the settlement are immediately below the surface (Adams 1999: 97-98). Situated in the floodplain based in a soil matrix, likely experiencing little impact form the desert, the Abydos Settlement Site seems to cover an area of about 8 ha (almost 20 acres), although it continues for a considerable distance under the modern village (O'Connor 2009: 82).

The earliest occupational evidence at the site, as excavated by Petrie, dates from late Predynastic times (Naqada III- c. 3200-3000 BC) to at least the second dynasty (c. 2890-2686 BC) (Adams 1999: 99; Petrie 1902: 9). The recent excavations of the Abydos Settlement Site in 1991 identified all or parts of nine houses built in the First Intermediate Period (c. 2160-2055 BC) with continuous use into the early Middle Kingdom (O'Connor 2009: 83). Although the site seems to have continuous use through the Late Period, most of the evidence of these settlements have been destroyed. Only the temple of Osiris-Khentyamentiu seems to display evidence of Old Kingdom, New Kingdom, and Late Period levels (Adams 1999: 98; Petrie 1902: 27-33).

Excavation History:

Auguste Mariette was the first to work at the Abydos Settlement Site, excavating a large area in the western corner of the site (Mariette 1998 reprint: 3-5). In 1902-3, Petrie excavated a large area of the cultic zone of the site, revealing the multi level strata, dating its use, to the Old Kingdom through the Late Period (Petrie 1902: 27-33, Adams 1999: 97). No further excavations took place at the site until 1979 when co-directors David O'Connor and William Kelly Simpson of the Pennsylvania-Yale Expedition conducted a series of test trenches. Based on the results of this work, the Abydos Settlement Site project was initiated in 1991 for one season under the direction of Matthew Adams (1999: 97), revealing the houses discussed above.

3.5.3.2 Abydos Middle Cemetery

Location/ Site History:

Beginning in the Naqada II/III period (c. 3200-3000 BC), about two kilometers away from the edge of cultivation, running towards the prominent break in the desert escarpment, the large elite burial ground of the earliest kings of ancient Egypt developed. This area includes cemeteries U, B, and Umm el-Qa'ab (Figure 3.3), housing the tombs of the kings up through the second (c. 2686 BC) dynasty

(Dreyer 1999: 109-114; O'Connor 2009: 139-141). Their corresponding large mud brick funerary enclosures are surrounded by many elite burials in small graves and built near the area of cultivation in an area that is now referred to as the North Cemetery (O'Connor 1999: 93-95, 2009: 159-181; Baines and Malek 2002: 116). However, in the fifth and sixth dynasties (c. 2494-2181 BC) another new cemetery developed, spreading out over the high desert plateau near the town's south corner (Figure 3.3), referred to at the Abydos Middle Cemetery (O'Connor 2009: 76; Richards 2002: 400; Frankfort 1930: 215).

Located on the desert edge and situated on a sandy matrix, the Abydos Middle Cemetery covers an area of about fifty hectare, housing the elite burials of many prestigious officials including members of the central government such as Weni, the Overseer of Southern Egypt and Djau, a vizier or prime minister (Richards 2002: 401; O'Connor 2009: 77). There were many others of prestigious titles including vizier and other provincial officials of the highest rank buried in the Middle Cemetery. This signals the desirability to be buried at Abydos, with some tombs even having texts referring to the boon of having 'a tomb chamber in Abydos' (O'Connor 2009: 77).

Excavation History:

Like the Abydos Settlement Site, Auguste Mariette was the first to excavate the Abydos Middle Cemetery, However, because of Mariette's lack of interest in context, his work at the Abydos Middle Cemetery only resulted in basic descriptions of the site (Richards 2006: 142, 2002: 400; Mariette 1998 reprint). Because of the havoc wrought onto the Middle Cemetery by Mariette's careless methodology, no one with the exception of Frankfort (1930) attempted to excavate the part of the Abydos Middle Cemetery that was the focus of Mariette's work (Richards 2006: 142). Between 1876-1995 there was no systematic investigation of the seemingly destroyed hill. However, in 1995 the University of Michigan Abydos Middle Cemetery Project under the direction of Janet Richards returned to the site with the goal of understanding the character of the late Old Kingdom cemetery as a whole. Beginning with a surface survey in the mid 1990's of the topography, architecture, and ceramic material, much seemed to remain that had not yet been excavated (Richards 2006: 143). This was confirmed in 1999 with excavations re-locating the tomb of Weni, including a newly discovered inscription and decorated material that Mariette's workmen had overlooked (Richards 2006: 143, 2002: 406; O'Connor 2009: 78-9).

The University of Michigan Abydos Middle Cemetery Project continues to work at the site today.

3.5.3.3 South Abydos (town of *Wah-Sut*)

Location/ Site History:

To the south of the main center of the ancient town of Abydos is a rather large area of low desert edge, referred to as South Abydos. This area was primarily developed as an area for the construction of a series of royal cult foundations during the Middle and New Kingdoms. The two main cult complexes that have been identified and excavated are those of Senwosret III (c. 1870-1831 BC) of the twelfth dynasty and Ahmose (c. 1550-1525 BC) of the eighteenth dynasty (Wegner 1999: 106). The complex and associated town (*Wah-Sut*) of Senwosret III is the origin of the analyzed teeth data, and the focus of this section.

The main center of the Senwosret III funerary complex (Figure 3.3) is a large, subterranean tomb with a T-shaped mudbrick enclosure wall built at the edge of the desert cliffs. About 750 meters from the tomb enclosure, at the edge of the low desert is a large mortuary temple also dedicated to the deceased king (Wegner 1999: 106-7, 1996: 145). Another 300 meters to the east of the mortuary temple are the remains of a large, planned settlement that housed the administrators and workers responsible for maintaining the mortuary cult of Senwosret III (Wegner 1999: 107, 2006b: 10, 1996: 181-190; 2001). The town is situated on the low desert edge on a sandy matrix right next to the floodplain, although the main body of the site is now currently under an area now encompassed by the Nile floodplain (Wegner 2001: 282-285). This may indicate that animals were raised in the nearby floodplain and were likely only brought into the site for slaughter and consumption, similar to the Giza Workmen's Village.

Recent work shows that this town was called *Wah-Sut*, an abbreviation of the name of the mortuary complex (Wegner 2006: 10; 2001: 281). Similar to other Middle Kingdom royal complexes such as that at Lahun, the temple and town lasted for only 150 years (Wegner 1999: 107) during the late twelfth and thirteenth dynasties (c. 1850-1700 BC).

Excavation History:

Between 1899 and 1902 the Egypt Exploration Society conducted the first excavations at the complex of Senwosret III. During this time, Randall-McIver excavated most of the temple and mapped its surrounding architecture (Randall-McIver 1902). In 1901, Weigall excavated and mapped the enclosure of the subterranean tomb, associated structures, and subsidiary buildings, which lead to the discovery of the tomb's entrance (Petrie 1902). After the Egypt Exploration Society's work, no excavations were conducted at the site until 1994 with the Yale University-University of Pennsylvania- Institute of Fine Arts, NYU expedition to Abydos. Its primary focus was on the mortuary temple and its surroundings, and a secondary focus on the excavations of the Middle Kingdom town site near the temple (Wegner 1999: 106, 1996: 145-190).

3.5.4 Amarna

Location/ Site History:

Located in middle Egypt on the Nile, roughly half way between the ancient cities of Memphis (near modern day Cairo) and Thebes (modern day Luxor) lies the site of *Akhetaten* (Horizon of the Aten), or as it is referred to today, Amarna (Kemp 1991: 267). Founded during the fifth year of his reign (c. 1349 BC), King Akhenaten chose to build an entirely new capital city on virgin soil dedicated to the cult of the Aten- the visible sun disk (Kemp 1991: 266-7). As for why Akhenaten chose to move the capital city to *Akhetaten*, his intentions are recorded on a series of boundary stelae, some of which are carved into the surrounding cliffs, and on the opposite side of the Nile, encircling the entire city. These stelae state that the Aten had led the king to the site and selected it since it had previously belonged to no other god or goddess. Within the limits of these stelae, the new capital city was built (Kemp 1991: 267).

The ancient city limits seemed to encompass an area roughly sixteen by thirteen kilometers, measured between boundary stelae (Kemp 1991: 269). This city, which likely experienced very little rainfall, is located on the dry, desert edge directly next to the floodplain mostly on a sandy matrix was made up of many different parts (Figure 3.4), with the most important being the Main City. It consisted of various state buildings and residences, notably the great temple to the Aten, along with several smaller Aten temples, and the 'Great Palace' (Baines and Malek 2002: 124). Other notable areas of the city include the North Palace and the Workmen's Village, which housed a community of men maintained by the government for cutting and decorating the tombs in the surrounding cliffs. The entire site was abandoned early into the reign of Akhenaten's son, Tutankhamun about fifteen years after it was first constructed, returning the capital city to Thebes (Baines and Malek 202: 123). It is this short occupational period that provides us with a unique look at an ancient Egyptian city in its entirety at one specific point in history (Kemp 1984-1989).

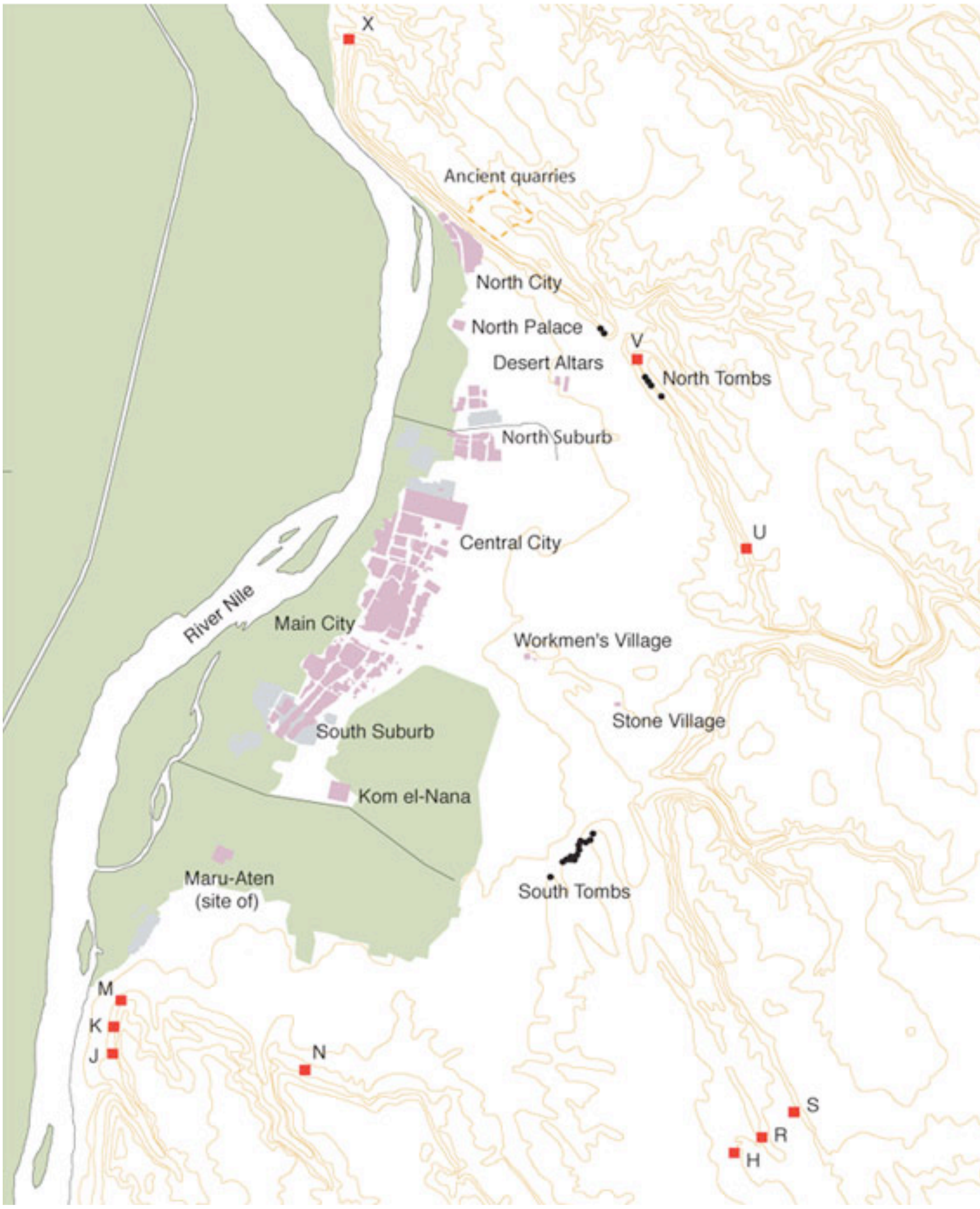

Figure 3.4: Map of Amarna (http://www.amarnaproject.com/pages/amarna_the_place/index.shtml)

Excavation History:

Although there were many visits to the site of Amarna since 1714 (Kemp and Garfi 1993: 10- 24; Bryan 2000: 62), the first modern archaeological work at the site took place in 1891-892 when Sir William Matthew Flinders Petrie opened excavations at a number of different locations throughout the site (Petrie 1974). Several expeditions at Amarna followed Petrie's work including work by the Deutsche Orient-Gesellschaft under the direction of Ludwig Borchardt in 1907 and 1911-1914 (Borchardt 1980, 1923), and the Egypt Exploration Fund (EEF) of London between 1921-1936 (Peet and Woolley 1923; Pendlebury 1936, 1932, 1931). Excavations in the city did not resume until 1977 with the Egypt Exploration Society under the direction of Barry Kemp (1984-1989, 1991: 261-317; Kemp and Garfi 1993; Weatherhead and Kemp 2007), which still continue today.

3.5.5 Giza Workmen's Village

Location/Site History:

To the west of the modern-day capital city of Cairo is the site that is most synonymous with ancient Egypt: Giza. The three pyramids dating to the fourth dynasty (c.2589-2503 BC) of Kings Khufu, Khafre, and Menkaure and their surrounding tombs sit on a plateau that rises in the high desert, west of the narrow neck of the Nile valley just below the apex of the delta (Lehner 2007: 4). Giza is a very complex site made up not only of the three famous pyramids, but the smaller queen's pyramids, and hundreds if not thousands of smaller tombs of elite from that time if not later. However, the focus of this section will be on the workmen's village (Area A) to the southeast of the pyramid plateau (Figure 3.5).

The Giza workmen's village is located on the desert edge, just above the level of inundation in a sandy matrix, which is bordered to the northwest by the large stone Wall of the Crow, separating the village from a possible harbor (Lehner 2007: 9). There is an enclosure wall that begins near the south face of the Wall of the Crow, and runs at an angle of thirteen degrees east of due south, with an opening at its intersection with the 'main street' and then curves around to run southeast and then east (Lehner 2007: 13). There are many areas of this large settlement as seen in Figure 3.6 and described in depth in Lehner's Giza Reports (2007).

Figure 3.5: Map of Giza (http://www.aeraweb.org/projects/gpmp/)

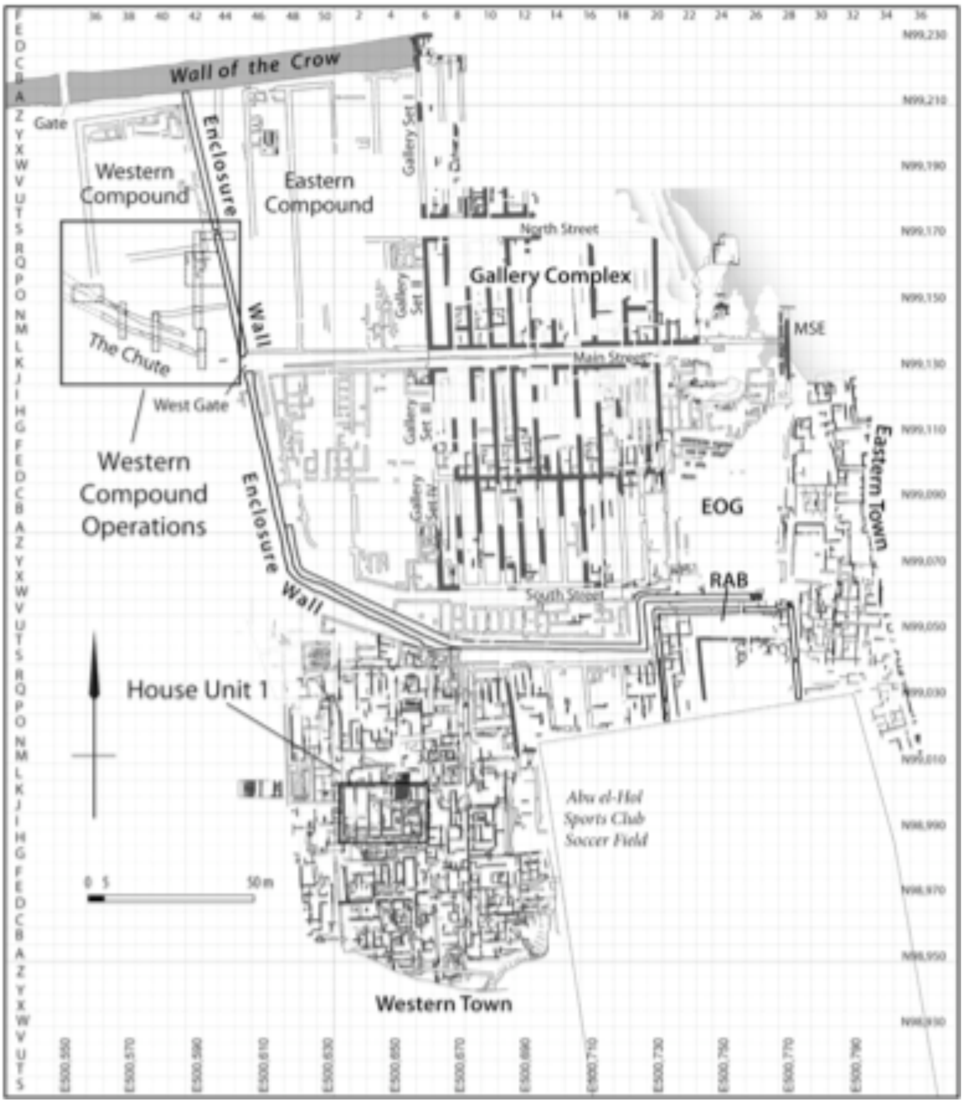

Figure 3.6: Giza Workmen's Village Map (Area A) (http://oi.uchicago.edu/pdf/09_10_Giza.pdf)

Excavation History:

Although there have been numerous explorers and archaeologists such as Caviglia, Belzoni, Lepsius, Mariette, Petrie, Reisner, Junker, and Hassan (Baines and Malek 2002: 156) that have carried out many systematic studies at Giza since the first half of the 19th century, most of their work concentrated on the pyramids and their surrounding tombs. Little to no emphasis was paid on finding the area of where the builders of all these structures may have been housed. However, during Petrie's 1880-81 excavation season, a series of structures located to the west of the outer enclosure wall of Khafre's pyramid were uncovered (Petrie 1990: 120). These structures at the time were identified as the city for the pyramid builders. However, during the re-excavation of these galleries beginning in 1988 by the Giza Plateau Mapping Project, no settlement debris was found, possibly indicating that these structures were rather used for craft production, based on the many quartzite, granite, alabaster, and diorite fragments that were uncovered (Lehner 1997: 224-5, 2007: 12; Conard and Lehner 2001: 57).

Another possible area where workers may have been housed was discovered and excavated between 1971-5 by Karl Kromer on the eastern edge of the plateau. His work yielded a substantial layer of Old Kingdom domestic debris including pottery and other artifacts, but no structures (Kromer 1978). This may support the idea that part of the workforce was housed in camps that may have covered all or part of the southern edge of the Giza plateau (Kemp 1991: 136). It was not until 1988 that the Giza Plateau Mapping Project commenced under the direction of Mark Lehner. Excavations took place not only in Petire's 'galleries,' but additionally in the newly discovered Area A (Figure 3.5, 3.6), just south of the Wall of the Crow that a substantial workmen's settlement was discovered. Work in this area still continues until today.

3.5.6 Kom Firin

Location/ Site History:

Lying about twenty-five kilometers from the current Rosetta branch of the Nile is the site of Kom Firin (Figure 3.7). Although the site has been known since the late nineteenth century, it has been the subject of very little attention (Spencer 2008: 1). The ancient name of the site has yet to be definitively identified, although there are a few possibilities including Kom Afrin (other spellings include Efrin or Farein) and Kom Kiffar (Spencer 2008: 7-8; Petrie 1886: 94). Covering an area of about 47 hectares, the site of Kom Firin was originally formed upon a large, some what elevated sand bank, often referred to as 'turtle backs' set on an ancient Nile distributary (Spencer 2008: 4). These 'turtle backs' were formed from the Pleistocene sands reshaped by shifting river courses, standing above the ancient floodplain, providing attractive locations for settlements in the unstable delta landscapes (Said 1993: 69-71). Although Petrie notes from his first visit to the site that the desert could be seen form Kom Firin (Petrie 1886: 194). This is no longer the case. Furthermore, the site likely experienced a considerably greater amount of rainfall as compared to the aforementioned sites, although it is difficult to know if ancient rainfall totals were similar to modern totals, which are around 40-55mm/year (Hurst and Black 1943: 13-

5). Although personal observation reveals that there can be fairly substantial rains every few years, amounting to a much larger amount (probably about 100+mm) as compared to than the average yearly totals from Hurst and Black (1943).

The earliest known structures at the site include a temple and a rather large enclosure dating to the Ramesside (c.1279-1213 BC) period (Spencer 2008: 23), although there has been some late Middle Kingdom material found in the nearby ancient cemetery (Spencer 2008: 15). The last occupational phase at the site dates to the Graeco-Roman period (Spencer 2008: 32). The layout of the Ramesside complex, however, is very similar to sites such as Zawiyet Umm el-Rakham (will be discussed in below section) and Amara West, which supports the argument that Kom Firin was a Ramesside stronghold, serving as a western defensive complex against the possible threat of Libyan invaders (Spencer 2008: 23).

The main areas of the site at which recent excavations have taken place include the Citadel, Ptolemaic enclosure, Ramesside enclosure, and Ramesside temple (Spencer 2008: 22- 32). With regards to the Ramesside temple, it is not known at this point to whom the temple was dedicated, but a Third Intermediate Period (c. 1069-664 BC) stela from Kom Firin suggests that cults of Sekhmet and Heka were present at the site and continued until the Late Period (c. 664-332 BC) (Spencer 2008: 6).

Excavation History:

The earliest description of the site is from Petrie's visit to the site while excavating at Naukratis (Petrie 1886: 94-5), although no map is provided. There is, however, a brief mention of the site during Griffith's (1888: 83) visit, noting the presence of two different sets of enclosures, and a temple. Systematic excavations of the site first commenced between 1949-1952 when Shafiq Farid worked at the temple and cemetery. His results, however, have never been published (Spencer 2008: 1). Between 1977 and 1983 there were a few small excavations seasons by the American Research Center in Egypt's Naukratis project. Larger scale excavations did not commence until 2003 with the British Museum under the direction of Neal Spencer and continue until the present (Spencer 2008: 2).

Figure 3.7: Map of Western Delta showing the location of Kom Firin, Saïs, and Kom el-Hisn (Spencer 2008: Figure 4)

3.5.7 Kom el-Hisn

Location/ Site History:

Located about twenty five kilometers southwest of the site of Kom Firin, about 10 kilometers southeast of the modern village of Dilingat, and about fourteen kilometers west of the Rosetta branch of the Nile (Figure 3.7) is the site of Kom el-Hisn (Cagle 2001: 37). Although most of the site has been converted into agricultural fields, the site still does have extensive remains of a fifth and sixth dynasty (c. 2500-2290 BC) Old Kingdom community (Figure 3.8) that was occupied at least into the early Middle Kingdom (c. 1890 BC). There are, however, some flint artifacts that have been found at the site dating to the first and second dynasties, although no substantial remains of this early period have been located (Wenke 1999: 416; Wenke et al. 1988: 13; Baines and Malek 2002: 168).

The site is thought to have been the ancient town of '*Im3w'* or *'Imw'*, and is mentioned in texts since the fifth dynasty. It is also likely located in a similar environmental context as Kom Firin, also experiencing similar moderate rainfall amounts.

Middle Kingdom inscriptions from Kom el-Hisn identify Hathor as the principal deity of the site, and remains have been found of a nineteenth and twenty-second temple dedicated to her (Wenke 1999: 416; Griffith 1888: 78; Baines and Malek 2002: 168). The majority of what has been excavated at Kom el-Hisn is that of the Old Kingdom rural community. The site has been concluded to be a specialized cattle-rearing center, most likely sending its herds, to Memphis, Giza and other large cult and settlement centers (Wenke 1999: 417; Wenke et al. 1988: 19; Redding 1991: 26, 1992: 104).

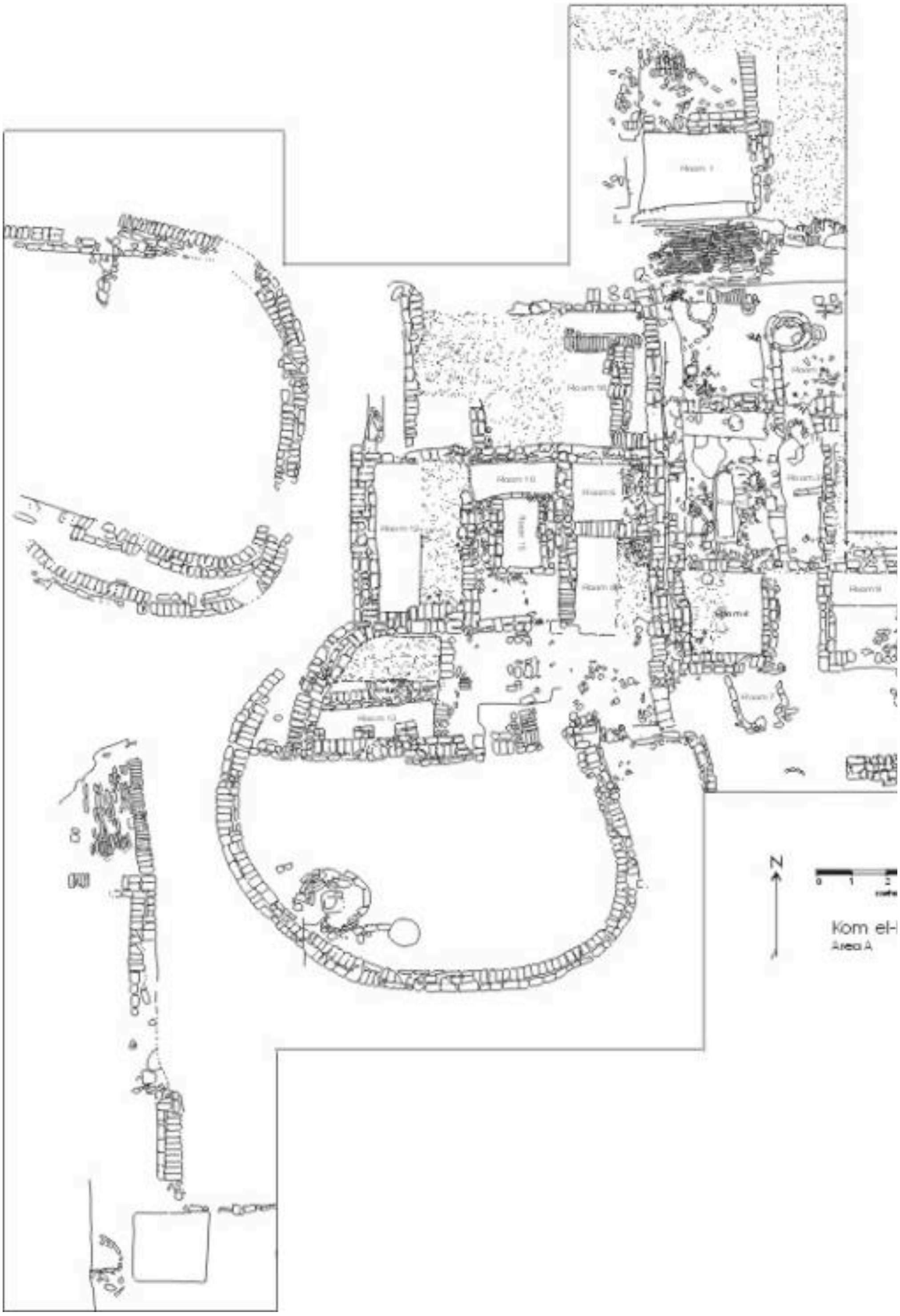

Figure 3.8: Map of Kom el-Hisn. Photo courtesy of Richard Redding

Excavation History:

The earliest visit to the site notes the presence of a brick enclosure wall with the remains of a pylon at its eastern end, as produced in a map by Griffith (1888: Pl. XXXIV). During the 1900's excavations at the site were conducted by Hamada el-

Amir and S. Farid who excavated almost 1,000 burials in the northern part of the site (Hamada and el-Amir 1947, Hamada and Farid 1947, 1948, and 1950), mostly dating to the First Intermediate Period.

Recent excavations conducted over three seasons in 1984, 1986, and 1988 took place in the main occupation areas in the southern part of the site largely revealing domestic Old Kingdom architecture (Cagle 2001: 41). One of the most important results of the studied material from the recent excavations seasons is the lack of cattle bones from the faunal assemblage, despite the relatively large quantity of cattle dung. As previously noted, this seems to indicate that Kom el-Hisn was a specialized cattle production center that was most likely part of a central government trade network (Redding 1991: 26, 1992: 104; Cagle 2001: 44).

3.5.8 Saïs

Location/ Site History:

Today the site of Saïs lies about thirty kilometers northwest of the city of Tanta, at the modern village of Sa el-Hagar in the western delta (Figure 3.7). The site lies on the western fringe of the triangular plain between the Rosetta and Damietta branches of the Nile (Wilson 2006:7). Although further work needs to be done on constructing the ancient waterways and their relationship to the archaeological material, it is highly likely that Saïs was also situated on a 'turtle back' (Wilson 2006: 12). Furthermore, the environment is also very wet and marshy, which unlike Kom Firin and Kom el-Hisn, has no access to the desert margin.

Although Saïs came to prominence as the capital city during the 26th dynasty (c. 664-525 BC), occupational evidence at the site dates all the way back to the prehistoric period. The prehistoric layers are divided into three main phases which have been distinguished by soil matrix color, pottery, and objects (Wilson 2006: 83): Saïs I, the early Neolithic dating to c. 5000- 4800 BC; Saïs II, the late Neolithic dating to c. 4500- 4300 BC; and Saïs III, the Buto-Maadi period dating to c. 3500 BC (Wilson 2006: 83). Occupational evidence has also been excavated from the Ptolemaic-Roman period (Wilson 2006: 132-6), New Kingdom (c. 1295-1069 BC)/Third Intermediate (c. 1069-664 BC) period (Wilson 2001, 2002, 2005), and possibly the Old Kingdom (c. 2686-2125 BC), though this level has not yet been excavated (Wilson 2002:5; 2005:2; 2006:107).

Despite the city's prominence as the capital of the 26th dynasty and the many accounts describing the city's palaces and temples by historians such as Herodotus and Strabo, no monuments exist at the site today, except for a few stone blocks visible on the surface. Thus, as a result of the current Egypt Exploration Society/Durham University mission at Saïs, the remains of the ancient site have been divided into two main areas: the Northern enclosure, an area about 750 meters to the northeast of the modern village of Sa el-Hagar, and the 'Great Pit' (Figure 3.9), the area directly north of the village (Wilson 2006: 97).

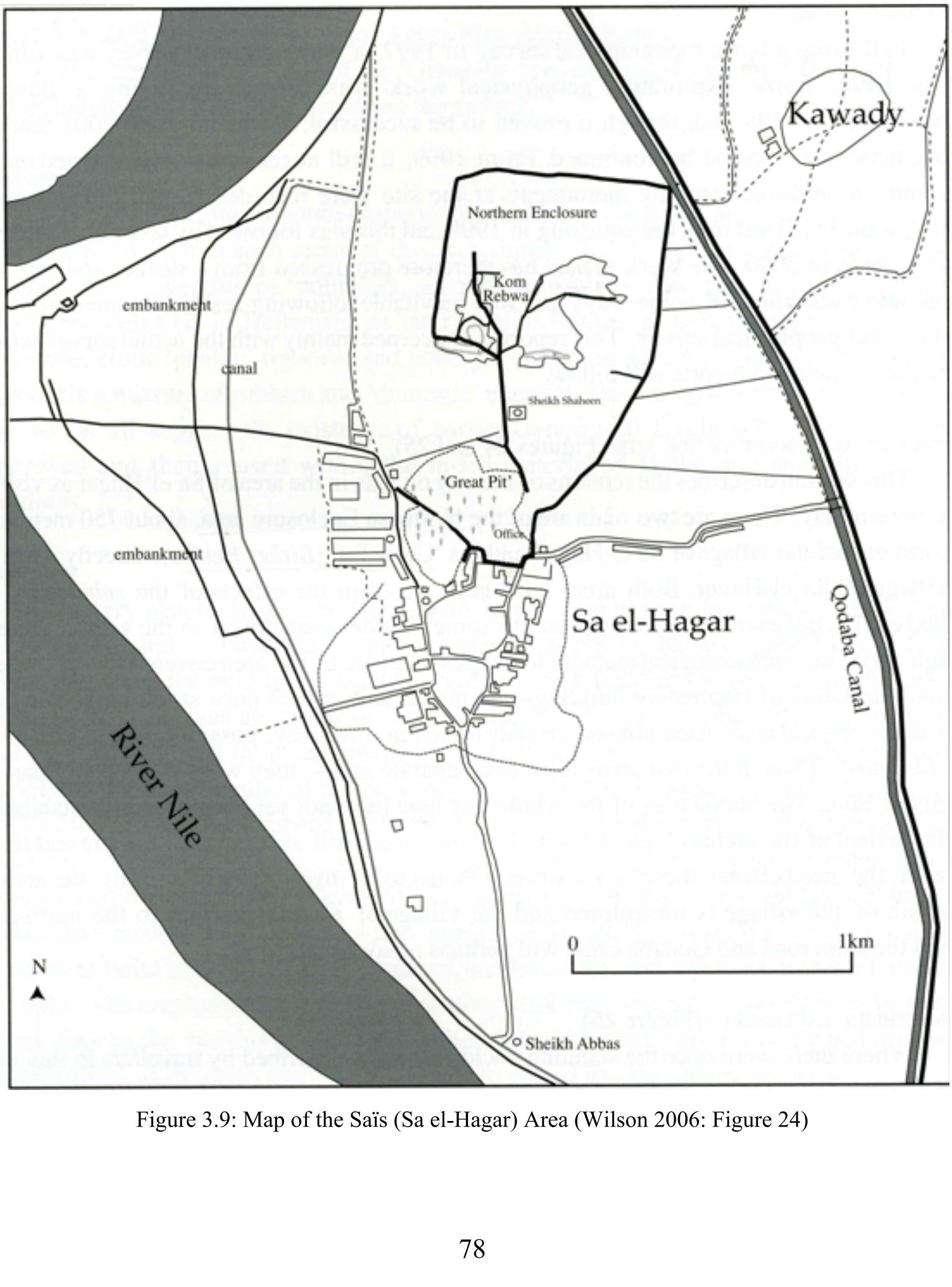

Figure 3.9: Map of the Saïs (Sa el-Hagar) Area (Wilson 2006: Figure 24)

Excavation History:

A complete description of all previous work at Saïs is provided in Penelope Wilson's 2006 publication on Saïs (2006: 87-96). So, as not to be completely repetitive, a brief listing of previous excavations at Saïs will be provided.

Auguste Mariette was the first archaeologist to work at Saïs between 1859-60. However, his excavation at the site does not seem to have been very profitable, as Saïs is not listed in any accounts on his work in the delta (Wilson 2006: 87). Between 1870 and 1930, a number of excavators worked at Saïs, mainly looking for bronzes, including Georges Daressy, who in 1901 worked in forty small trenches in the southwest corner of the 'Great Pit." Although not many objects were found during his excavations, he did note that the *kom* at Saïs had been dug away in the previous twenty years by the locals (Daressy 1901: 230-9 in Wilson 2006: 89-90).

Modern excavations at Saïs commenced from the 1930's by the Egyptian Antiquities Organization/Supreme Council of Antiquities with various trenches throughout the site (Wilson 2006: 91-96). The current Egypt Exploration Society/Durham University excavation began with a number of survey seasons from 1997-1999. Excavations began in 1999 and continue to the present, with work done in the two main archaeological zones of the Northern Enclosure and the 'Great Pit' (Wilson 2001: 1-8; 2002: 2-6; 2005: 1-8; 2006: 97- 150; 2006b 75- 126).

3.5.9 Zawiyet Umm el-Rakham (ZUR)

Location/ Site History:

ZUR is located 320 kilometers west of Alexandria (Figure 1.1) along the Mediterranean coast, and seems to have been founded during the reign of Ramses II (c. 1290-1224 BC). A costal fortress settlement located on the desert edge, ZUR would have had access both to the sea and freshwater from wells (Penelope Wilson, personal communication), and likely experienced similar amounts of rainfall to Marsa Matruh, which is reported to have about 160mm of rainfall/year (Hurst and Black 1943: 13).

It is possibly the largest and most westerly of the western fortified settlements serving as protection against possible Libyan raids (Snape 2001: 19). Although not much is known about the history of ZUR, the site was known as *Hut-Ka* (House of the Bull) during pharaonic times, and as *Apis* during the Graeco-Roman period as noted by several classical historians including Pliny the Elder and Strabo (White 1999: 141-2).

At this point there is no evidence to indicate that any fortifications protected Egypt's western borders before the time of Ramses II (Snape 2003: http://www.geocities.com/zurdig/Role_Frame.htm). However, like the forts of the second cataract in Nubia and in the North Sinai, it seems that the western forts were more than just military installations. They seem to have played a multi-faceted role, controlling all aspects of the territory, extending a range of socio-economic controls including possible trade contact with Libyans and merchants using the trade routes along the North African coast (Snape 2003: http://www.geocities.com/zurdig/ConclusionsFrame.htm). The main area of excavation is the fortress itself and the six areas inside it: the temple and chapels (Snape and Wilson 2007), the storage magazines, 'Libyan squatter camp', the southern building, the residential area, and the gateway/defensive wall (Snape 2003: http://www.geocities.com/zurdig/IntroFrame.htm).

Excavation History:

The site was first discovered by a local farmer in 1946 and was not fully inspected until 1949 by Labib Habachi (Snape and Wilson 2007: 1). Excavations began in 1953, followed by a four-week season focusing on the temple in 1954, and a short two seek season in 1955 (Snape and Wilson 2007: 3). However, a plan was not published until 1980 (Snape and Wilson 2007: 5). In 1991 the temple was re-cleared by the Egyptian Antiquities Organization (Snape and Wilson 2007: 5). The University of Liverpool commenced its fieldwork program in 1994 with an aim of re-clearing the rear part of the temple and to excavate its courtyard and the chapels immediately to the south. This work was done with the goal of producing a detailed plan of the temple and chapels (Snape and Wilson 2007: 6), with the last excavation season in 2001 (Snape 2003: http://www.geocities.com/zurdig/IntroFrame.htm).

3.5.10 Mendes

Location/Site History:

Mendes, the largest surviving city-mound in the delta lies about fifty-three miles south of the present day Mediterranean coastline and about twenty miles east of the Damietta branch of the Nile. The site would have also been located on a 'turtle back' set on the floodplain in a very marshy environment, also likely experiencing moderate amounts of rainfall as compared to modern estimates form the nearby city of Mansura which is reported to have about 55mm/ year (Hurst and Black 1943: 15). The overall site measures about 2 miles north to south and about 800-900 meters east to west. In antiquity Mendes almost certainly lay on a major branch of the river, connecting it to both the sea and the rest of Egypt via the Nile (Brewer and Wenke 1992: 193, Redford 2001: 376).

As early as the Naqada III period (c. 3200-3000 BC), a settlement existed at the site, although more recent excavations show evidence dating to the Naqada II period (c. 3500-3200 BC) and possibly even earlier (Matthew J. Adams, personal communication). The site remained important throughout the First Intermediate Period and Middle Kindgom based on the numerous textual references to the site (Redford 2001: 376).

The name Mendes is derived from its ancient name: *Pr-b3-nb-Ddt* or "House of the Ram, lord of the Abiding Place." Both the ram and fish goddess (*H3t-mhit*, "She who is preeminent among the fishes") were honored at the site, with the temple to the ram in the northern part of the town and the *H3t-mhit* cult center in the eastern side of the town overlooking the harbor (Figure 3.10) and Mendes branch of the Nile River (Redford 2001: 367).

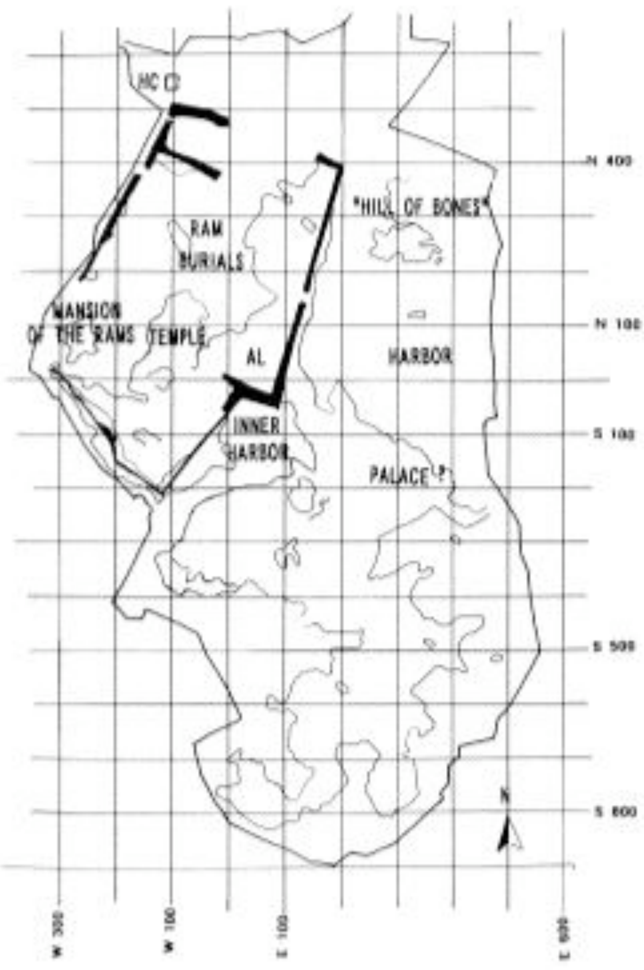

Figure 3.10: Map of Mendes (Redford 2004: Figure 1)

Excavation History:

Mendes was first visited be Auguste Mariette in 1867 (Redford 2001: 367) and was first excavated by Edouard Naville in 1892 (Naville 1894). The earliest controlled excavations at Mendes, however, were not until the 1960's with several campaigns in the north-west enclosure carried out by New York University between 1963-1980 under the direction of Bernard V. Bothmer and Donald Hansen (Bothmer et al. 1976, 1980). In 1990 Robert Wenke and Douglas Brewer from the universities of Washington and Illinois resumed excavations (Brewer and Wenke 1992), followed a team from the University of Toronto in 1991 under the direction of Donald Redford working in both the temple and royal necropolis (Redford 2001: 376, 2004). Redford's work at Mendes continues up through today, but is currently under the auspices of the Pennsylvania State University.

3.5.11 Tell el-Borg

Location/ Site History:

Tell el-Borg is situated approximately ten kilometers east- northeast of the modern town of Qantara Sharq in the north Sinai, and five kilometers southeast of the ancient site of Tell Hebua II (Hoffmeier 2004: 85). The site is a New Kingdom military fortress on Egypt's eastern frontier with Sinai, and was most likely one of the forts on the 'Ways of Horus', the ancient military road connecting Egypt with the Levant (Hoffmeier and El-Maksoud 2003: 169). The site has been tentatively identified as 'The Dwelling of the Lion" or *Sese* based on the *Payprus Anastasi I* and battle reliefs of King Seti I at Karnak (Hoffmeier and El-Maksoud 2003: 196-7). The *Papyrus Anastasi I* is a New Kingdom hieratic text, containing a satirical letter from one scribe to another and details the road across the Sinai Peninsula including twelve different place names (Gardiner 1920: 103). The battle reliefs of King Seti I occupy the exterior north wall of the great hypostyle hall at Karnak depicting the wars waged by him in the early part of his reign. There are a series of intermediate scenes that represent the road between Egypt and the Levant, now referred to as the 'Ways of Horus (Gardiner 1920: 99-100, Plates XI- XII).

Although the site is an entirely desert environment today, it is likely that the ancient environmental conditions were much wetter and greener, as the site would have been located just on the outskirts of the Nile delta (Figure 3.11) in a very marshy environment with access to water from the nearby Nile branch/ canal. In fact, in areas where there has been some recent land reclamation, when just a bit of water is added, greenery is seen to instantly sprout. Additionally, recent excavations have revealed an early, defunct branch of the Nile that cut through the site in the New Kingdom times, possibly serving as a natural defense to the temple and funerary areas, and emptied into a palaeo-lagoon about two-three kilometers to the east (Hoffmeier and El-Maksoud 2003: 195). This evidence all points to a much greener environment than that observed today.

Recent excavations have revealed the site to have three major features; first is the main tell area of the site, notable including fields II, III, and VI, and was the scene of heavy military activity by the Israeli and Egyptian armies in the 1960's and 1980's (Hoffmeier 2004: 86). Field II contained many limestone and pink granite fragments, suggesting there may have been one or more temples in the vicinity that were violently dismantled (Hoffmeier and El-Maksoud 2003: 184). Field III is a cemetery that contains many large mud-brick tombs (Hoffmeier 2004: 103-111). Field VI is the domestic area, made up of several reed huts (Hoffmeier 2004: 89-90). Although there is some question as to whether the occupants of this area were low ranking soldiers or transients (Hoffmeier 2004: 90-1), recent analysis of the faunal remains reveals a fairly large amount of pig remains from this area, thus supporting a likely permanent settlement of low-ranking soldiers (Bertini, In Press B). The other two areas of the site are Field IX, a low lying trough, which was the subject of geological investigations revealing the now defunct branch of the Nile (Hoffmeier 2004: 86) and fields IV, V, and VIII, the remains of the eighteenth and nineteenth-twentieth dynasty fortresses (Hoffmeier 2004: 87).

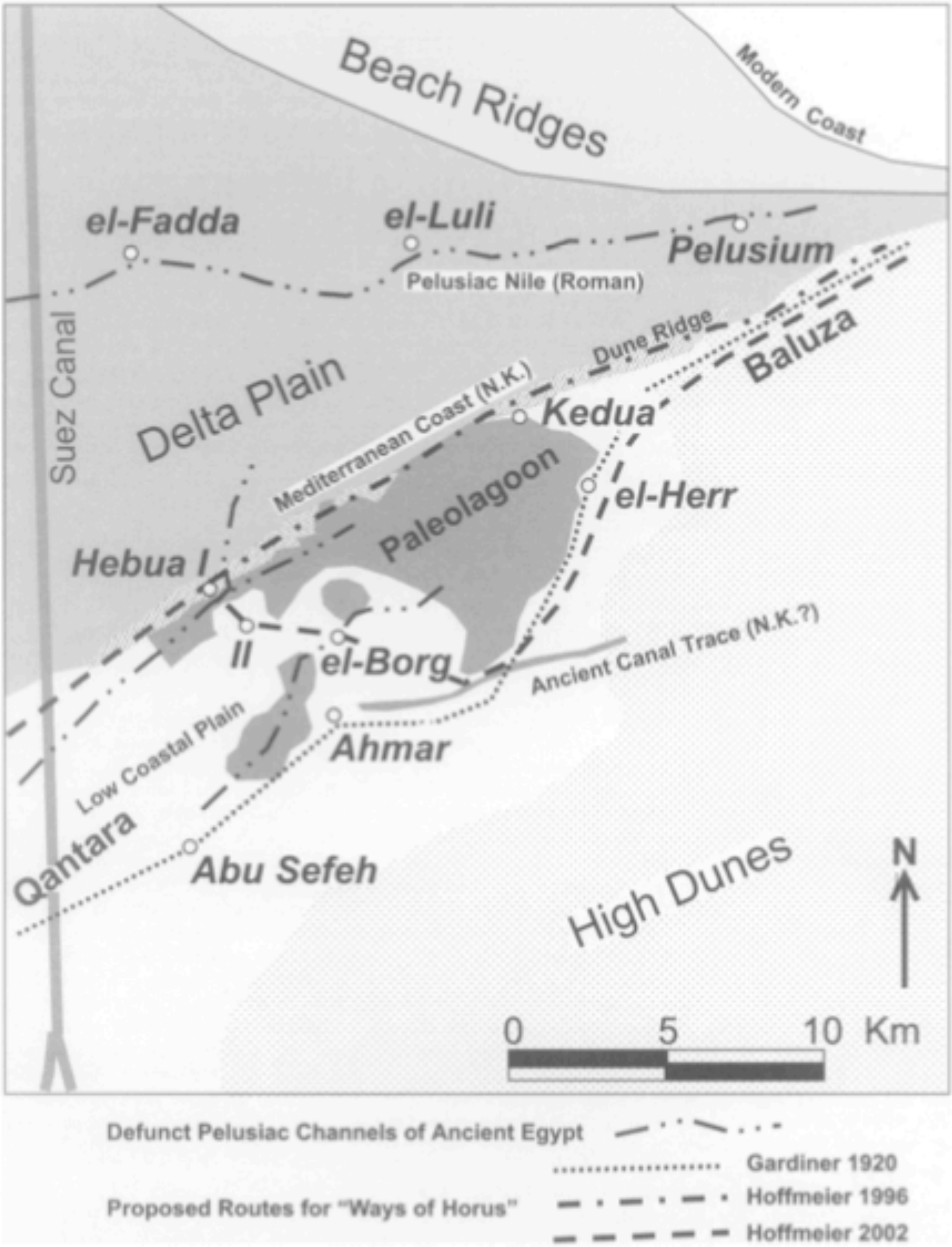

Figure 3.11: Map of Tell el-Borg and North Sinai (Hoffmeier and El-Maksoud 2003: Figure 1)

Excavation History:

There has not been much archaeological investigation in the north Sinai, largely due to the military activity from the 1940's through early 1980's (Hoffmeier and El-Maksoud 2003: 171). However, during the Israeli military occupation of the Sinai after the 1967 war, Eliezer Oren carried out a systematic archaeological survey of more than 150 New Kingdom sites between the Suez Canal and Gaza between 1972 and 1982 (Hoffmeier and El-Maksoud 2003: 171).

In 1994 the ‘East Frontier Canal’ survey commenced in the north Sinai under the direction of James Hoffmeier and Mohamed Abd el-Maksoud as a salvage project in response to the threat of the As-salam irrigation project (Hoffmeier and El-Maksoud 2003: 172). Two further visits were made to the region during the course of the survey in 1995 and in 1998. During the 1998 visit, members of the Supreme Council of Antiquities came across a New Kingdom site a few kilometers east of Qantara East, and about three kilometers north of the el-Arish road. This site they had found was Tell el-Borg (Hoffmeier and El-Maksoud 2003: 173-4). In 1999 the first survey of the site commenced under the direction of James Hoffmeier, with excavations beginning in 2000 (Hoffmeier and El-Maksoud 2003: 174). These excavations continued until 2007, with the most recent study season in May 2008.

3.5 Summary

The sites were selected based on the three criteria of settlement type, time period of occupation, and geographic location. It is not possible to say that all the Delta sites are similar to one another, as it topography varies from one location to another. This is especially so when compared to the sites from Upper Egypt, as they all come from different geographic locations, environments, and site contexts. After discussing all the sites in the last section, Table 3.2 provides a summary of all the sites, their site type, and environment type.

Site	Time Period	Site Type	Environment Type
Aswan	c. 664BC-AD 395	Settlement	Riverside
Elephantine	c.2686-2125 BC	Settlement	Riverside
Abydos Settlement Site	c.2160-2055 BC	Settlement	Floodplain
Abydos Middle Cemetery	c.2686-2125 BC	Cemetery	Desert Edge
South Abydos	c.1870-1831 BC	Settlement	Desert Edge
Amarna	c.1352-1336 BC	Settlement	Desert Edge
Giza	c.2686-2125 BC	Settlement	Desert Edge
Kom Firin	c.1550- 069 BC	Settlement/ Possible Fortress Settlement	Floodplain Edge
Kom el-Hisn	c.2686-2125 BC	Settlement	Floodplain Edge
Saïs	c. 1295-664 BC	Settlement	Floodplain
Mendes	c.2686-2125 BC	Settlement	Floodplain
ZUR	c.1550-1069 BC	Fortress Settlement	Costal Strip/ Desert Edge
Tell el-Borg	c.1550-1069 BC	FortressSettlement	Marshy land

Table 3.3: Total sites analyzed along with their site and environmental type.

Although most of the above sites are of settlements, they differ as some are state supported (such as Giza, and the Workmen's Village at Amarna) where as the rest are not. Instead the rest of the sites rely on the local herdsman who individually raised pigs and caprines. Where these settlement sites differ is in the variety of ecological niches that they represent and the stresses that each animal would experience as a result of the different environments.

Animals at riverside settlements such as Elephantine and Aswan have the potential to experience two different types of stresses that, coincidently, occur right about the same time. As these riverside sites are the most southern of all the collected data sets, the potential for stress as a result of the summer heat in June-August would be considerable. Furthermore, being located directly on the river, or in the case of Elephantine right in the middle of the river, the stress as a result of the annual flood occurring around July through September/October would be great as well. Moving further north to the Abydos sites, two different environments are encountered between the three different sites at this one location.

Compared to other Upper Egyptian sites, Abydos is located on the desert edge, and is a considerable distance away (about thirteen kilometers) from the Nile (Patch 1991: 100). Furthermore, Butzer (1976:108) proposes that in antiquity the Nile in the region of Asyut (about 125 kilometers north of Abydos) would have ran further east than its present course. Thus, it does not appear that the river came in contact with any part of the site located in the low desert, except possibly during inundation (Patch 1991: 77). Although it is possible that there could have been some stress as a result of the annual flood in July through September/October, other stresses that animals could have encountered at Abydos would also be the intense summer hear in July through August and possibly also some stress from winter (planting season) as a result of the dramatic decrease in temperatures (especially at night) and possible decrease in food resources as well.

Other desert edge settlements include Amarna and Giza. However, each of these two sites presents two different scenarios. First, although Amarna is located rather close the Nile and the floodplain, the Workmen's Village is located a considerable distance in the desert in an elevated region that was not likely affected by the annual inundation. Thus, the more likely stresses animals would experience here would be rather similar to Abydos, namely the intense summer heat in July through August and possibly temperature decreases in the winter along with a decrease in food resources at the same time. Giza, however, presents a slightly different situation as being a fully state supported site, it is possible that animals were reared elsewhere (possibly in the Delta) and brought into Giza when needed (Redding 1992). Thus, it becomes necessary to turn to the Delta environments.

As mentioned earlier, there are a variety of different environments that exist in the Delta. The four main groupings that material discussed in this thesis come from include: the floodplain, floodplain edge (possibly above the inundation level), costal strip, and marshland. Floodplain sites include Saïs and Mendes and would most likely encounter stress that would result from the annual inundation in August through October, as it is likely that the flood would reach the Delta as much as a month later than areas such as Aswan in Upper Egypt. It is possible that floodplain edge sites such as Kom Firin and Kom el-Hisn would experience stress from the annual inundation as well, although it is also possible that they may have been above the level of inundation (Baines and Malek 2002: 18). With respects to both these sites, it is possible that the both temperature and food decreases as a result of the winter could have an affect on the animals as well, and this is an issue that will be explored further in the coming chapters.

Costal strip sites such as Zawiyet Umm el-Rakham are likely to only experience stress from the dramatic temperature decreases in winter. Marsh land sites such as Tell el-Borg has the potential to have continued stress on animals throughout the year, although winter stress (both temperature and food decrease) is the more likely factor. Furthermore, marsh environments are ideal for pigs, so this issue as to if this particular environment had a negative effect on pigs will be looked at further in chapter 6.

The Abydos Middle Cemetery is the only non-settlement, and will provide a basis for comparison with settlement sites to indicate whether animals in cemetery (and perhaps temple contexts if a sample had been available) did indeed have different sizes and defect patterns. If such were the case, then there may then have been a different husbandry regime to normal domesticates and the issue will be explored in the following chapters.

4 The Pig in Ancient Egypt

Despite the confusion surrounding the pig from classical sources, notably Herodotus, along with the modern Islamic pig taboo, the pig was one of, if not the most commonly consumed animal by the vast majority of the ancient Egyptian population. Despite the lack of artistic and textual sources, it is one of the most commonly identified species in the faunal assemblage from most ancient Egyptian settlement sites.

This chapter will look at both the natural history of the pig (its taxonomy, domestication, social organization, shelter, reproduction, and diet) along with the various ancient sources (artistic, textual, and its physical remains from archaeological sites) will be used to create as broad of a picture as possible on the pig in ancient Egypt.

4.1 Natural History of the Egyptian Pig

4.1.1 Taxonomy and Distribution of the Pig throughout Egypt

*(*Order: *Artiodactyla* Family: *Suidae*)

Recent DNA studies have shown that the origins of Sus are located in the Islands of South East Asia (ISEA). Wild boar then spread into the Indian subcontinent and eventually as far west as North Africa/Western Europe and as far east as China/Japan (Larson *et al.* 2005; Larson *et al.* 2007; Giuffra *et al.* 2000; Kijas & Andersson 2001). Domestic pigs are all descended from one species, the wild boar, *Sus scrofa* (Clutton Brock 1987: 71)*,* which was originally found all over North Africa. There are about twenty-five subspecies of *Sus scrofa*. The *sennaarensis* subspecies are attributed to northeast Africa (Clutton Brock 1987: 71, Porter 1993: 205). There is the possibility of the *sennaarensis* subspecies occurring in Egypt, but since little is known about it, for the purposes of this study, all pig species will be identified as either *Sus scrofa* or its domesticated form, *Sus scrofa domesticus*. Wild boar were relatively common in the El Moghra Oasis, Wadi Natrun, Fayum, Nile Delta, and other parts of middle Egypt (Manlius and Gautier 1999: 573) until the early 1900's. Their extermination was brought about, starting in 1846, by a campaign organized by the Egyptian government to exterminate the wild boar. It is estimated that 860 boar were killed. The final extermination occurred in the Wadi Natrun in the early 1900's (Epstein 1971: 326). These original wild boar are possibly the precursors of the domestic pig in both ancient and modern Egypt. However, it is likely that the modern domestic pig populations are of mixed blood, and is a topic that will be returned to in the next chapter.

In the present day, domestic pigs are mostly confined to Coptic villages throughout Egypt, notably the Zabalin garbage collectors in Mokkatam, and various Coptic pig farms around Cairo and in the Delta and Middle Egypt, including El Bayadiya, a village about 14km north of the ancient site of Amarna. The estimated number of pigs in Egypt today range from 250,000- 400,000, although it is not known exactly how many have been slaughtered as a response to the recent swine flu (H1N1) outbreak in 2009 ("Egypt slaughters pigs to stop flu" http://news.bbc.co.uk/2/hi/middle_east/8024946.stm; "Culling the Innocent" http://weekly.ahram.org.eg/2009/948/eg7.htm).

4.1.2 Appearance

The modern wild boar (*Sus scrofa*) is a flat-sided shaggy pig with a long snout. It is relatively large, with leaf shaped ears and a short dorsal mane. The colours vary between dark grey-brown, and a dirty tawny colour (Kingdom 1997: 329; Porter 1993: 205) (Figure 4.1).

Figure 4.1: Image of a wild boar (Sus scrofa) (http://www.poica.org/editor/case_studies/wild_boar.jpg)

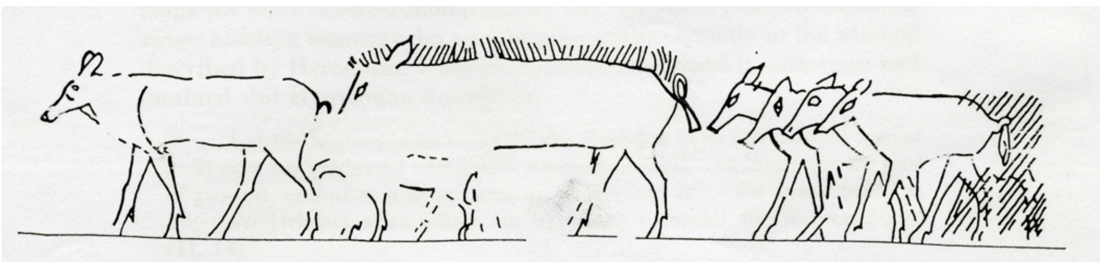

Figure 4.2: "Marsh animals" swine form tomb of Khety at Beni Hassan (Darby *el al.* 1977: Figure 4.7)

Although it is difficult to establish the appearance of pigs from the archaeological remains, there are some confirmed representations of domestic pigs from the New Kingdom Theban tombs of Amenemhet (TT123) and Nebamun (TT145) as well as some small figurines dating to the Predynastic/Early Dynastic Period (c. 4000-3000 BC) (Darby *et al.* 1977: 180; Newberry 1928: 211). In them, the ancient Egyptian pig is similarly seen to be a high-legged, ridge backed animal, fat but with a slender snout, and dark, bristly skin (Shaw 1984: 49). These representations bear some resemblance to the slightly earlier image of pigs from the Middle Kingdom tomb of Khety at Beni Hassan (Figure 4.2), although it is possible that this image may in fact be of wild boar and not domestic pigs

4.1.3 Domestication of the Egyptian Pig

Quoted by Price (1984: 3): domestication is defined as the "process by which a population of animals becomes adapted to man and the captive environment by some combination of genetic changes occurring over generations, and environmentally induced developmental events reoccurring during each generation." It is difficult, however, to pinpoint a definition of domestication that is "general enough to account for the wide variation observed in different species, in different environments, yet specific enough to be meaningful in terms of the biological processes involved (Price 1984: 3)."

As mentioned above, domestic pigs are the descendants of a sub species-group of wild boar, *Sus scrofa*, which have a wide range of distribution from Europe to East Asia (Zeuner 1936: 256; Clutton Brock 1987: 71). For quite some time, pigs were thought to have been domesticated in the Near East and were brought into Europe (Childe 1958: 34), and even Egypt (Porter 1993: 205; Germond and Livet 2001: 62; Lobban 1998: 137, Manlius and Gautier 1999: 574). This view, with regards to ancient Egyptian material, is partly supported by the fact that the earliest known Near Eastern archaeological evidence for 'domestic' pigs comes from the sites of Jarmo (Perkins 1973: 280; Clutton Brock 1987: 72; Brothwell 1969: 41), Çayönü Tepesi (Ervynck *et al.* 2001; Dobney *et al.* 2007), Hallan Çemi (Redding and Rosenberg 1998a,b; Redding 2005), and Gürcütepe (Peters *et al.* 2005) and span from roughly the 9th to 7th millennium BP (Larson *et al.* 2007: 30). Like cattle, the domestic pig has not been found in Egypt at sites dating to earlier than the Neolithic revolution (Zeuner 1936: 259).

The criteria for differentiating wild boar verses domestic pigs in archaeological assemblages was established during the end of the nineteenth century based on the analysis of faunal assemblages from various European stone age sites (Albarella et al. 2006). Concluding that two different forms of pigs were present in these assemblages, the Danish zooarchaeologist Herluf Winge used both metrical and morphological criteria to separate these two groups into wild boar and the domestic pig. The criteria that he established are still used today. For example, if the lower third molar is greater than 40mm in length it probably belongs to a wild animal, whereas those under 40 mm in length are more likely to be domestic, although there is some overlap (Winge 1900). Other criteria such as the use of the size index scaling technique (Meadow 1999) in which different measurements can be combined using a log transformation allows for a larger sample size to be created in order to more directly compare a population to a standard value of either modern and/or archaeological standards (Payne and Bull 1988; Albarella and Payne 2002). This can be used to differentiate between different populations, and will be applied to the Egyptian material in the next chapter.

Other ways in which one can differentiate wild boar from the domestic pig is through DNA testing. Although work has been carried out on samples from Europe and East Asia (Larson *et al.* 2007; Larson *et al.* 2005; Kijas and Andersson 2001; Giuffra *et al.* 2000), no Egyptian samples have ever been taken in order to establish whether the ancient Egyptian pigs have any genetic link to the earlier domestic and wild forms from the Near East. Perhaps future work can be carried out to clarify this issue, but it is beyond the scope of the present work.

Other easier to use markers used to differentiate between wild and domestic pigs can include geographic markers, i.e. locations where it is unlikely that pigs would have reached without the help of humans (Albarella *et al.* 2006: 211), as well as age profiles, expecting younger, selected populations to be domestic and older populations to be wild (Albarella *et al.* 2006: 217). A problem in archaeological assemblages arises when wild populations are extensively hunted. This would likely result in a larger number younger individuals present, giving a quasi-domestic mortality curve. This, however, is likely to be a pattern showing populations of pigs on the verge of domestication (Albarella *et al.* 2006: 217).

Known 'domestic' pigs do not appear in ancient Egyptian material until c.5000 BC at the Lower Egyptian site of Merimde Benisalame on the western Delta edge (Bosessneck 1988: 76; Houlihan 1996:12) and possibly at Saïs (Bertini, Linseele, and Ikram, In Preparation), thus adding to the belief that pigs were domesticated in south-west Asia. New research (Albarella *et al.* 2006, Dobney *et al.* 2007, Larson *et al.* 2005, 2007), however, indicates that there may be more than one domestication zone including mainland Europe, East Asia, India, Italy, and South-east Asia, in addition to the Near East, which could also include Egypt.

Albarella *et al*. (2006: 209) notes that unlike sheep and goats, whose geographically limited distribution area restricts the search for the origins of their domestication to a small region, pigs are spread over much more of the Old World, encompassing all the very cold tundra and dry desert regions. Because of this large distribution area from North Africa extending all the way across China, it is possible that, in addition to the early domestication of pigs in south-west Asia, they might have been domesticated elsewhere at the same time. It is possible that pigs, as scavengers, were attracted to human settlements, and perhaps either began to scavenge through the human organic refuse, or to accept food from humans, who in time began to confine pigs (Dawson 1998: 7). The pigs' living conditions obviously changed, and thus it is likely that the animal would show a physiological impact from both dietary changes and confinement. This is where LEH is useful as it can serve as a record of the stresses that the pig experienced. In a recent publication on the transition of wild boar to domestic pig in Eurasia (Dobney et al. 2007), it is demonstrated that all Neolithic assemblages (including those from Europe, China, Japan, and the Near East) tend to show LEH index values that are higher than those of wild boar except when the archaeological data are compared with those of recent populations of south-west Asian boar, which show a surprisingly high frequency of LEH. The reason for this result remains unclear (Dobney et al. 2007: 73). It is demonstrated that having a high LEH frequency can possibly be another way to signify a domesticated pig in addition to morphology, body part/size, age structure, and sex ratios (Redding 1998: 66). Significantly, Dobney's article notes the presence of a data set from the site, Zengpiyan in China, dating from c.10550 to 5600 BC, that shows early evidence of pig domestication, roughly current with (or possibly earlier) than Jarmo, (c.7600-6400 BC) and Çayönü Tepesi (c. 10200- 7500 BC) (Dobney *et al*. 2007: 67). The Zengpiyan data shows a high frequency of LEH, although one should remember that there are some uncertainties about the dating and stratigraphy of the site. This may indicate either a wild boar population with very high levels of physiological stress or a very early domestic pig population or perhaps both (Dobney et al. 2007: 77). If there had been some 'local' domestication in China, then the data adds to the likelihood that there was more than one area of domestication.

Returning to Egypt, some sources note that pigs may not have entered Egypt from south-west Asia via the Sinai, but were rather domesticated from the wild forms already in Egypt (Reed 1966; Houlihan 1996: 25; Brewer *et al.* 1994: 94). This evidence partly comes from the ancient wild boar remains that have been found in excavations in the Fayum (Lobban 1998: 138, Hassan 1984: 59-62; Diener *et al.* 1978: 498; Clutton Brock 1982: 73), however, possible finding of wild boar remains from the Fayum may be incorrect. The bones from the Caton-Thompson excavations have been lost, and recent excavations have yielded no wild boar remains (Veerle Linseele, personal communication). This theory of indigenous domestications is also supported by the basic biological needs of the pig. The pig is thermodynamically ill adapted to the hot, dry climate of deserts (Harris 1974: 42), particularly those of the Near East, including the Sahara and the Negev/Sinai. It can die if exposed to direct sunlight and air temperatures over 98F/36C. Since pigs have an inefficient system for regulating their body temperature, and an inability to sweat, they have to dampen their skin with external moisture, and prefer to do this by wallowing in mud (Harris 1974: 42).

Taking into consideration how a pig's body reacts under high temperatures, it is highly unlikely that any pigs were brought from Asia into Egypt, or that wild forms migrated into Egypt at this time. It would have been too hot on the land crossing through Sinai and they would have died. However, if they entered Egypt during the Holocene wet phase (c. 5500 BC and maybe earlier) then the environment would not have been as dry and harsh and it would have been possible for them to enter Egypt. Most probably, from the wide distribution of wild boar, and the ideal environment of the Nile Valley for boar to flourish in, Egypt may have been another zone of domestication, though most likely occurring at a later time as compared to south-west Asia and China. A conclusion may never be reached on this unless DNA samples of both ancient and modern material can be processed. But, taking geography into consideration, and the difficulty of moving pigs across the Sinai, it is highly possible that there was indigenous domestication of pigs within Egypt .

4.1.4 Social Organization

Modern wild boars are highly social, contact animals, which live within a series of fixed points: resting area with a nest, drinking area, wallow, and rubbing area (Estes 1991: 212). The family unit usually consists of the sow with her litter, which remains close until the next litter is born (Estes 1991: 212; Haltenorth and Diller 1980: 31). Males usually are on guard nearby, asserting dominance by their size, and marking trees with their tusk and tusk gland secretions (Estes 1991: 212).

When considering the pig material from ancient Egypt, there are three lines of evidence that can lead to some answers on the social organization of pigs in antiquity: artistic depictions of pigs (though limited), zooarchaeological analysis including information on morphology, body part/size, age structure, and sex ratios (Redding 1998: 66), along with modern ethnographic evidence.

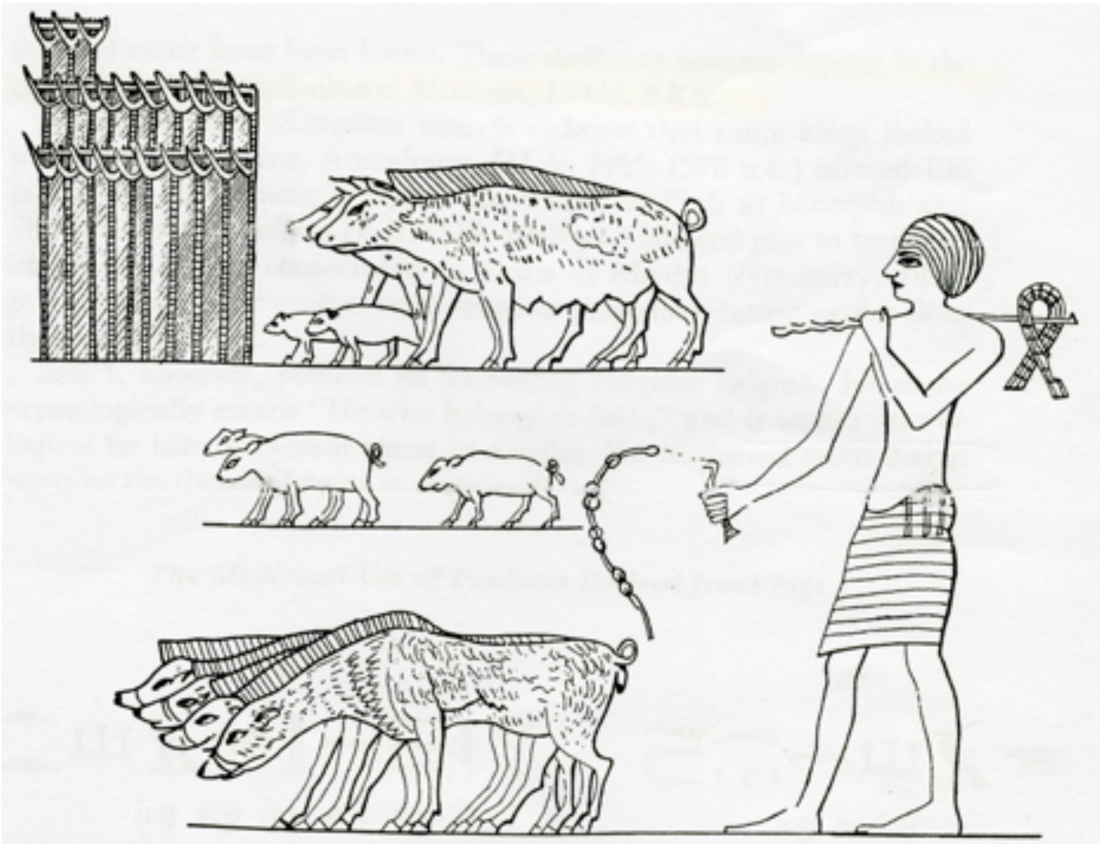

Figure 4.3: Swine assisting farmer from Tomb of Ineni at Thebes (Darby *el al.* 1977: Figure 4.9)

Beginning with artistic lines of evidence (though this will discussed in greater detail later), there are a few representations of confirmed domestic swine. Piglets can be seen with the sow in representations from the tomb of Ineni (Theban Tomb #81;

Porter and Moss I: 160) (Figure 4.3) and in the tomb of Nebamun (Theban Tomb #145; Porter and Moss I: 257), although the relief is badly damaged. These pictures show the social unit of the sow with her litter. Though males are seemingly absent, this may be representative of the practice of killing the males once they reach reproductive maturity, only keeping a few for breeding (Hecker 1984: 158). Because males then become a minority in number compared to females and piglets, this may account for why they are not shown, or possibly because a fertile sow and her offspring were more valued by the ancient Egyptian tomb owner throughout eternity (Salima Ikram, personal communication).

Looking at archaeological evidence, information can be obtained about the social organization through zooarchaeological analysis, most notably from information on mortality profiles and sex estimations. Taking the site of Amarna as an example, it was concluded that there are two distinct age groups in the pig remains from the Workmen's Village (Hecker 1984: 157-8). One group is between 2 and 8 months old at death and the other between 14 and 24 months old at death. Hecker concludes that the 14 and 24 month age group primarily represents females, and the other group males. This would mean that females were slaughtered just after reaching their reproductive maturity, while males were slaughtered just before their reproductive maturity. At the age of reproductive maturity the pigs would become too difficult to manage because of their size (Hecker 1984: 158). The practice, therefore, illustrates a predetermined social organization that is the product of domestication.

Finally, from observing modern pig populations in Egypt, similar practices are seen. In the village of El Bayadiya, sows are seen with their piglets roaming throughout the village. The piglets always follow the sow, who is quite protective of her young. Typically there is at least one male who is selected only for breeding proposes. The majority of piglets (both male and female) are killed at a young age (about six to ten months), similar to the ancient practices at Amarna (Hecker 1984: 157-158).

4.1.5 Shelter and Comfort

Shelter and comfort are two issues that are linked together when dealing with pigs, especially considering the pig's biological constraints regarding heat. As noted previously, wild boar will build nests for their litter, with a wallow nearby. They will also have an area for scratching and rubbing themselves on objects after wallowing, enabling them to groom parts of their bodies they otherwise cannot reach (Estes 1991: 212). It is also noted (Harris 1974: 42-3; Diener *et al.* 1978: 496) that pigs can die in temperatures over 98F/36C unless they have access to mud wallows to counter their inability to sweat. Such issues have to be taken into consideration for the successful survival and breeding of domestic pigs. It is possible, though, that the pigs of both ancient and modern Egypt were and are better able to adapt to higher temperatures, since temperatures in Cairo over the summer can reach over 100F/38C. In fact, modern wild pigs in southwestern Iran thrive in summer daytime temperatures over 120F/47C (Redding 1991: 23). Although the Nile Delta and Fayum Oasis may have been the ideal zone for maintaining pigs, remains are found further south at sites such as Amarna, Elephantine, and possibly even further south, as long as the animals had access to wallows and shelter. In ancient Egypt, there is evidence for two types of swine management: free-range (Miller 1990: 126) and pens (Shaw 1984, Kemp 1991: 256).

Pigs in tropical zones are usually left to roam as they will, acting as scavengers, often eat human refuse (Redding 1991: 23). This is most likely how pigs were used in ancient Egypt, and is a practice still seen today in the village of El Bayadiya and, latterly, with the Zabalin in Cairo (Haynes and Hakim 1979: 103). There are actually many advantages to this management strategy choice of free-ranging. Pigs typically have more space to roam around and behave naturally in addition to reducing many health related problems associated with their keepers, animal welfare concerns, and environmental issues caused by dust, waste, noise, and odour. Furthermore, raising pigs outdoors using pasture can reduce the cost of setting up pens and decreases the disease burden of pigs (McCosker 2010: 9).

The problem with sites in hotter climates is the difficulty of providing pigs with good locations to graze and wallow in order to withstand the high temperatures. Pens provide an obvious solution, and there is at the moment only one known example of multiple pigsties at the Workmen's Village at Amarna (Shaw 1984: 47-55; Bowmann 1986: 34-49; Hulin 1986: 50-59; Bowmann 1987: 47-55; Heodorn 1987: 56-69; Kemp 1991: 265).

As the Workmen's Village is a south-facing site with no natural shade, particularly exposed to the sun and to the hot summer winds from the south, it is essential to construct shelters for the pigs to ensure survival (Shaw 1984: 49-50).

A number of pens were excavated in the 1980's (Shaw 1984: 47-55; Bomann 1986: 34-49; Hulin 1986: 50-59; Bomann 1987: 47-55; Heodorn 1987: 56-69); some with semi-circular walls measuring 1.6 by 1.7 meters. One particular group of pens labeled Building 400 (Shaw 1984) consists of five (possibly six) basic components with small doorways and often with multiple wooden poles set across the threshold. The floors were covered with a brown organic layer, rich in grain husks, and containing many coprolites. Some units even contained stone troughs, suitable for food or water (Shaw 1984: 47). These sties were compared with a detailed description of Roman pigpens from c. 36 BCE.

"Each sow should have her separate sty in which to feed her pigs; because she does not drive pigs of a strange litter, and so it they become mixed she deteriorates in breed… The sty should be constructed about three feet high and a little more than that across, at such a height from the found that if the sow when pregnant should try to jump out, she will not abort her young. The height of the pen should be such that the swineherd can easily look around it, to prevent little pigs from being crushed by the mother, and be able to clean the bottom without trouble. The sty should have a door with the lower sill one and three feet high, so that the pigs can not jump over it when the mother leaves the sty (Varro 1934: 359- 361)."

From this description and its similarities to the Workmen's Village sties, in addition to the coprolite specimens collected that have been identified as belonging to pig (Shaw 1984: 48-9, 58-9), the excavators concluded that the buildings in the Workmen's Village were pigpens. Although the Workmen's Village pigpens are the only known example at this time, there is the distinct possibility that other ancient Egyptian examples might have been found. In fact, there were mudbrick pens excavated at the Old Kingdom western delta site of Kom el-Hisn, although it is not known at this point what species were kept in them (Richard Redding, personal communication). However, since the majority of ancient Egyptian settlements were in the river region or delta and not in the desert, most pigs were probably free-range and not penned, providing an inexpensive resource that an individual family could rear to supplement other sources of protein (Redding 1991: 28).

4.1.6 Reproduction

The farrowing season of modern wild boar and domestic pigs can be late winter and early spring (or summer in the case of Egyptian seasonality), according to the regional climate (Haltenorth and Diller 1980: 31; Redding 1991: 22). The gestation period is roughly between 112-175 days (Haltenorth and Diller 1980: 31; Estes 1991: 213). A wild boar can typically bear four to five piglets, and a domestic pig (Haltenorth and Diller 1980: 31; Estes 1991: 213; Diener et al 1978: 498) can bear up to fourteen piglets. Females may conceive at 18-20 months (Estes 1991: 213) of age. It is because of this short period of reaching reproductive maturity, and the number of piglets in a litter, that pigs are such an effective source of meat.

In Egypt it was considered that, like Europe, there were birthing seasons in March and October (Redding 1991: 22); thus birth occurred twice a year (Brewer 1994: 95). Modern domestic pigs are known have five litters every two years (Haynes and Hakim 1979: 104). Births in both March and October have also been confirmed in interviews conducted by the author with pork butchers in Cairo (Mr. Magdy, personal communication) and by swine herders in the Coptic village of El-Bayadiya.

In all the modern Egyptian pigs, each litter produces roughly eight to twelve piglets (Miller 1990: 132; Haynes and Hakim 1979: 104; Mr. Magdy, Shobra Pork storeowner, personal communication, 2008). The modern breeds, however, are seemingly a mixture of Egyptian and American pigs (Mr. Magdy, Shobra Pork storeowner, personal communication, 2008). In El Bayadiya, the more primitive Egyptian breed produces roughly five to eight piglets in each litter (Pig owners in the village of El-Bayadiya, personal communication), more likely (based on their appearance, although DNA tests will be needed to confirm) comparable to ancient Egyptian pigs (Mr. Magdy, Shobra Pork storeowner, personal communication, 2008). These pigs are free range during the day, returning to the pens at night under the escort of their keeper. They are slaughtered between six to ten months of age.

4.1.7 Diet

Although pigs are omnivorous, they do not have a high demand for protein and carbohydrates (Miller 1990: 128). Their best weight gain comes from food with low cellulose: nuts, fruits, tubers, grass, plants, roots, berries, and most importantly, grains (Harris 1974: 41-2; Haltenorth and Diller 1980: 30), which puts it in direct competition with humans (Harris 1974: 42, Redding 1991: 22; Perkins 1973: 280).

Though pigs can also eat organic refuse matter, they rarely consume human waste (Haynes and Hakim 1979: 103; Harris 1974: 36; Miller 1990: 129). It is this omnivorous scavenging that has made the pig an important component of the mutually beneficial relationship between pigs and humans for over 8,000 years

(Miller 1990: 129), yet surprisingly it is one of the reasons that makes them taboo in the Islamic and Jewish religions.

4.2 Ancient Egyptian Sources on the Pig

It has long been the position of Islam and Judaism that the pig was abhorred, and not to be eaten. With reference to ancient Egypt, it is possible that the pig was also abhorred by certain religious groups at particular times and was also regarded as a lower status meat (Ikram 1995: 31-32) and the theory has been supported by a small quantity of artistic representations, and even fewer textual references to swine (Ikram 1995: 32). The negative association with the Egyptian god, Set (Faulkner 1985: Chapter 112), further supports the negative view of the pig. When looking at the faunal remains from archaeological contexts, however, it appears that pigs played a very important part of the diet throughout ancient Egyptian history (Ikram 1995: 211). Before addressing this question and relating it to known swine husbandry practices, it is important to discuss the artistic (Ikram 1995: 305, Table IV) and textual references to swine, and the insights they provide in understanding swine management practices.

4.2.1 Artistic Representations

From the Old Kingdom, there is only one representation possibly showing a pig (Figure 4.4), in the sixth dynasty tomb of Kagemni (Porter and Moss III: 521-525) at Saqqara. This relief, however, is somewhat controversial because some scholars describe the animal as that of a 'young dog' and not a pig. Some argue that it is definitely a pig (Hecker 1982: 60) based on the form of the snout and tail and even go so far as to say that the ancient Egyptians were known to drink the pig's milk and force feed piglets by mouth to mouth contact (Lobban 1994: 66). Others (Firth & Gunn 1926 vol.1: 114; Darby *et al.* 1977:184) doubt that this is a pig, but rather is a dog. Personal observation reveals that the snout and tail does resemble a pig, but the clear presence of claws instead of hoofs, in addition to the presence of a dog represented in the scene above, tends to support the fact that it is a dog, despite there being no inscription. A firm conclusion, however, may never be reached.

Figure 4.4: "Pig" kissing scene from the tomb of Kagemni at Saqqara (Personal Photo)

There is also one known relief from the Middle Kingdom that represents what most have concluded to be ambiguous marsh animals, possibly wild boar (Darby *et al.* 1977: 185; Dawson 1928: 598) from the tomb of Khety (Porter and Moss IV: 154-159; Newberry and Griffith 1983) (Figure 4.2) at Beni Hasan. Despite the vague representation of the feet of these animals, and the earlier inconclusiveness as to these animals' identification, the more recent agreement is that these animals are in fact pigs, although whether they are domestic or not is open to interpretation (Hecker 1982: 60). There are a few more scenes from the New Kingdom at El-Kab in the tombs of Paheri (Porter and Moss V: 177-181; Tylor and Griffith 1984) and Renni (Porter and Moss V: 183-184; Tylor 1900). These scenes are considered to be the earliest representation of domestic swine in an agricultural scene, depicting them being driven over fields of newly sown grain, treading on it under the care of a herdsman (Newberry 1928: 212; Darby *et al.* 1977: 186). There are also scenes in the Theban tombs of Amenemhat (Figure 4.5) (Porter and Moss I: 236-7 [TT 123]), Nemamun (Porter and Moss I: 41, 257, 258 [TT 124, 145, 146]), and Ineni (Figure 4.3) (Porter and Moss I: 159-163 [TT 81]). The scenes from the tombs of Amenemhat and Nebamun (TT145 and TT146) show pigs in agricultural scenes being depicted as high legged, ridge backed, and fat, but with a slender snout and dark, bristly skin

(Shaw 1984: 49). These characteristics show similarities to a small selection of pigs still in Egypt today that also seem to have the same dark hair with a bristling back. Two scenes, one from the tomb of Ineni and one from the tomb of Nebamun (Theban Tomb #124), are of special note because they show swine being driven over fields of newly sown corn to tread on it (Newberry 1928: 212). These representations exactly depict the method described by Herodotus (Newberry 1928: 212; Darby *et al.* 1977: 187):

… "*thereupon each man sows his field and sends swine into it to tread down the seed, and waits for the harvest; he then makes the swine to thresh his grain, and so garners it* (Herodotus II: 14)."

Other representations showing pigs, albeit in a religious setting, come from the tomb of Horemheb (KV 57), the burial sarcophagus of Seti I, tomb of Ramses VI (KV9) and the tombs of all the kings of the nineteenth dynasty. These all depict the Judgement Scene from the *Book of Gates*. This scene depicts a pig, representing Set, being driven along/away by a baboon, which represents the god Thoth (Darby *et al.* 1977: 175). This negative view of the pig as Set, brings up the second line of evidence: textual references.

Figure 4.5: Swine assisting the farmer. Tomb of Amanemhat (TT# 123) at Thebes (Darby et al. 1977: Figure 4.10)

4.2.2 *Textual References*

There are very few textual references to the pig, and a scant quantity of these support its abhorrence (Hecker 1982: 59). The main line of reasoning from Egyptian sources for this conclusion, as mentioned before, comes from its association with the god, Set (Book of the Dead 112:125). There are classical sources that also support this conclusion of abhorrence, including Plutarch (1970: 223) and Herodotus who states:

"… Swine are held by the Egyptians to be unclean beasts. Firstly if an Egyptian touch a hog in passing by, he goes to the river and dips himself in it, clothed as he is; and secondly swine herds, native born Egyptians though they be, are alone of all men forbidden to enter any Egyptian temple; nor will any give a swine herd his daughter in marriage, not take a wife from their women; but swine herds intermarry among themselves… (Herodotus II: 47)*"*

Of the Egyptian textual references that do exist, there seem to be three different categories of texts in which the pig is mentioned: offering/possession lists, medical texts, and magic/mythology texts.

Offering and possession lists do not provide much information on the pig or its management, but do give a small idea as to their quantity. The earliest mention of the domestic pig comes from the biography of Meten (Sethe 1906: 3) who held important administrative posts in Lower Egypt during the Third Dynasty (Newberry 1928: 211). The text says that on the death of his father, Meten was given his property, including "people and small cattle", with cattle actually being asses and pigs according to their determinatives (Newberry 1928: 211). Pigs are also included in an inventory list of Thutinekht's possessions in *The Eloquent Peasant* (Simpson 2003: 44) along with other desired farm products, indicating wealth. This suggests that rearing pigs did not cause a loss of status (Hecker 1982: 60; Darby *et al.* 1977: 185):

"his Upper Egyptian corn [wheat], his barley, [his] asses, [his] swine, his small cattle…".

Other offering lists that contain references to pigs include: the Abydos decree of Seti I at Nauri (Griffith 1927), stating that the pig was bred in the temple at Abydos (Newberry 1928: 211) and the tomb of Renni, the mayor of El-Kâb (Sethe 1906 Urkunden IV 75,1.15) stating that he possessed 1500 pigs. There is also an account from the royal scribe of Amenhotep III that the property given by the king to the temple of Ptah at Memphis included 1000 pigs and 1000 young pigs (Petrie 1909: Memphis V Pl. 1XXX, 1.24; Newberry 1928: 211). The stela of Menthuweser, dating to c. 1950 BC (Williams 1913: 18), gives the only instance of the title "Overseer of Swine" that has been found in Egypt (Newberry 1928: 211).

Considering Herodotus' account of pigs in Egypt and the paucity of textual and artistic references, it is possible to reach the conclusion that pigs were less economically important as compared to ovicaprids and cattle. However from the evidence mentioned above, there is nothing to suggest that pigs were not eaten, swineherds were segregated, or that anyone was given the specific task of only looking after swine (Dawson 1928: 607). Thus, it is possible that Egyptians not serving in temples did not regard swine with any negative view but rather enjoyed its meat upon occasion (Salim Ikram, personal communication).

The second category of texts, the medical documents, do not seem to provide a negative view of the pig either. There are examples of medical texts that mention certain parts of a pig in prescriptions, including (Dawson 1928: 600): the brain, eyes, teeth/tusk, liver, gall bladder, fat, grease, blood and even dung. There is one prescription from the Hearst Medical Papyrus (Chapter 16: lines 4-6) "against the bite of a pig", which is possibly the only negative textual reference. Given this wide variety for medicinal uses of the pig, it is doubtful that Herodotus' statements are correct, as then they most likely would not be used at all.

Magic/mythology texts are the third category of documents, in which the only negative references to pigs occur. This negative view of the pig from its association with the god, Set, is not seen until the Middle Kingdom. Its first appearance is in the Coffin Texts:

"And Re said: 'Look again at yonder black pig'. And Horus looked at this black pig, and Horus cried out because of the condition of his injured Eye, saying: 'Behold, my eye is like that first wound which Seth inflicted on my Eye', and Horus became unconscious in his presence. And Re said; 'Put him on his bed until he is well' It so happened that Seth had transformed himself into a pig and had projected a wound into his Eye. And Re said; 'The pig is detestable to Horus'. Would that he were well, said the gods. That is how the detestation of the pig came about for Horus's (sake) by the gods who are in suite." (Faulkner 1973: 153)

This theme is further reiterated in the New Kingdom funerary text, the Book of the Dead:

"...Now the black pig was Suti (Set) who had transformed himself into a black pig, and be it was who had aimed the blow of fire which was in the eye of Horus then Ra said unto those gods, the pig is an abominable thing unto Horus; O but he shall do well although the pig is an abomination unto him. Then the company of the gods, who were among the divine followers of Horus when he existed in the form of his own child, said, 'Let sacrifices be made [to the gods] of his bulls, and of his goats, and of his pigs (Faulkner 1985: Chapter 112)."

There are a number of debates surrounding the origin of the link between Set and the pig, including questionable translations of the actual word 'pig', or even the possibility that the pig is the Set animal (Simoons 1994: 17). Ultimately, the origin of the link between Set and the pig is, at this point, unknown. Griffiths does state that an early tie between Set and the pig is doubtful, and convincing evidence is lacking for such a tie even in the Old Kingdom (Griffiths 1960: 31-33). Going back further in prehistory, the origins of the Horus-Set myth are seemingly unknown (te Velde 1967: 79) and even the existence of Set and the Set animal is a matter of controversy (te Velde 1967: 7-12; Hornung 1982: 103; Griffiths 1980: 122). Of note, there are other animals that can be associated with Set and appear in representations in tombs such as the donkey and the hippo, so it may just be one of a band of 'select' disruptive animals and potentially dangerous ones which are part of the universe beyond normal human/divine control (te Velde 1967: 13; Penelope Wilson, personal communication).

Although we may never know the origins of this one known negative portrayal of the pig from ancient Egyptian sources, nor the exact reason for lack of reference to them in artistic and textual sources, examination of pig remains from excavated settlement sites reveal a rather different picture, showing the pig as one of the most, if not the most commonly managed and consumed animal throughout dynastic Egypt. This can possibly be explained by the fact that pig rearing in ancient Egypt was maintained by individuals to supplement other sources of animal protein (Redding 1991: 23). If individuals raised pigs, this might also explain why the pig is so under-represented in tomb and temple scenes.

4.2.3 Archaeological Sources in Egypt

Although pigs seem to be occasionally consumed by the royal family — at least during the New Kingdom, since their remains have been found in royal palace dumps at both Malkata (Ikram 1995: 213) and Amarna (Payne 2005, 2006) — they are far more common at settlements sites. From the analysis of pig remains (Table 4.1), it does appear that pigs are an important part of the ancient Egyptian diet beginning as early as the Neolithic and Buto/Maadi period (c.5000-3500 BC) because of pig bones found at sites such as Merimde Benisalame, Fayum, Ma'adi, and El-Omari, and most recently discovered at Saïs.

Site	Period	Number of Pig Elements	% Pig	Source
Merimde-Benisalame	Neolithic	6568	41%	Von den Driesch & Boessneck 1985
Saïs	Neolithic	353	54%	Bertini, Linseele, and Ikram, In Preparation
Hierakonpolis	Predynastic	66	7%	Mc Ardle 1992
Ma'adi	Predynastic	21045	15%	Boessneck et al.1989
		38	21%	Hecker 1982
Kom el-Hisn	Old Kingdom	397	51%	Wenke & Redding 1989
Giza	Old Kingdom	17	1%	Kokabi 1980
		536	3%	Redding 2007
Tell el-Dab'a	13th dynasty	63	5%	Boessneck 1976
Amarna (Workmen's Village)	New Kingdom	302	47.3%	Hecker 1982
El-Hibeh	New Kingdom	6	7%	Redding 1984
Kom Firin	New Kingdom	950	47.9%	Bertini, In Press
Tell el-Borg	New Kingdom	43	5%	Bertini, In Press
		107	8.7%	Loyet, In Press
ZUR	New Kingdom	2	0.5%	Bertini & Ikram, in Preparation
Saïs	TIP	271	39.3%	Bertini and Linseele, In Press
Malkata	New Kingdom	74	9.5%	Ikram 1995
Saïs	26th Dynasty	5	7%	Bertini, In Preparation

Table 4.1: Percentages calculated based on total number of identified species

Egyptian late Neolithic and Predynastic villages were self-sufficient, with pigs and sheep being the dominant domestic animals (Redding 1991: 25) although there are a few sites, notably in the delta that have a very small percentage of sheep in comparison to that of pigs, notably Saïs (Bertini, Linseele, and Ikram, In Preparation) and Mendes (Brian Hesse, personal communication) in the Neolithic/Predynastic levels. Pigs served as a source of protein, and sheep provided both wool and milk, in addition to some meat.

This pattern seems to continue throughout the Old Kingdom. However, with an increasing demand for grain, a shift in animal husbandry occurred, resulting in a greater need for cattle in order to plough, transport, and thresh grain. Cattle also had other advantages such as they require less labor to control and maintain, they provide more milk per unit of labor, and cattle dung is a superior fuel for cooking and heating (Redding 1991: 24). As the status of cattle grew in importance, so did that of goats, because goats made use of plants in waste areas while sheep competed with cattle for food (Redding 1991:24). Thus, as agricultural intensification lead to an increase in the use of cattle, it also resulted in a decrease in pigs, since pigs were in competition with humans for grain and, possibly, space as well (Redding 1991:25).

This theory is tenable since there seems to be a decline in pig use in the Middle Kingdom. However, this apparent decline could simply be due to the lack of excavated Middle Kingdom settlement sites with the only published faunal data coming from the town of *Wah-Sut* at Abydos, a town associated with the maintenance of the funerary cult of Senwosret III (Rossel 2007: 166). New Kingdom sites, however, reveal a different pattern, with pig remains making up the largest percentage of identified mammal remains seen at sites such as Amarna (Hecker 1982), Kom Firin (Bertini, In Press), and at Sais New Kingdom levels (Bertini, Linseele, and Ikram, In Preparation). Exceptions are only at a few sites, typically ones with military/border defense purposes such as Tell el-Borg and Zawiyet Umm el-Rakham (Bertini and Ikram, In Preparation). These exceptions are likely due to either the environmental conditions of these sites or the site provisioning at the time, which most likely did not include the pig as a valuable resource due to its lack of secondary products (Bertini, In Press B).

Pig rearing in ancient Egypt did not yield a surplus that could be manipulated by the state. Rather pigs were maintained by individuals, and therefore presumably exempt from taxation (Redding 1991: 23). This is most likely due to the fact that pigs are both easier to raise and reproduce more rapidly than cattle, the higher status animal that was more commonly consumed by the elite and were more suitable for large scale feeding. Compared to sheep and goats, pigs have huge advantages, namely in growth rates and meat weight:

"Over a lifetime a pig can convert 35% of the energy in its feed to meat compared with 13% for sheep and a mere 6.5% for cattle. A piglet can gain a pound for every three to five pounds it eats, while a calf needs to eat ten pounds to gain one. A cow needs nine months to drop a single calf, and under modern conditions, a calf needs another four months to reach four hundred pounds. But less than four months after insemination, a single sow can give birth to eight or more piglets, each of which after six months can weigh over four hundred pounds (Harris 1985: 67)."

If pigs were indeed raised by individuals for food, predictions on pig survivorship and sex ratios can be made. Firstly, adult remains would rarely be found. Secondly, young would be killed and consumed just after weaning, but before they began to consume food that would put them in competition with humans or adult breeding pigs, i.e. between three to six months (Redding 1991: 23). As for sex ratios, one male pig can serve up to fifty females, thus adult remains should almost exclusively be female (Redding 1991: 23).

This does seem to be the case at most ancient Egyptian sites such as Amarna where 43.3% (N=39) of pigs were killed before nine months, 13.4% (N=12) survived beyond their second year, and only a few survived beyond their third year. This data seems to show a preferred slaughter age between two to nine months and fourteen to twenty-four months (Hecker 1984: 157-58), seemingly supporting the idea that males were killed just before or as they reached reproductive maturity, while females would be killed after they reached their reproductive age. This pattern is also seen at sites like Kom el-Hisn, where the majority of pig remains fall between one and two years of age (Redding 1991: 25), at Merimde Benisalame where 47% of the remains were under the age of six months (von den Driesch and Boessneck 1985: 25), Hierakonpolis where the majority of Predynasitc pigs were also slaughtered either shortly before or after reaching adult body size (McArdle 1992: 55), and at both Kom Firin and Tell el-Borg where the majority of pig remains are between twelve to eighteen months (Bertini, In Press A,B).

From the collected data thus far, Redding's (1991:28) conclusions on the role of the pig in ancient Egypt as a locally maintained, inexpensive resource of protein supplement, seems to be correct. He further notes that a major factor in the shift away from the pig in the Middle East is due to agricultural intensification, as they compete with humans for food and agricultural space.

4.2.4 *Consumption Fluctuations of Pork Throughout Dynastic Egypt*

After the unification of Upper and Lower Egypt, Darby *et al*. (1977: 173) note that evidence of pork consumption in Lower Egypt nearly disappeared, demonstrating an assimilation by the northerners of their southern conquerors traditions.

In an attempt to confirm this statement from the very limited number of reports on faunal remains from both upper and lower Egypt during the Early Dynastic period, only the Lower Egyptian site of Mendes shows possible evidence for a decline in pork consumption. This evidence, however, dates to a slightly later period, the Old Kingdom (Brian Hesse, personal communication).

Preliminary analysis from the excavated area dating to Naqada III (c.3200 BC) to Dynasty 6 (c.2180 BC) at Mendes shows a large number of pig remains, especially from the contexts that have been dated to the period between Naqada III and Dynasty 3 (c. 2640 BC). However, a sharp drop in the amount of identified pig remains does seem to occur in the period between Dynasty 4 (c. 2600 BC) and 6 (Brian Hesse, Personal Communication), a period slightly later than that described by Darby *et al.* (1977). It is difficult to explain why this drop occurred at Mendes during this time, particularly since other sites in both Upper and Lower Egypt do not exhibit this decrease in identified pig remains. On the other hand, this may simply be due to the sample or the area excavated. Two other Old Kingdom sites that show different yet complementary patterns in the amount of identified mammal remains are that of Giza and Kom el-Hisn.

It has been thoroughly demonstrated that during the Old Kingdom, the central government had created a provisioning system to feed the builders of the pyramids by raising animals —particularly cattle, sheep, and goats — at regional centers outside Giza (Redding 1991, 1992, 2007, Wenke *et al.* 1988). This was done because it was not possible to rear sheep, goats, and cattle within the inadequate space near Giza and to support the large herds of animals that would have been needed to support the builders (Redding 2007). Thus, animals were most likely raised in grassy areas with easy access to water, like the environs of the Nile Delta, for which Kom el- Hisn proves to be the best-known example (Redding 1991, 1992, 2007, Wenke et al. 1988). At this point, 536 pig fragments have been identified out of over 175,000 animal bone fragments that have been studied so far (Redding 2007) from the Giza Workmen's Village. However, at Kom el-Hisn, there is an abundance of pig remains (NISP= 728) (Redding 1992: 102), making up over 51% of the identified mammals for the entire site. This could support the suggestion that pig was a lower status animal (Ikram 1995: 31-2), and thus was consumed at small sites and the poorer areas of the large state centers/ high status sites. However, if this was the case, then one could assume that swine would not have been consumed at Kom el-Hisn either, since this was a site that was provisioning the high status site of Giza. Thus an alternative explanation is needed.

Returning to the fact that other animals were not reared at Giza due to a lack of space, the same would have been true for pigs. Another problem is that pigs would have been inadequate for provisioning any large-scale workforce in the ancient world, as they cannot be herded and do not travel well over long distances. Additionally, since the only evidence for secondary resources that pigs provided in ancient Egypt is fat from medical texts (Dawson 1928: 601; Ebers 82/14**)** they were likely less valuable when compared to cattle, sheep, or goats, which provide essential secondary resources such as milk and wool (Redding 2007). It is possible that the pig hides could have been rendered, although evidence about this is weak (Salima Ikram, personal communication).

Because of the pig's unsuitability for feeding workers on a large scale, in addition to the fact that they did not yield any secondary resources, the Egyptian workforce administrators did not want to have them kept as stock. Simply put, they did not fit into the economic provisioning system of Giza. Thus, they were not involved in the inter-regional exchange in the same way that cattle, sheep, and goats were (Redding 2007). Pig remains, however, were still identified, signalling that although the central administration did not consider them a valued provisioning resource, individuals must have reared them as an additional source of protein.

In the Middle Kingdom, a period of increased agriculture and irrigation intensification particularly in the Fayum oasis may have caused the drainage of the pig's habitats, transforming it into areas of cultivation (Lobban 1994: 70; Callender 2000: 164). Combined with the beginning of a religious association of pigs with the god Set, the factors might explain a possible Middle Kingdom decline in pig rearing (Redding 1991: 21), although there is at least one representation of pigs at Beni Hassan in Khety tomb 17 (Ikram 1995: Table IV). At this point, however, there is little physical evidence for a decline in pigs (Darby *et al.* 1977: 175), as only one report on recovered animal remains from a Middle Kingdom site has been published to date, that of the town of *Wah-Sut*. A fairly large number of pig remains can be found (N=360) throughout the entire site (Rossel 2007: 163). Renewed study and possible excavation of Middle Kingdom sites are needed in order to reach further conclusions, although personal observations at Kahun did reveal some pig remains on the surface at the site, so it can be assumed that there will be more if excavation and the subsequent faunal analysis takes place. If, however, there was a decrease in pork consumption during the Middle Kingdom, it had ended by the New Kingdom, when pig remains tend to make up the largest percentage of identified mammal remains (Table 4.1).

Despite the accounts by ancient observers (Herodotus, Plutarch etc.) that were most likely observations made in one area or later realizations based on much earlier religious codes from Egyptian texts (Darby *et al.* 1977: 204), and the lack or artistic representations, and its association with Set, archaeological evidence does confirm that the pig was present and was consumed in ancient Egypt (Ikram 1995: 33). Having confirmed this presence and in large numbers, the chapter now turns to how the pig was raised in ancient Egypt and the various physiological stresses it encountered.

4.3 Conclusions

Having looked at both the natural history and the ancient Egytpian sources on the pig, given the Nile valley as a ideal environment for pigs to exist in, and given the fact that wild boar were native to Egypt, it is possible that Egypt may have been another zone of indigenous pig domestication. Furthermore, in areas of extreme environmental conditions, such as the site of Amarna, alternative pig rearing regimes such as penning are known to have taken place.

The fact that there are very few textual references to pigs, and even fewer artistic representations is probably due to the fact that pigs were a low status animal (Ikram 1995: 31-32) that were locally maintained by villagers as an inexpensive, additional source of protein (Redding 1991: 28). Nonetheless, it is known that some royal and administrative centres such as Malkata and Giza had pigs present, albeit in small numbers (Ikram 1995: 208; Redding 2007: 264). Furthermore, since there is minimal evidence for any secondary resources from pigs that could be taxed or controlled by the state, this may account for their low status and the lack of artistic/ textual references.

In order to examine better how the pigs that were consumed throughout Egyptian dynastic history were managed, encountered physiological stresses they encountered and the possible presence of wild boar in the archaeological samples, the study will now turn to the data collected from eleven different arcaheological sites in addition to one modern pig sample. Chapter 5 will address the age distribution and size range of the pigs and Chapter 6 will look at the presence and frequency of linear enamel hypoplasia (LEH) on their teeth.

5 Age and Biometrical data of Modern and Archaeological Egyptian Suids

This chapter will examine two data sets of pig remains for both their age of death and biometry. The first is a collection of modern pigs collected by the author from the environs of Cairo, Egypt, This sample was analyzed to act as a control group and to create a more appropriate standard to which the ancient Egyptian archaeological material can be compared. The second data set consists of evidence collected from eleven archaeological sites throughout Egypt spanning the time period from the Old Kingdom (c. 2686-2125 BC) through the Ptolemaic-Roman (c. 332 BC-AD 395) period.

5.1 Introduction

It has been established that measurements of animal bones from archaeological sites can be an extremely valuable tool for the distinction of taxa, morphological types, sexes and also age groups (Albarella and Payne 2005; Albarella 2002; Boessneck and von den Driesch 1978). Although biometry works best in zooarchaeology when there is a large sample size to ensure statistical reliability, in the case of ancient Egyptian material it is not always possible, due in part to the preservation of faunal material (or teeth in the case of this paper), but more importantly due to the amount of excavated material. As previously mentioned, faunal material from ancient Egyptian archaeological sites has only recently begun to be saved and studied. The sites from which material has been recovered often represent only a few excavated trenches, resulting in a total faunal assemblage number of individual specimens (NISP) of no more than 10,000. Delta sites, in particular, are a challenge due to the very high water table that poses a problem for both the preservation of faunal material and the actual amount of the site than can be excavated before reaching the water-table. The few exceptions in this study that are large sample sizes come from sites that have been continuously excavated for well over twenty years (such as Amarna and Abydos) and whose excavations kept the faunal remains, sites that were large state supported centres (such as the Giza Workmen's Village), or sites that were continuously occupied for long periods of time throughout ancient Egyptian history (such as Elephantine and Aswan), thus providing large samples from the amount of settlement debris built up over time.

Although there are a few large samples of ancient Egyptian faunal material, biometrical studies on any animal species are rare. As a result of these problems, there is a complete lack of pig biometrical data in Egyptian archaeology. This thesis hopes to contribute to the discussion through the analysis of pig teeth remains, the measurements of which will be discussed in this chapter. This thesis will also discuss the age distributions of all archaeological remains, which can be important for analysis animal use patterns as well as the presence of enamel hypoplasia that will be discussed in the next section.

From the eleven sites where pig data has been collected, most of the samples of individual measurements are too small to provide significant results. Thus, the pig width measurements from all eleven sites in this thesis are analyzed using the size index scaling technique (Meadow 1999), which relates the measurements to standard measurements of a sample of Neolithic domestic pigs from Durrington Walls, United Kingdom (Albarella and Payne 2005), a very green environment that experiences varied temperatures along with wet, windy conditions. The pig measurements are also compared with a second set of standard measurements of Turkish wild boar (Payne and Bull 1988) from the central Anatolian plateau region, which, unlike the United Kingdom, is a semi-arid region receiving little annual rainfall. The last is a set of measurements from the Egyptian modern pig sample. The relative size of each of the eleven site's measurements in comparison to the Durrington Walls standard is calculated as the decimal logarithm of the ratio between the measurement and its standard (Simpson, Roe, and Lewontin 2003: 89-95).

As stated by Albarella and Payne (2005: 392), this method allows different measurements to be compared directly, in which the distribution of the archaeological measurements are shown in relation to the "0" line provided by the Durrington Walls standard. The only problem with this type of analysis is that by combining different types of measurements there is some loss in resolution. However, the great advantage is that it allows for larger samples to be dealt with, and also enables a direct comparison of teeth data from many different sites (Meadow 1999: 285; Albarella 2002: 52; Albarella *et al*. 2006: 195.)

The sites discussed in this section include almost all the sites previously mentioned in Chapter 3, with the exception of the Abydos Middle Cemetery and Zawiyet Umm el-Rakham, as no pig teeth were present in either of these two samples.

As the central focus of this thesis is to investigate the changes in husbandry practices throughout dynastic Egypt, the sites discussed in this section are arranged based on their time period of occupation, with four groupings: Old Kingdom (c. 2686-2125 BC), First Intermediate Period/Middle Kingdom (c. 2160-1650 BC), New Kingdom/Early Third Intermediate Period (c. 1550-664 BC), and Ptolemaic/Roman (c. 332 BC- AD 300) in addition to the modern data collected.

5.2 Modern Egyptian Domestic Pigs

All archaeological data in this thesis is compared with three different standards. The first two, as previously mentioned, are the modern Turkish wild boar (Payne and Bull 1988) and the Neolithic domestic pigs from Durrington Walls, UK (Albarella and Payne 2005). Although these two standards are commonly used by zooarcaheologists, there was a need to establish a standard that may be more relevant to ancient Egyptian material. Thus, a sample of domestic pigs was collected in order to establish a modern Egyptian standard along with proving a control group with a known life history to which the archaeological material will be compared. This sample consists of nineteen domestic pig mandibles, collected from the Shobra Pork store in Cairo on March 25, 2008. The pigs were raised on a private farm outside Mohandessein, Cairo and fed a diet primarily of potatoes, tomatoes, and other various grains and vegetables (Mr. Magdy, Shobra Pork Store owner, personal communication). An attempt was made to collect more modern pig mandibles, however, there are only a small number of pigs in Egypt, and these are mostly confined to Cairo. Following the 2009 pig cull, the collection of more pig samples proved to be very difficult.

As mentioned in the previous chapter the wild pig, *Sus scrofa* were a native species to Egypt, but were completely exterminated in the early 1900's (Epstein 1971: 326). The modern domestic pig currently in Egypt — or the population present before the 2009 pig cull — is a mixed breed of the Egyptian domesticate with European and American breeds (Mr. Magdy, Shobra Pork Store owner, Personal Communication). To confirm this, four hair samples were taken in 2007 from pigs at the same location where this sample was collected to look at its mitochondrial DNA. Three of the hair samples possessed standard European haplotypes, however, the fourth had a standard East Asian haplotype, which can often be present in Europe and the United States since many breeds are hybrids between European and Asian domestic pigs. Since only mitochondrial DNA was looked at, the rest of the genome could well be Egyptian derived, however efforts to type those markers have failed so far (Greger Larson and Keith Dobney, Personal Communication). Thus, more modern samples are needed for further analysis.

5.3 Results

5.3.1 Age and Sex of Modern and Archaeological Egyptian Pigs

Key Points

Most pigs seem to have been slaughtered at a subadult age range (about one and a half years), with an average mandibular wear score (MWS) peaking at 25.

Sexing was only possible on the modern material with an almost equal distribution between males and females.

General Results

Figure 5.1 is a comparison of all the age distributions of both modern and archaeological pig mandibles following Grant (1982) plotted as a running mean based on the number of mandibles that were able to have a MWS calculated (see Appendix 2). All the sites seem to display a normal distribution, peaking at an average MWS of 25, about one and a half years (Hambleton 1997, 1999; Halstead 1985).

The author was able to establish the sex for the modern sample only. This was based on information from the pork storeowner (Mr. Magdy, Personal Communication) and was confirmed on the basis of the canine teeth and their alveolar sockets (Harcourt 1971). The conclusion drawn from the material was that nine females and ten males are present in the assemblage, giving an almost equal percentage of both sexes in the population (as seen in Appendix 2).

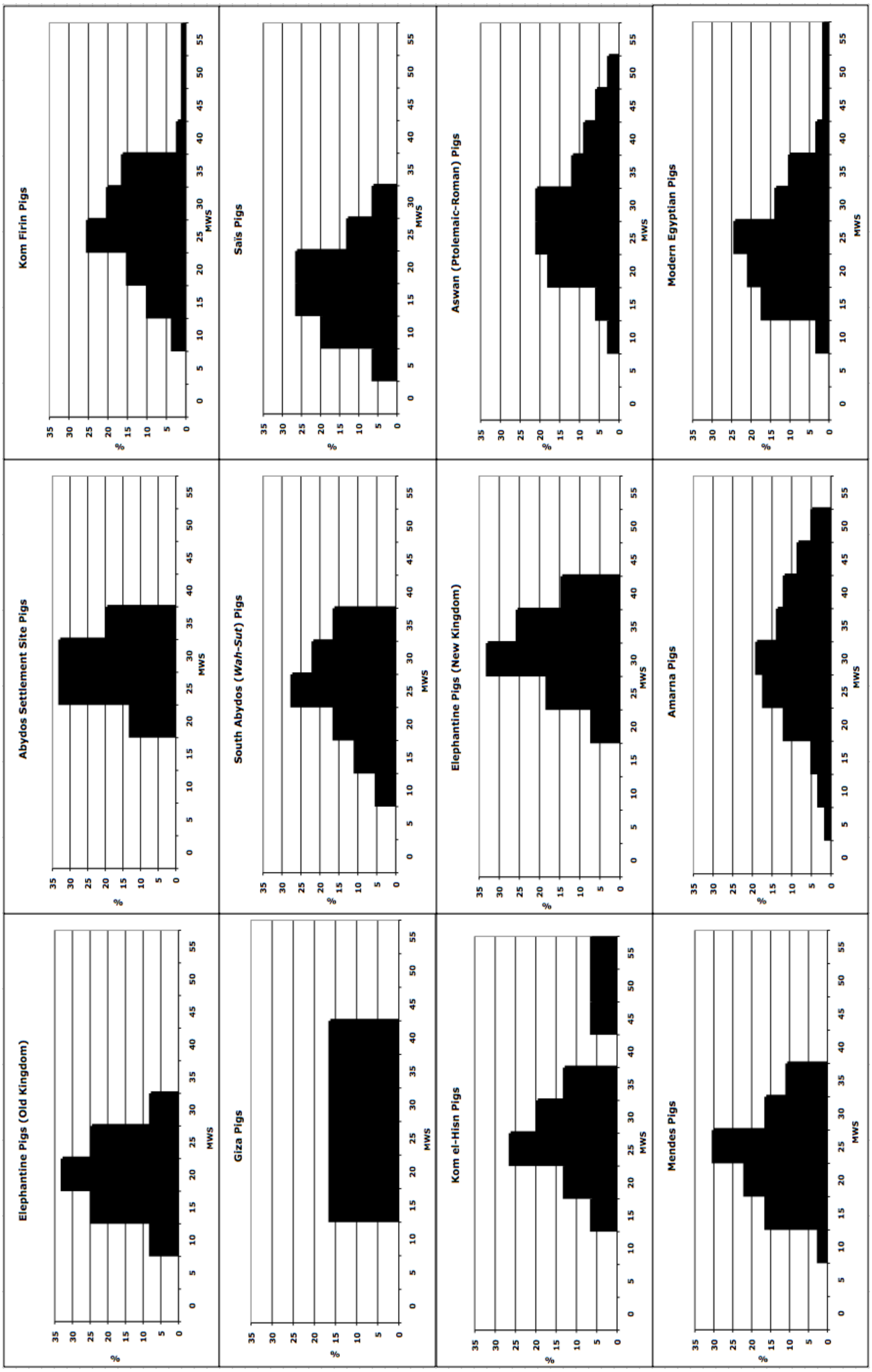

Figure 5.1: Comparison of age distributions for all archaeological and modern pig populations

5.3.2 Size of the Modern and Archaeological Egyptian Pigs

<u>Key Points</u>

When simultaneously compared, there are significant differences between the size of the width measurements of the pig of the modern and archaeological pig samples ($P \leq 0.0001$, Chi Square test).

Most of the pig samples from the sites have a broad distribution in tooth size (based on tooth width), although they still seem to indicate a single, probably domestic population. There are, however, a few sites that seem to have some likely wild specimens present in the sample.

There is a shift in size of pigs between the Old Kingdom and the Middle Kingdom, with the Middle Kingdom (and subsequent time periods) being slightly larger than the domestic Neolithic Durrington Walls standard, while the earlier Old Kingdom pigs are smaller.

<u>General Results</u>

Table 5.1 provides summary statistics for measurements of the first, second, and third molars (posterior width for the first and second molar and the anterior width for the third molar- see Figure 5.3 a-c) from all thirteen pig samples. Just as there are a varied number of teeth from each site, the mean, standard deviation, and coefficient of variation (*V*) varies significantly between each pig sample. The *V*, a direct comparison of the dispersion and variability of different values (Simpson, Roe, and Lewontin 2003: 89) is of especial note as it suggests that a number of pig samples have more than one population present, possibly including wild boar.

Figure 5.2 shows the width measurements combining all tooth types (M1, 2, and 3) for each of the thirteen pig sample, in addition to a breakdown of the three different areas at Amarna from which pig remains were collected using the size index scaling technique (Meadow 1999) as discussed in section 5.1. The combination of different tooth types and measurements through log transformation allows for a larger sample size to be created in order to compare more directly a population to a standard value (the Durrington Walls, modern Turkish wild boar, and modern Egyptian standard). The chosen measurements (posterior width of first and second molar, and anterior width of third molar) were selected, as these are the dental measurements that are least variable and are also less affected by age/occlusal wear and sex.

As indicated by the P-value, there are significant differences between the sample sizes, indicating the presence of more than one pig population, possible including wild boar. This is confirmed by the *V* as seen in table 5.1, where sites that have a *V* greater than 6 likely indicate the presence of more then one population (likely including wild boar). Sites whose values are less than 6 indicate a single, domestic population.

There is also an overall trend overtime (Old Kingdom through Middle Kingdom and continuing through the Ptolemaic-Roman periods) is a decrease in size as compared to the domestic Neolithic Durrington Walls standard. All ancient site populations were considerably smaller than the modern Turkish wild boar standard, while slightly larger than the modern Egyptian standard.

Specific Site Patterns

This section will briefly describe the size distribution patterns (based on tooth width) of the archaeological pig assemblages. It will make use of the *V* (see Table 5.1) to look at the presence of more than one pig population, and compare the sample sizes to the established width standards from Durrington Walls and the modern Turkish wild boar as seen in Figure 5.2. Sites with either very high *V* or large sample sizes to ensure statistical variability also had histograms created of the individual M1, 2, and 3 width measurements constructed to show what the raw data looks like and are seen in Figures 5.3a-c. Their results are discussed here and are organized by time period and site.

Elephantine (Old Kingdom)

Angela von den Driesch and Joris Peeters have carried out continuous work on the faunal assemblage from Elephantine since the 1970's (Angel von den Driesch, Personal Communication). Due to the vast amount of faunal material it is re-buried after analysis. Thus, teeth were only available for study from the past three seasons of excavation at the site. A total of five pig mandibles were examined, which consisted of seven teeth from which width measurements were taken. These mandibles all date to Old Kingdom levels of the 2nd-3rd dynasties (c. 2890-2637 BC) (Dietrich Raue, Personal Communication). Although this is a very small sample (more pig teeth were looked at dating to the New Kingdom levels), a normal distribution is observed is observed, with a slight shift to the left, indicating that the pigs are slightly smaller than the Durrington Walls standard. Although this might indicate smaller, fully domestic pigs, looking at the *V* (Table 5.1), one population is seen in the m1 (*V*=6.74). However, the m2 displays the highest recorded *V* of 20.01. Although this would support two different populations, given the fact that this *V* represents a total of three teeth, the *V* may not necessarily be indicative of the entire population simply due to the small sample size.

Giza

Continuous work has also been carried out on the faunal assemblage from the Giza Workmen's Village by Richard Redding (2007; 2010) since the Giza Plateau Mapping Project began excavations on the plateau in 1988. Similar to the case at Elephantine, due to the vast amount of excavated faunal material at the site, after analysis the remains are re-buried. Thus, the pig tooth material that was available for study came only from the 'Buttress Building' in the Giza Workmen's Village dating to the 4^{th} dynasty (c. 2613- 2492 BC) (See Figure 3.6) Excavated in 2006, the 'Buttress Building' is a large double wall enclosure in the northwest corner of what turned out to be a large royal administrative building and storehouse (Lehner 2002).

A total of five pig mandibles, consisting of fourteen teeth had their width measurements taken (mean= 0.008), which also displays a tight, normal distribution indicating one population. This is also supported by a very small *V* for all three teeth from Giza- 5.49 (m1), 5.88 (m2), and 2.28 (m3) indicating one population of domestic pigs.

Kom el-Hisn

Work on the Kom el-Hisn faunal assemblage was conducted by Richard Redding (1992, In Press; Wenke *et al.* 1988) based on the three seasons of excavation that took place in the 1980's. A large amount of the faunal assemblage has been lost since the time of excavation. However, a portion of the faunal material was available for study, courtesy of the University of Michigan Museum of Anthropology. This comes from the floors and garbage deposits associated with the 5^{th} and 6^{th} dynasty (c. 2494- 2818 BC) residential structures (Redding 1992: 101).

A total of thirty-two teeth from eleven mandibles had their measurements taken. Like the Giza sample, the Kom el-Hisn sample also appear to represent a single domestic pig population as indicated by the small *V* of all three teeth- 7.62 (m1), 6.86 (m2), and 6.86 (m3).

Mendes

The Mendes' faunal assemblage analysis was started by Douglas Brewer in the early 1990's, with one season of faunal analysis that resulted in a brief report on the identified remains (Brewer and Wenke 1992: 196). No other work was done on the faunal assemblage until Brian Hesse resumed work in 2007 until 2010. As all faunal material has been saved since 1989 with the start of the University of Washington/ Illinois/Toronto and now current Pennsylvania State University expedition, a large amount of the faunal sample was available for dental data collection. Although the available material covers a large time span from the Old Kingdom through to the Ptolemaic period, surprisingly, all the pig teeth come from the Old Kingdom levels- dating to the 1st-6th dynasties (Matthew J. Adams, Personal Communication), although there are post-cranial pig remains that do come from later contexts (Brian Hesse, personal communication).

Compared to the other Old Kingdom sites, the Mendes teeth sample is much larger, consisting of thirty-three mandibles with sixty-two teeth. Unlike the previous size distributions discussed, the Mendes population has a very high *V* in all three teeth- 19.22 (m1), 13.43 (m2), and 11.59 (m3). This is also visually seen in Figures 5.3a-c, displaying a bimodal distribution, indicating the presence of two different populations- likely wild boar and domestic pigs.

Abydos Settlement Site

As mentioned in Chapter 3, the Abydos Settlement Site (dating to the First Intermediate Period- c. 2686-2055 BC) was excavated in 1991 for one season, during which all recovered faunal material were analyzed by Richard Redding at that time (Richard Redding, personal communication). As all the excavated faunal remains were saved, analysis of all recovered pig teeth was possible, consisting of a moderate sample size of thirty-five teeth from twelve mandibles. A very broad, yet normal distribution is observed (mean = -0.003) that may also include some wild boar present. The *V* does reveal some differences between the teeth. Although a small sample size, the m1 has the highest *V* of 18.54. The m2 decreases to 13.42, and decreases even further in the m3 to 7.69. This supports two populations of wild and domesticated pigs in the m1 and 2, and only one population in the m3.

South Abydos town of Wah-Sut

The faunal remains from the South Abydos town of *Wah-Sut* were excavated and analyzed between 1999- 2004 by Stine Rossel (2007, 2006). Like the material from the Abydos Settlement Site, all faunal material was saved. From amongst these, forty-eight teeth from nineteen pig mandibles were analyzed. These show a slightly tighter normal distribution as compared to the Abydos Settlement Site (mean= -0.03). This indicates one population of domestic pigs, which is confirmed by the fairly low *V*'s of 9.97 (m1), 7.79 (m2), and 7.69 (m3).

Elephantine (New Kingdom)

As mentioned in the Old Kingdom section, the Elephantine bones, including the New Kingdom sample, come from the available faunal material of the past three seasons of excavation that had been not been already analyzed or re-buried. The New Kingdom pig sample consists of a total of thirty-nine teeth from sixteen mandibles. Based on the *V* of all three teeth (4.40, 6.77, and 5.11) only one population of domestic pigs seems to be present. This is also supported by the metric evidence, which shows a tight, normal distribution, consisting of smaller, domestic pigs. No wild boar seems to be present.

Amarna

One of the most unique sites in Egypt for the study of faunal remains, particularly pig remains is Amarna, as this is the only known site that until now that has evidence of pig pens. Analysis of the faunal remains from the site has actually been conducted by a number of zooarchaeologists beginning in the early 1980's. The first to work on the faunal remains form the Workmen's village was Howard Hecker in the 1980's, who only published a preliminary report (Hecker 1984). Rosemary Luff continued work on some of the faunal remains in the 1990's (Luff 1994; Luff and Brothwell 2007), followed by Phillipa Payne who from 2004 to 2006 analyzed some of the remains from the Main City (Payne 2005b, 2006). The most recent, and complete analysis of all faunal remains is still currently being conducted by Anthony

Legge who since 2007 is analyzing all previously recorded faunal material as well as the recently excavated remains (Anthony Legge, Personal Communication).

As all faunal material has been saved from the current excavations under the direction of Barry Kemp since 1977, a very large body material was available for dental analysis, resulting in the largest assemblage of pig teeth that will be discussed in this dissertation. The pig teeth from Amarna came from three different areas of the site: the Amarna Main City, the Workmen's Village, and the Stone Village. However, for the purposes of this research they have been combined into one large sample. The *V* of the three teeth are: 6.45, 8.04, and 8.06 and visually seen in **FIGURES** all indicating one population of domestic pigs.

Kom Firin

The analysis of the remains from Kom Firin was personally undertaken in 2008, covering the British Museum's excavation of the site from 2002-2008 (Bertini, In Press A). Thus, the entire sample collected to date was available for dental analysis. This turned out to be the second largest sample of pig teeth after Amarna, totaling 109 teeth from forty-six mandibles. Although a seemingly normal distribution is observed in Figure 5.2a, it is slightly skewed to the right, indicate that some wild boar are present. The *V* of the three teeth (11.99, 8.59, and 7.24) confirms this, which like the Abydos Settlement Site, points to two populations in the m1 and 2, and only one in the m3. Both wild and domestic pigs are present in this sample, which can visually be seen in the histograms of the raw teeth measurements in Figures 5.3a-c.

Saïs

The Saïs faunal analysis was also personally undertaken, along with Veerle Linseele (Bertini and Linseele, In Press) covering the current Egypt Exploration Society/Durham University excavations at the site, which began in 1999. Subsequently, all faunal material was available for dental analysis, which amounted to twenty-eight teeth from eleven mandibles. A slightly imbalanced curve is visible, which is not quite a normal distribution. However, it is skewed to the right indicating that some wild boar may also be present. The *V* confirms this with fairly high values for the m1 (11.18) and the m3 (12.91). The m2 is slightly lower (7.84), but still seems to point to the presence of two populations. This, like the Mendes sample indicates that both wild and domestic pigs are present.

Tell el-Borg

Like the Kom Firin and Saïs assemblages, faunal analysis of the Tell el-Borg assemblage was also personally undertaken in 2008, representing all excavated material from the 2003-2007 seasons (Bertini, In Press B). However, the dental assemblage in this dissertation represents all excavated material from the first excavation season at Tell el-Borg in 2000, as all faunal material has been saved until then. Despite what has been saved, the pig teeth assemblage was the smallest collected, totaling eight teeth from three mandibles. Although the *V* for the m3 (9.95) indicates the possibility of some wild boar present, the small sample size (5 teeth) males it difficult to be certain. No *V* can be calculated for the m1 and the *V* based on three teeth for the m2 is 4.39.

Aswan (Ptolemaic- Roman)

The only Ptolemaic-Roman period assemblage comes from the Aswan settlement. Work on the Aswan settlement faunal assemblage has been conducted by Johanna Sigl, and is still in progress (Johanna Sigl, personal communication). As all remains from excavated contexts have been saved, a moderate size of pig mandibles was available for analysis totaling forty-five teeth from seventeen mandibles dating to the Ptolemaic-Roman period. The *V* for the three teeth (9.59, 9.77, and 8.22) indicates one domestic population, with the possibility of some wild boar present. This is also seen in the histograms showing the raw measurements of the three molars (Figures 5.3a-c).

First Molar Summary Statistics (WP):

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine (Old Kingdom)	5	10.07	11.87	10.84	0.73	6.74
Giza	5	9.92	11.47	10.93	0.60	5.49
Kom el-Hisn	11	10.16	13.18	11.55	0.88	7.62
Mendes	11	8.19	14.94	12.02	2.31	19.22
Abydos Settlement Site	9	8.33	14.58	11.65	2.16	18.54
South Abydos	12	9.48	13.4	10.83	1.08	9.97
Elephantine (New Kingdom)	16	9.76	11.69	10.67	0.47	4.40
Amarna	44	8.48	12.14	10.69	0.69	6.45
Kom Firin	46	8.34	15.49	12.01	1.44	11.99
Saïs	10	10.9	14.68	12.07	1.35	11.18
Tell el-Borg	1	-	-	11.27	-	-
Aswan	16	8.12	12.81	10.84	1.04	9.59
Shobra	19	8.88	11.74	10.16	0.66	6.49
Albarella and Payne (2005)	125	9.8	12.4	10.9	-	5.0
Payne and Bull (1988)	18	-	-	12.5	0.46	4.0

Second Molar Summary Statistics (WP):

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine (Old Kingdom)	3	8.71	13.21	10.96	3.18	20.01
Giza	4	12.6	14.31	13.26	0.78	5.88
Kom el-Hisn	9	11.41	14.55	13.41	0.92	6.86
Mendes	23	10.02	17.75	15.04	2.02	13.43
Abydos Settlement Site	13	10.43	16.9	13.93	1.87	13.42
South Abydos	17	11.55	15.05	12.95	1.01	7.79
Elephantine (New Kingdom)	13	10.47	13.65	12.55	0.85	6.77
Amarna	37	11.14	16.74	13.18	1.06	8.04
Kom Firin	36	11.99	17.9	13.85	1.19	8.59
Saïs	14	10.49	14.65	13.52	1.06	7.84
Tell el-Borg	3	12.79	13.95	13.44	0.59	4.39
Aswan	17	10.22	14.94	13.21	1.29	9.77
Shobra	19	11.14	14.67	12.81	0.79	6.17
Albarella and Payne (2005)	68	12.5	15.9	14.2	-	4.5
Payne and Bull (1988)	15	-	-	16.3	0.61	4.0

Third Molar Summary Statistics (WA):

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine (Old Kingdom)	0	-	-	-	-	-
Giza	5	15.3	16.3	15.77	0.36	2.28
Kom el-Hisn	12	14.65	18.8	16.43	1.44	8.76
Mendes	28	13.13	19.86	16.39	1.90	11.59
Abydos Settlement Site	13	13.17	17.79	15.34	1.18	7.69
South Abydos	19	12.69	17.33	14.69	1.18	8.03
Elephantine (New Kingdom)	10	13.43	15.59	14.68	0.75	5.11
Amarna	30	12.13	17.34	15.31	1.25	8.16
Kom Firin	27	13.72	18.21	16.15	1.17	7.24
Saïs	5	14.72	19.79	16.97	2.19	12.91
Tell el-Borg	5	15.22	19.32	16.68	1.66	9.95
Aswan	12	12.44	16.68	14.59	1.20	8.22
Shobra	17	11.31	15.33	13.92	1.15	8.26
Albarella and Payne (2005)	42	13.9	17.5	15.7	-	6.0
Payne and Bull (1988)	5	-	-	18.3	-	-

Table 5.1: Width Summary Statistics for all pig populations and established standards used

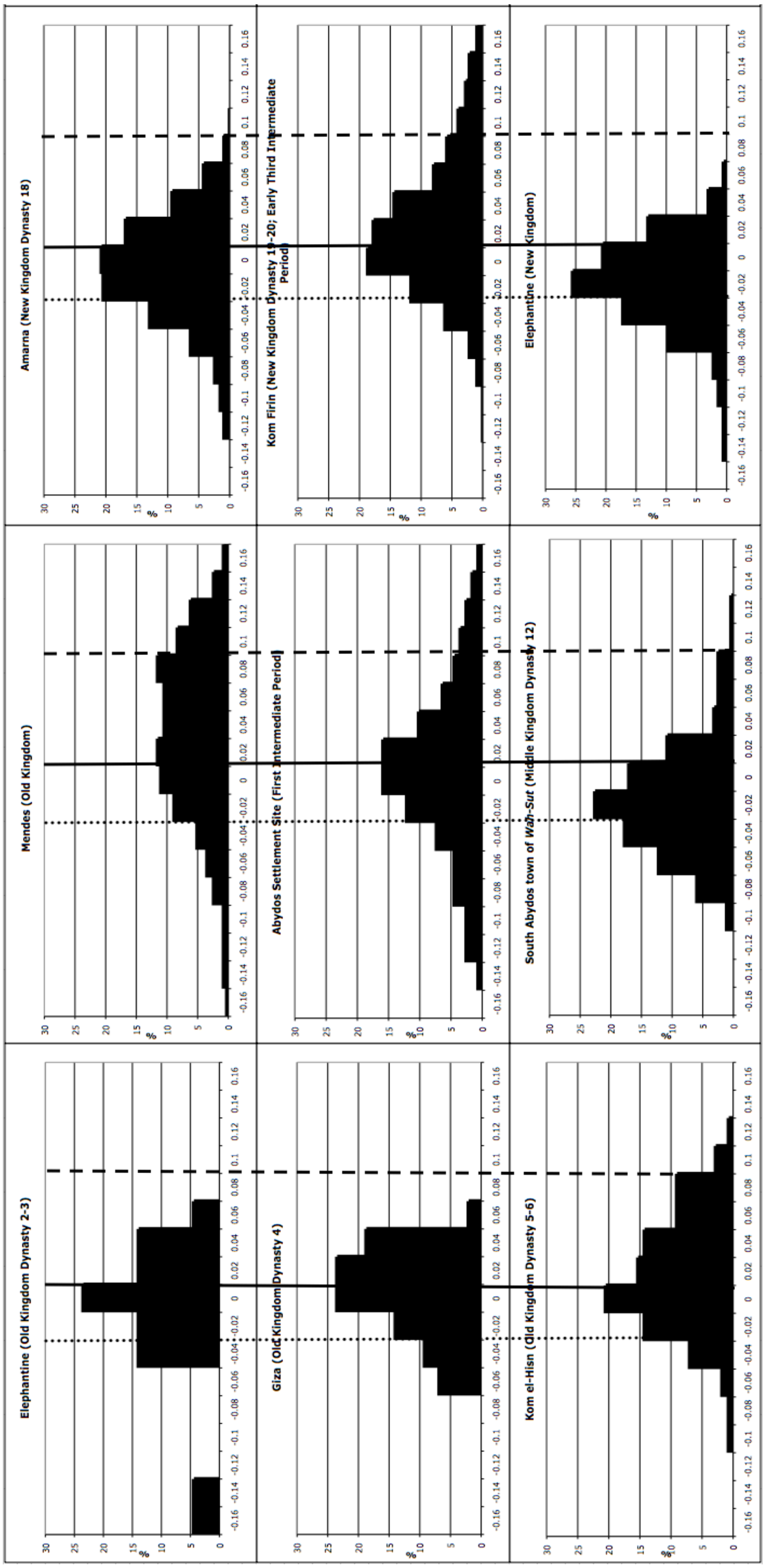

Figure 5.2a: Comparison of pig lower tooth measurements from all Egyptian populations. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents Durrington Walls standard, Dotted line at -0.04 represents modern Egyptian standard and Dashed line at 0.08 represents modern Turkish wild boar standard.

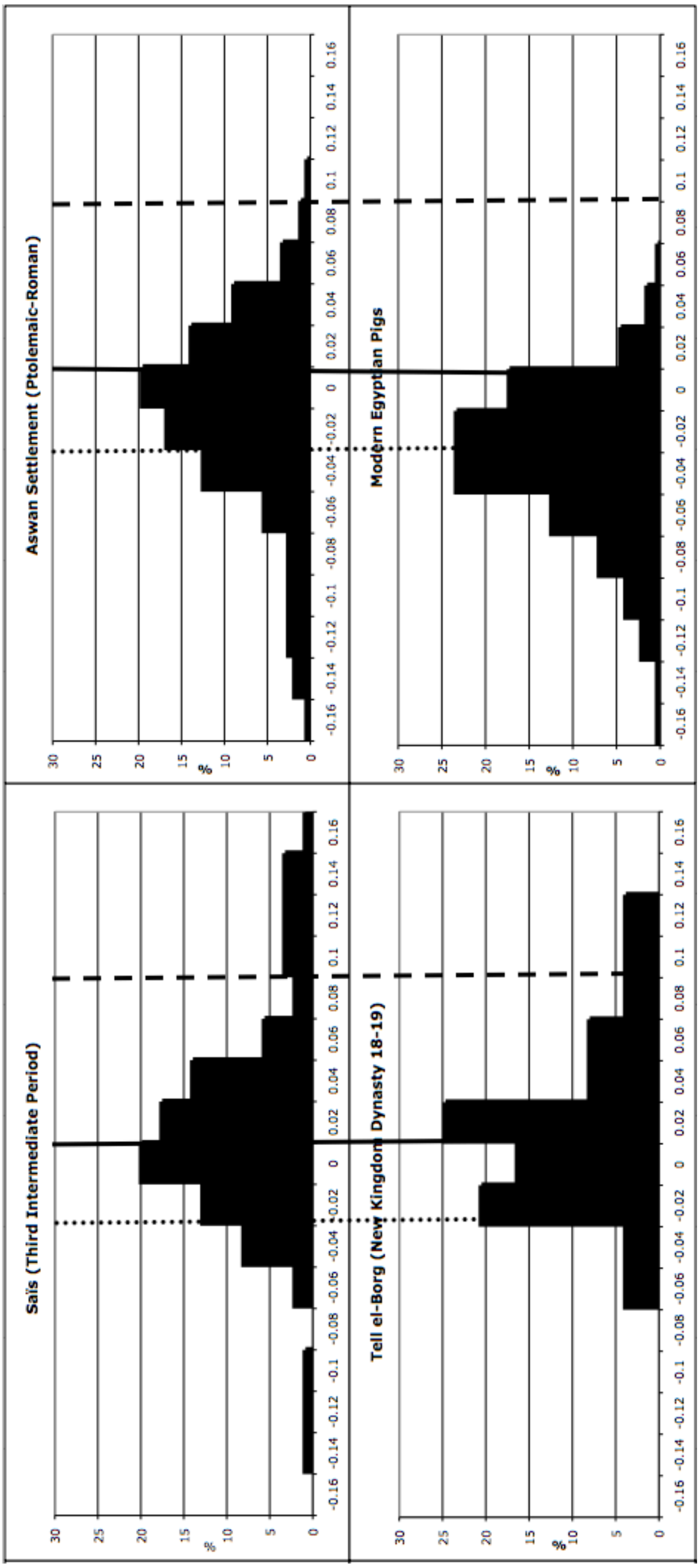

Figure 5.2b: Comparison of pig lower tooth measurements from all Egyptian populations. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents Durrington Walls standard, Dotted line at -0.04 represents modern Egyptian standard and Dashed line at 0.08 represents modern Turkish wild boar standard.

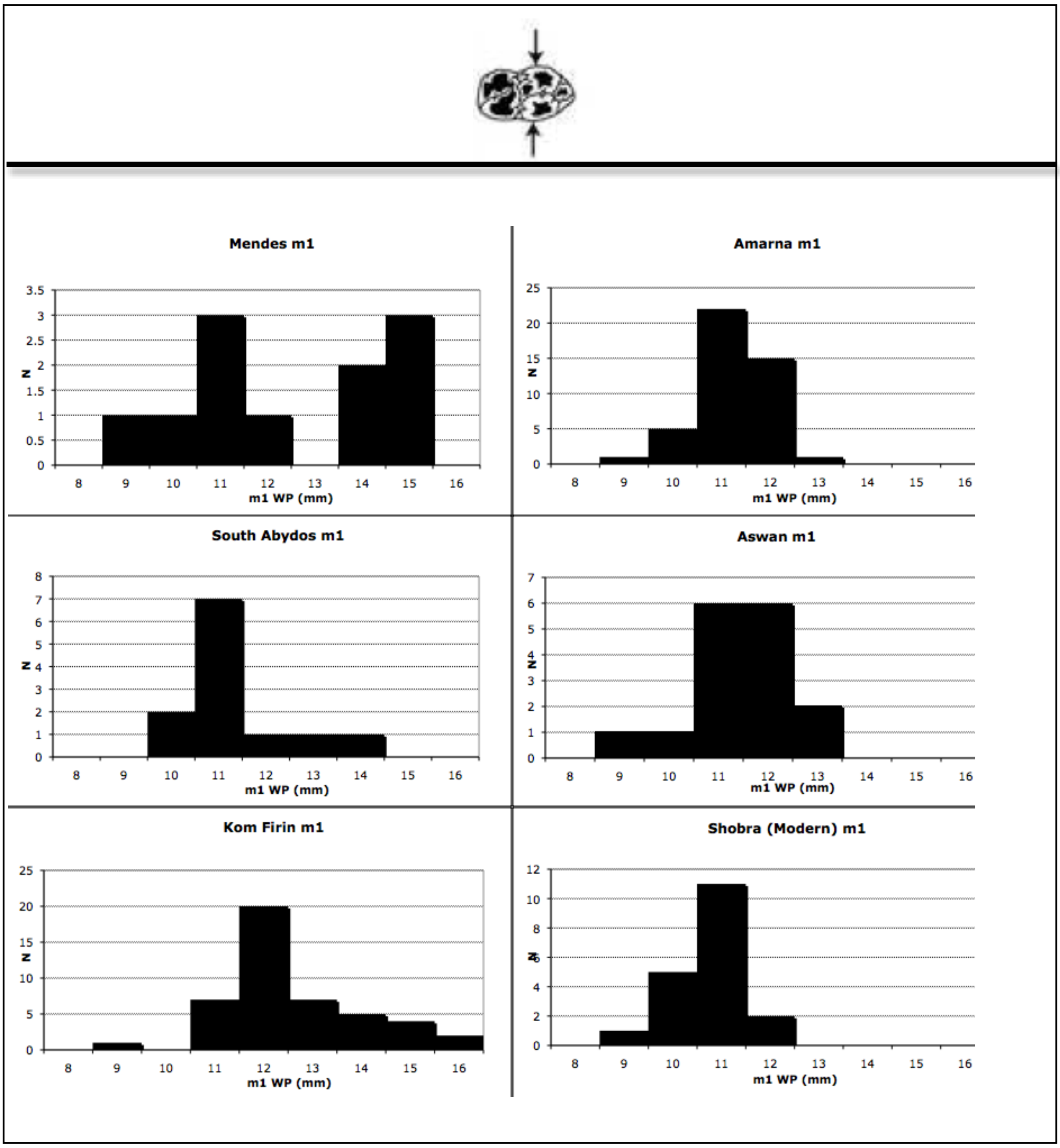

Figure 5.3a: Comparison of raw first molar posterior widths from selected Egyptian pig samples. Measurements greater than 13mm are thought to be from wild boar.

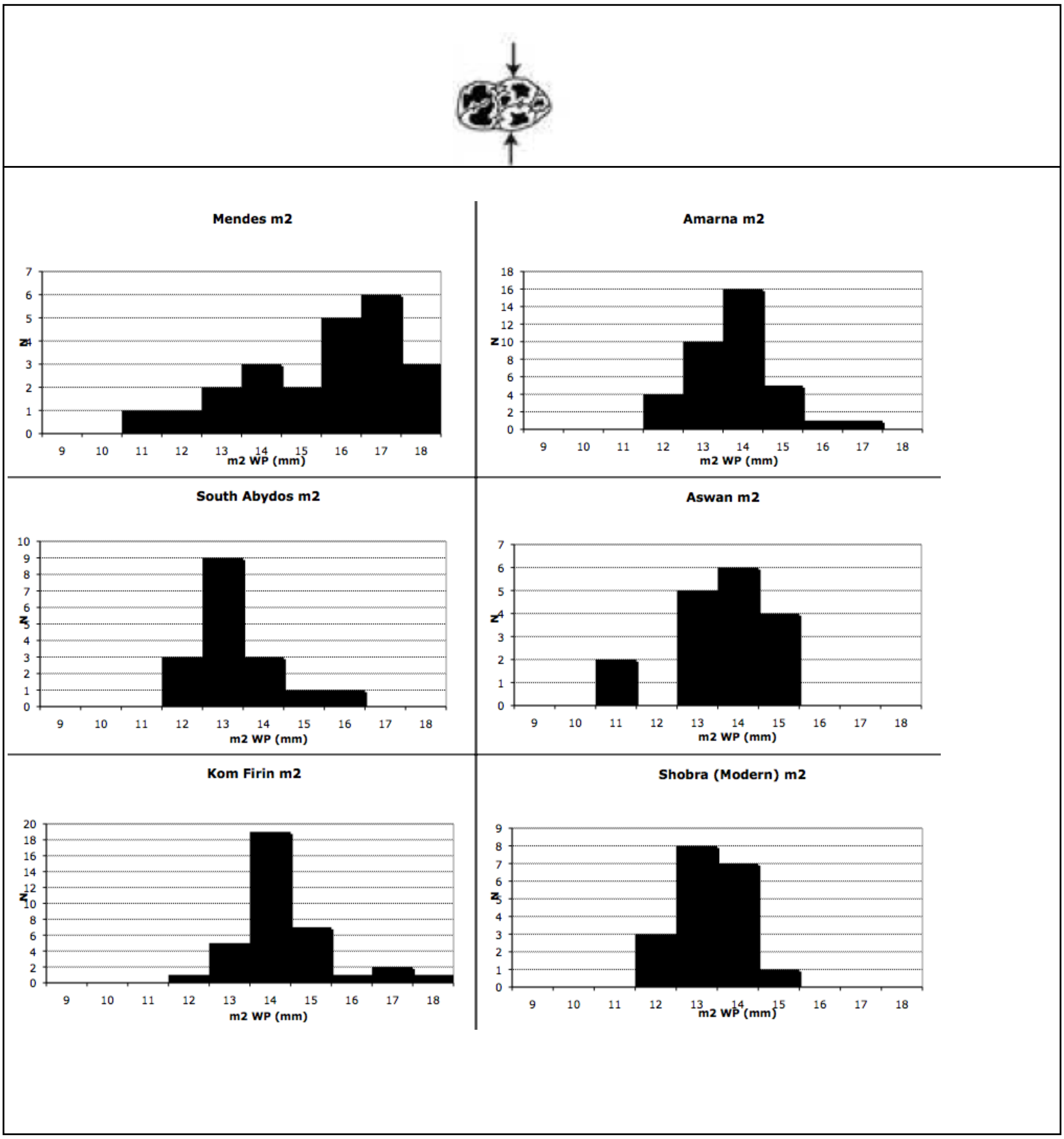

Figure 5.3b: Comparison of raw second molar posterior widths from selected Egyptian pig samples. Measurements greater than 16mm are thought to be from wild boar.

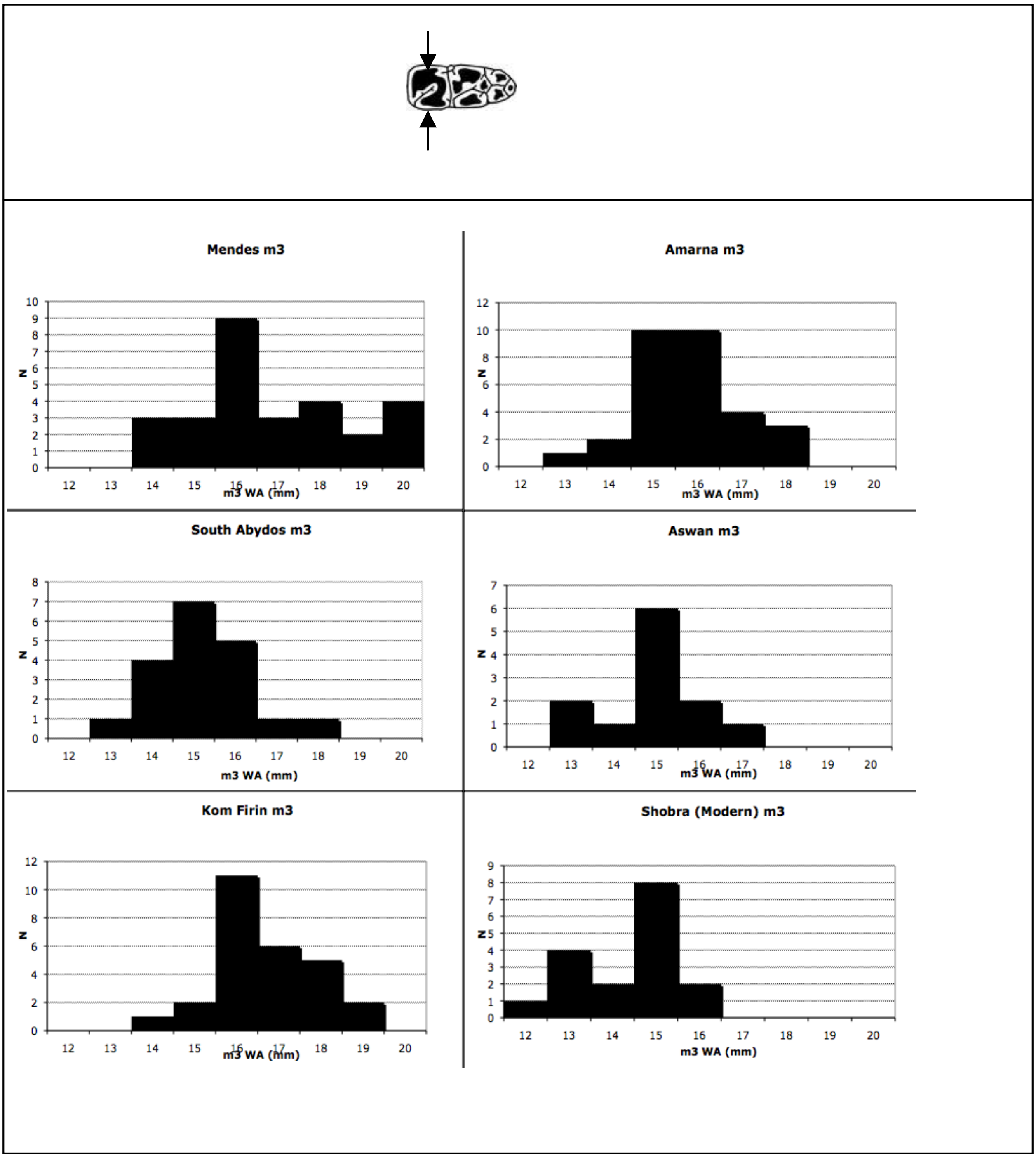

Figure 5.3c: Comparison of raw third molar anterior widths from selected Egyptian pig samples. Measurements greater than 17mm are thought to be from wild boar.

5.4 Discussion

5.4.1 Age and Sex of Modern and Archaeological Egyptian Pigs

Beginning with the modern population of pigs, most seem to have been killed at about a year and a half based on their mandibular wear score (Grant 1982), which peaks at 25. However, the Shobra pork storeowner reported that the pigs were killed between six to ten months (Mr. Magdy, personal communication). Taking into consideration the problems with Grant's ageing method, as discussed by O'Connor (2004: 271; 2003: 159), analysis of eruption data is important to give a more exact age. All nineteen mandibles have their second molar completely formed, and all third molars are either developing or in the early stages of wear. Based on the eruption sequence of pig teeth (Mc Cance *et al.* 1961; Mohr 1960; Briedermann 1972), this would put the two mandibles that have their third molars developing anywhere between fifteen to eighteen months. The other seventeen mandibles that have the third molar just erupted/in early wear stages (See Appendix 2) can be aged to at least eighteen to twenty months, corresponding with the ages calculated based on the MWS. Thus, unless these pigs, which are a hybrid European-Asia breed, as was established based on the DNA results discussed in the previous chapter, have a highly accelerated development rate, it is unlikely that this sample is between the age of six to ten months as reported by the Shobra pork store owner, Mr. Magdy. Unless the butcher had no clue as to the actual age of the pig, this reported young age was more likely given in order to conform to the age preference for pork in Egypt. The analysis of the teeth would give an average age of the pigs to about eighteen months, meaning that the pigs were born around April 2006.

Like the modern sample that has a MWS peak at 25, most of the archaeological samples also seem to have a killing peak at an immature age, a MWS of 25. These animals were likely to be between eighteen to twenty one months at time of death, which is similar to the results of previous work on age distributions at other sites such as Kom el-Hisn and Amarna. Redding's survivorship curve (1991: 25) suggests that the slaughter of pigs at Kom el-Hisn reached its peak between twelve to twenty-four months of age, based on epiphysial fusion. Previous work at Amarna reveals a similar pattern, with the preferential age of slaughter falling into one of two categories: two to eight months (mostly males) and fourteen to twenty-four months (mostly females), and a very small percentage surviving into their third year (Hecker 1984: 157-158).

Although Hecker's reported age of slaughter may be similar to the age distribution in this analysis, there are some important differences to note. Firstly, in Hecker's analysis, he first states that analysis of thirty-nine mandibles suggested that the pigs were killed before nine months, about the same number killed before twenty-four months, and about twelve mandibles showed that the pigs survived beyond their second birthday, totalling 89 mandibles (Hecker 1984: 157-158) from which the slaughter ages were calculated. Although there are a total of 116 teeth from Amarna of which age, size and hypoplasia data have been recorded, only nineteen mandibles could have age data recorded. This is obviously a large discrepancy between the 89 mandibles that Hecker reported in 1984. Thus, unless an age was estimated based on an incomplete mandible, the only other explanation for this discrepancy is that large portions of the faunal sample have since disappeared.

Nevertheless, the Amarna sample recorded and discussed in this dissertation has a normal distribution, which also happens to have the widest age range in all the recorded Egyptian pig samples. This is possibly reflective of the more intensive pig-rearing regime at Amarna where they were kept in pens due to a heavier demand for meat that was needed to support the citizens of the workmen's village. The age distribution encompasses all three age groups that Hecker discusses, with a peak at a MWS of 25, which is at about eighteen to twenty-one months of age.

This distribution highlights the difficulty when using a percentage running mean with very small sample sizes. Although population trends can be easier to see visually when using a percentage running mean, possible bi-modal distributions become difficult to detect when there is a small sample size. This is particularly noted in instances such as Giza where only two mandibles were able to have their MWS calculated. However, when plotted as a running mean, because of such a small sample size, it appears that six mandibles were able to have their MWS calculated and are all displaying different MWS stages.

Kom el-Hisn and Kom Firin also display interesting age at death distributions. Although the Kom el-Hisn age distribution is based on five mandibles and the Kom Firin on twenty-six, both distributions appear to be skewed to the right of the mean. This indicates that a few older individuals are present in both populations, which could possibly be females being kept for breeding purposes only. While Kom el-Hisn dates to the Old Kingdom and Kom Firin to the New Kingdom, both sites are located fairly close to each other in the western delta, indicating that there was no change in the desired age of slaughter during this approximately 1, 200 year period. Only sites like Amarna (and possibly Saïs and Ptolemaic/Roman Aswan as well) that have more intensive involvement in rearing seem to have pigs being slaughtered at an earlier age (approx MWS around 5-10).

At this point it is difficult to discuss the exact season of birth/death, but this is an issue that will be discussed in further detail in the next chapter with reference to the presence of enamel hypoplasia.

As stated in section 5.3.1, sexing of the entire sample was only possible for the modern sample of pig mandibles, which includes ten males (53%) and nine females (47%). Data on the sex of the archaeological remains was recorded when possible, but was only possible for about five mandibles throughout the entire archaeological pig assemblage, and thus is not large enough to conclude accurate sex estimations.

5.4.2 Size of the Modern and Archaeological Pigs

Referring back to the summary statistics Table 5.1, the overall trend of the widths for each of the three molars at each site is that the mean width of Upper Egyptian sites is lower than the Lower Egyptian sites. The first explanation that comes to mind is the better access to food in the delta region as compared to the dry, more desert environment of Upper Egypt. Another possibility is that some wild individuals may be present as seen in Figure 5.2, where the size distributions of some lower Egyptian sites (such as Mendes, Kom Firin, Saïs, and Tell el-Borg) are skewed to the right, falling within the wild boar size range.

As stated in section 5.3.2, the P-value ($p \leq 0.0001$) indicates that there are significant differences in the sizes of the widths of the analyzed pig molar samples. Without having to perform a multi-variable ANOVA test, the easiest way to see where any differences may occur in the pig samples is to look at the coefficient of variation as seen on Table 5.1. A number of the pig samples in Table 5.1 display V that range as high as 20.01 (Elephantine Old Kingdom Second Molar). However, when the total sample number is 10 or below, the V may not necessarily be indicative of the population simply due to the small sample size. Thus, the sites of Mendes, South Abydos, Amarna, Kom Firin, Aswan, and the modern Shobra pig populations will be looked at further. This is due to the fact that they all have sample sizes that are greater than 10 teeth and have a *V* greater than 7 in at least one of the molars, signaling the presence of a second population. Furthermore, histograms (Figures 5.3a-c) of the raw width measurements for each of the three molars have been constructed to visually show what the data looks like.

Since the Shobra (modern) sample is the only one that is confirmed to represent a single, fully domestic population, it will serve as the baseline in which to compare the other samples. Furthermore, the *V*'s of this sample (as in Table 5.1) are 6.49 (m1), 6.17 (m2), and 8.26 (m3), confirming a single population.

Since the Shobra sample is one population, based on Figures 5.3a-c, the measurements of 13mm and above for the m1, 16mm and above for the m2, and 17mm and above for the m3 will be considered wild boar. On an interesting note, the Shobra sample also shows similar results to Mayer *et al.* (1998)'s differentiation of wild from domestic pig teeth. Although this article does not discuss the m1, the m2 has the exact same cut-off point of 16mm and above are considered to be wild (Mayer *et al.* 1998: Table 1). The m3, however, (Mayer *et al.* 1998: Table 1) is slightly larger at 18mm. Although the m3 cut-off points are close, for the purposes of this research, the Shobra sample cut-off point of 17 mm and above will be used.

Starting with the site of Mendes, two populations defiantly seem to be present as evidenced by the *V* of 19.22 (m1), 13.43 (m2), and 11.59 (m3). Mendes is even visibly bimodal in Figures 5.3a-c showing both a domesticated and wild population present. The percentage of wild and domesticated teeth is about equal in both the first and third molars, although there are slightly more wild second molars. Kom Firin, however, displays a different pattern.

The *V* of the three teeth from Kom Firin are 11.99 (m1), 8.59 (m2), and 7.24 (m3). Based on this high value of the m1 and m2, more then one population is present. So why does the m1 have the highest *V* and m3 the lowest? A similar situation is seen at the European Neolithic site of Gomolava (Rowley-Conwy *et al.* In Press: 16-17), where it is concluded that wild and domestic pigs were killed at different ages. The percentage of domestic animals is highest in the m1m which is the earliest erupting tooth and lowest in the m3, which erupts last. If most domestic pigs were killed young, few would have erupted m3's. If more wild boar were killed as adults, their m3's would be relatively more common (Rowley-Conwy *et al.* (In Press: 16-17). This can even be visually seen in Figures 5.3a-c where the m3 has a significantly lower percentage of domestic pigs present as compared to the m1 and m2. Thus, like at the site of Gomolava, the pig economy at Kom Firin was likely based on the slaughter of juvenile domestic pigs and the hunting of more adult wild boar.

The sites of South Abydos, Amarna, and Aswan all seem to be one population based both on their low *V* (Table 5.1) and as seen in Figures 5.3 a-c. However, all sites have some teeth that fall into the wild boar range. Although it is possible that there may be one or two wild boar in the mix, it is possible that sexual dimorphism could be another explanation- especially at Amarna. Between the m1 and m2 teeth as seen in Figures 5.3a-c, two teeth fall into the wild boar range. However, the m3 has 7 teeth that wall into the wild range. Although the Kom Firin hunting of older wild boar scenario is possible, given both the intense pig rearing regime at Amarna coupled with its desert environment, it is highly unlikely that wild boar are present. Thus the more likely scenario is the few m3's that fall in to the wild boar range represent the few females that were kept for breeding purposes whereas the m1 and m2's are the juvenile domestic pigs slaughtered for consumption.

Referring back to one of the main objectives of this dissertation, which is to ascertain if there are diachronic changes in animal husbandry throughout Egyptian dynastic history, we can now refer to Figure 5.3, which combines all the sites according to their time period. The table allows us to calculate changes in the animal's size over time and it shows a shift from larger sized pigs in the Old Kingdom to smaller pigs in the Middle Kingdom. As there is insufficient data available from Neolithic and Predynastic Egyptian contexts (or at least none that was available for this study), analysis had to start with data from the Old Kingdom, at a time when pigs are already considered to be fully domestic (Bosessneck 1988: 76; Houlihan 1996:12).

As mentioned in Chapter 3, a limited amount of Neolithic data was collected from the site of Saïs (dating to c. 5000- 4300 BC), but it has not been included due to its very small sample size. Despite the small sample, it did seem appropriate to include the data (totaling 9 teeth from four mandibles) that was available as a rough comparison to the summary data to see if there may be any change over a slightly larger time period than just the Old Kingdom through to the Ptolemaic-Roman period.

Like the Third Intermediate sample that is also from Saïs, the Neolithic size distribution (mean= 0.005) is also slightly imbalanced, although it is skewed to the right indicating slightly larger sized pigs in comparison to the Old Kingdom, although they still fall within the domestic size range. It is possible that there may have been more wild specimens present, but based on a very small sample size.

The Old Kingdom sizes (overall mean= 0.01) are slightly larger (in part due to the larger sample size that was available) which is seen by being skewed to the right, with what seems to be a few wild boar present. However, a shift begins to occur in the First Intermediate Period (mean= -0.003), where a broad, normal distribution is visible, with even amounts of what seem to be both domestic and wild boar present. In the Middle Kingdom (mean= -0.03), another shift occurs, skewing the data to the left, where almost no wild specimens seem to be present. It is possible that this is due to the increase of more intensive involvement and/or different strategies in pig rearing, although later data, makes this difficult to be certain. Later periods, the New Kingdom and Third Intermediate Period, do show what seems to be a small percentage of wild boar still present, but the overall size of the pigs still seems to be in the domestic range. This is most likely due to the fact that wild boar remained in the Nile delta until their extermination in the early 1900's and were most likely still being hunted then.

The only problem to note with these distributions is that the First Intermediate Period, Middle Kingdom, Third Intermediate Period, and Ptolemaic-Roman distributions all represent one site each. Although a shift in pig size is visible over time, with future research increasing the sample size, it is possible that the precise nature of the size shifts could change.

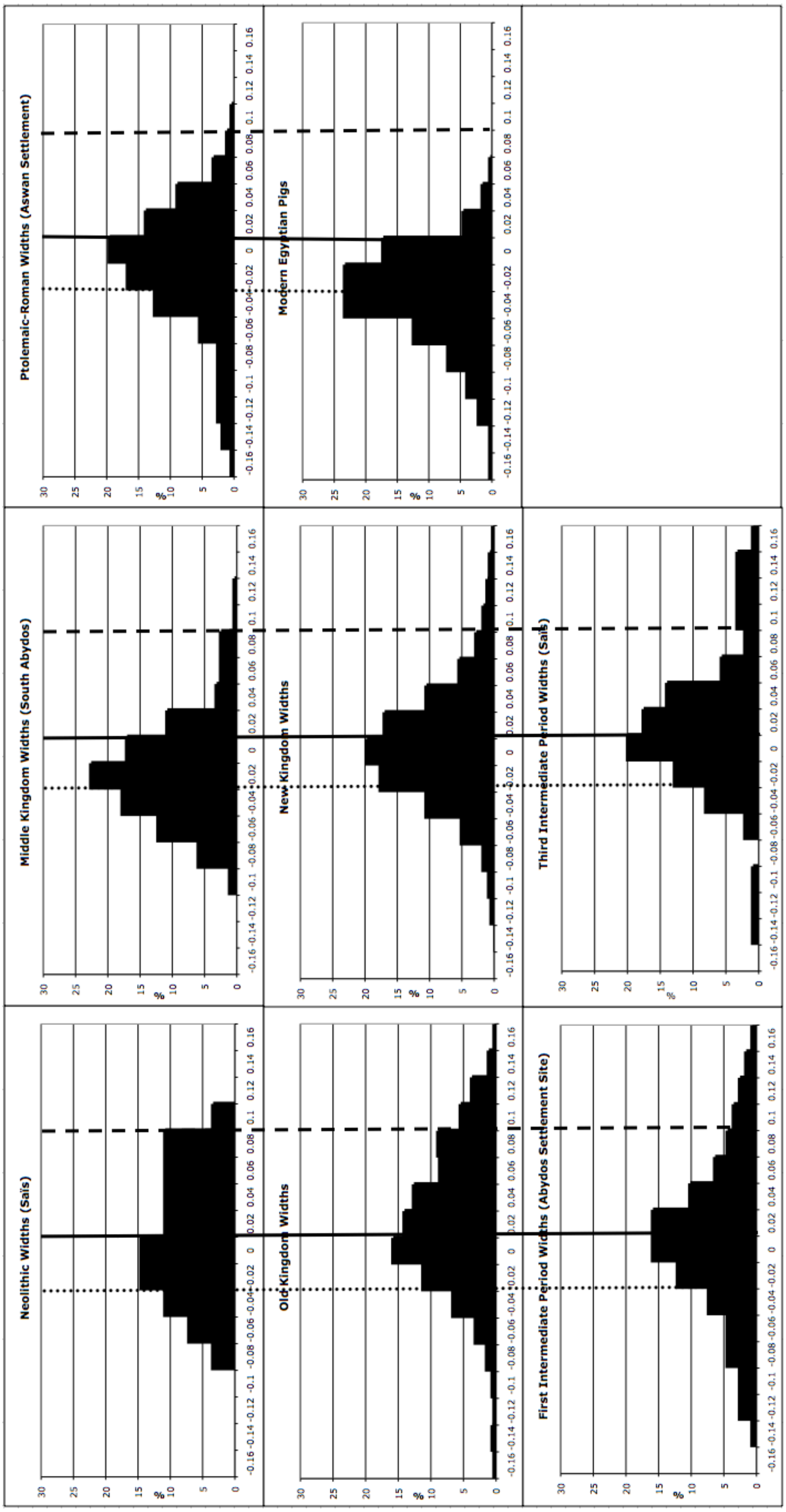

Figure 5.4 Comparison of pig lower tooth measurements from all Egyptian populations based on time period. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents Durrington Walls standard, Dotted line at -0.04 represents modern Egyptian standard and Dashed line at 0.08 represents modern Turkish wild boar standard

5.5 Conclusions

5.5.1 Age and Sex of Modern and Archaeological Egyptian Pigs

To summarize the age data, most pigs were- and still are slaughtered at a subadult age (about eighteen to twenty-one months). This is a pattern that is seen throughout Egyptian dynastic history and continues into the present day. This is possibly due to the fact that the meat is more tender at an earlier age and the fact that males have that chance of becoming more aggressive at an older age. Despite the younger age that modern pork butchers report in order to conform to the age preference for pork, eruption and wear data confirm the eighteen to twenty-one months age of slaughter. However, there are a few younger along with older individuals (most likely kept only for breeding purposes) present in both the modern and archaeological assemblages.

5.5.2 Size of the Modern and Archaeological Pigs

Overall, the size distributions based on tooth width seem to indicate that not only were their wild boar present in some of the recorded populations, but there also seems to be a decrease in size throughout dynastic Egypt, possibly related to more intensive pig rearing regimes that developed overtime. However, it seems to be the case that wild boar still were present, as in some of the sites that do have a small percentage of teeth falling within the wild boar size range which might indicate that they were still continually hunted (albeit in small numbers compared to the presence of domestic pigs) throughout all of dynastic Egypt.

6 The Presence of Enamel Hypoplasia in Modern and Archaeological Egyptian Suids

This chapter will examine further the two pig data sets (modern and archaeological) discussed in the previous chapter through the study of enamel hypoplasia by applying the methodology discussed in Chapter 2. Just as the modern sample was important in the previous chapter for providing a basis for biometrical comparison, the modern sample, with its known life history is crucial in the analysis of LEH, as it is important for understanding population factors (such as diet and environment) that can affect the presence of enamel hypoplasia (Upex 2010: 113). By examining known dietary and environmental factors relevant to the modern pig sample, and linking them to the occurrence of hypoplasia, a baseline can be established to which the archaeological material can be compared. The data analysis will thus be used to address the three key research questions: 1) interpreting swine husbandry practices; 2) understanding possible seasonality and dietary/ physiological impacts; and 3) interpretation of defect type and severity.

6.1 Key Research Questions

Previously, it has not been possible in Egyptian zooarchaeology to address the three research questions (establish the frequency of LEH, variability with diachronic change, and modern and archaeological population similarities) that are the main objective of this dissertation. The collection of data relating to pig LEH here is used as a tool for a wider understanding of animal husbandry, and it is also evaluated for its potential in general in Egypt through the below three research questions that will be addressed in this chapter.

1) Interpreting swine husbandry practices

The question of interpreting swine husbandry practices and possible changes throughout dynastic Egypt through the presence of enamel hypoplasia is the main goal of this dissertation. As there is currently no information available on the presence of enamel hypoplasia in either ancient or modern Egyptian pigs, this chapter will begin by using the modern Egyptian pig data collected to establish general stress patterns of frequency and chronology of enamel hypoplasia from this sample with a known life history. The results will then provide a baseline for understanding the influence of the environment and diet on the formation and severity of enamel hypoplasia, to which the archaeological data can be compared. This section will also try to establish whether coherent patterns do indeed exist in the archaeological material that reflects ecological setting and/or husbandry practices. The issue of variability in conjunction with diachronic change will also be addressed.

2) Understanding seasonality and physiological impacts

The second theme that will be addressed in this chapter is to see if the presence of enamel hypoplasia can provide seasonal markers both in the past and the present. Two different aspects of seasonality will be discussed using the distribution of enamel hypoplasia on the tooth crown:

Physiology and animal husbandry: Previous work on pigs (Dobney & Ervynck 1998, 2000; Dobney et al. 2002; Ervynck & Dobney 1999, 2002; Ervynck *et al.* 2001) has established that physiological events such as birth and weaning can produce a marker within the distribution of enamel hypoplasia on the tooth crown. Thus, this section will look at these established physiological markers in the eleven archaeological pig assemblages with semi-unknown management strategies.

Seasonal Environmental Factors: The Nile and its annual flood is the major environmental factor in ancient Egypt (and pre-1960 modern Egypt), the second aspect of seasonality to be investigated is the possible impact of the annual flood on the frequency of hypoplasia. This unique environmental aspect of Egypt will be used to address to potential of enamel hypoplasia to be used as a marker for seasonal climatic changes in archaeological populations.

3) Interpretation of defect type and severity

It has been noted (Witzel *et al.* 2006) that different types and severity levels of enamel hypoplasia can be related to different forms and severity of specific stress events dependent on the season of birth that will be discussed on the seasonality section. Although this is a methodology that up to this point has only been applied to caprines and humans, the same methodology (as discussed in Chapter 2) will be applied to pigs, to see if there is a link between types of hypoplasia and severity levels to specific events in the animal's life. It is noted, however, that this is an area of enamel hypoplasia studies that requires future research (Upex 2010: 288-289), in which this study hopes to contribute.

6.2 Results

A total of 562 recordable pig teeth were analyzed from all of the archaeological sites, along with 57 pig teeth from the modern pig mandibles collected, totaling 619 pig teeth that will be analyzed in this study. An inventory of the archaeological material studied is presented in Table 6.1**.** All tooth types are sufficiently abundant in the study collection and from most sites a large number of teeth were available. The fact that some tooth types are underrepresented at some sites is a combination of both taphonomic factors (such as preservation and recovery) and differences in age profiles of the slaughtered pig populations represented.

SITE	**TIME PERIOD**	**M1**	**M2**	**M3**	**Total Teeth**
Elephantine	Old Kingdom	5	3	0	**8**
Giza	Old Kingdom	5	4	5	**14**
Kom el-Hisn	Old Kingdom	11	9	12	**32**
Mendes	Old Kingdom	13	24	33	**70**
Abydos Settlement Site	First Intermediate Period	9	13	13	**35**
South Abydos	Middle Kingdom	13	20	19	**52**
Elephantine	New Kingdom	16	13	10	**39**
Amarna	New Kingdom	45	38	33	**116**
Kom Firin	New Kingdom	48	38	27	**113**
Saïs	Third Intermediate Period	10	14	5	**29**
Tell el-Borg	New Kingdom	1	3	5	**9**
Aswan	Ptolemaic-Roman	16	17	12	**45**
Shobra	Modern	19	19	19	**57**
TOTAL	**ALL SITES**	**211**	**215**	**193**	**619**

Table 6.1: Total pig teeth from all sites

6.2.1 Interpreting swine husbandry practices

<u>Key Points</u>

There is a high frequency of enamel hypoplasia (calculated using complete teeth) in the Old Kingdom Elephantine swine sample as compared to both the modern and other archaeological samples.

Amarna has the lowest frequency of enamel hypoplasia (calculated using complete teeth), which is almost the same frequency as the modern sample, and considerably lower than the other archaeological samples.

When simultaneously compared, there are no significant differences in the frequency of hypoplasia between any of the archaeological or modern pig samples (p=0.338, Chi square test).

<u>General Results</u>

The data discussed in Table 6.2 and comparisons of the relative frequencies between all thirteen data sets are seen in Figures 6.1-6.3. Of the 562 recordable pig teeth analyzed from all the archaeological sites in the study, 375 (67%) had hypoplasia, and of the 57 modern teeth analyzed, 33 (58%) displayed evidence of hypoplasia. Thus, the total number teeth analyzed in this study amounts to 619 teeth, of which 408 (66%) have hypoplasia present. The defects affected 34% of all the first molars (both modern and archaeological), and 80% of all the second and third molars studies. A breakdown of the modern verses archaeological teeth studied is seen in Table 6.3.

As there are twelve different pig samples, the percentage of enamel hypoplasia for each of the three molars per site is seen in Table 6.4.

SITE	TIME PERIOD	# OF COMPLETE TEETH	# OF TEETH WITH LEH	% OF TEETH WITH LEH
Elephantine	Old Kingdom	8	7	88%
Giza	Old Kingdom	14	11	79%
Kom el-Hisn	Old Kingdom	32	22	69%
Mendes	Old Kingdom	70	49	70%
Abydos Settlement Site	First Intermediate Period	35	24	69%
South Abydos	Middle Kingdom	52	39	75%
Elephantine	New Kingdom	39	28	72%
Amarna	New Kingdom	116	66	57%
Kom Firin	New Kingdom	113	72	64%
Saïs	Third Intermediate Period	29	20	69%
Tell el-Borg	New Kingdom	9	7	78%
Aswan	Ptolemaic-Roman	45	30	67%
Shobra	Modern	57	32	56%
TOTAL	**ALL SITES**	**619**	**407**	**66%**

Table 6.2: Comparing archaeological and modern pig populations in terms of frequency of enamel hypoplasia.

Tooth	Modern Population	Archaeological Population	Total Population
M1	11%	39%	36%
M2	79%	81%	81%
M3	79%	82%	81%

Table 6.3: Percentage of teeth affected by enamel hypoplasia

Site	**TIME PERIOD**	**% of M1**	**% of M2**	**% of M3**
Elephantine	Old Kingdom	100%	67%	0%
Giza	Old Kingdom	40%	100%	100%
Kom el-Hisn	Old Kingdom	36%	89%	83%
Mendes	Old Kingdom	38%	79%	76%
Abydos Settlement Site	First Intermediate Period	11%	85%	92%
South Abydos	Middle Kingdom	62%	85%	74%
Elephantine	New Kingdom	38%	92%	100%
Amarna	New Kingdom	33%	71%	73%
Kom Firin	New Kingdom	35%	84%	85%
Saïs	Third Intermediate Period	50%	86%	60%
Tell el-Borg	New Kingdom	0%	67%	100%
Aswan	Ptolemaic-Roman	38%	76%	92%
Shobra	Modern	11%	79%	79%
TOTAL	**All Sites**	**36%**	**81%**	**81%**

Table 6.4: Percentage of teeth affected by enamel hypoplasia for each site

6.2.2 Understanding seasonality and physiological impacts

<u>Key Points</u>

The majority of all occurrences of enamel hypoplasia in the thirteen pig samples on all three molars is on the cervical half of the tooth crown.

In the modern Egyptian sample the numbers of defects peak when the pigs' ages are: birth to one month old; 8/9 months old; and about 19/20 months old.

Based on the modern Egyptian sample the average estimates as to the numbers of defects peak when the pigs' ages are: birth to one month old; 3 months old; 8/9 months old; and about 19/20 months old.

<u>General Results</u>

The distributions of hypoplasia on the anterior and posterior cusp of all the analyzed sites organized by molar are shown in Figure's 6.1-6.3. As discussed in Chapter 2, calculations are based on the running means of the values of the individual tooth height classes recorded. The use of running means was chosen for the analysis in order to smooth variation and allow underlying trends to become more clearly visible (Dobney and Ervynck 2000: 601; Upex 2010: 109).

In the modern Egyptian pig population from Shobra, defects of the first molar are located in the middle of the tooth crown, with the majority of defects occurring between 3.5-6.5 millimeters above the root enamel junction (REJ). A different pattern, however, is seen on the second and third molars, where defects are located in the cervical 7.5 millimeters of the tooth crown on both teeth, with the majority of defects located about 3.5 millimeters of the tooth crown above the REJ on the second molar and about 4.5 millimeters of the tooth crown above the REJ on the third molar.

The distribution of hypoplasia on the archaeological material is slightly different to the modern material, with all the defects located in the cervical 7.5 millimeters of the tooth crown, with the majority of defects located between 2.5-3.5 millimeters above the REJ. There are a few sites, however, that have a second peak at about 6.5 millimeters above the REJ.

Second molar hypoplasia distributions from the archaeological sites are exclusively located in the cervical 8.5 millimeters of the tooth crown, with the majority of defects located in the 3.5 millimeters of the crown above the REJ. Similar to the first molar, there are a few sites that have a second peak of hypoplasia at 7.5 millimeters above the REJ.

Third molar hypoplasia distributions from the archaeological sites are almost exactly like the second molar as defects are also exclusively located in the cervical 8.5 millimeters of the tooth crown, with the majority of defects located in the 3.5 millimeters of the crown above the REJ. Again, a few sites also have a second peak of hypoplasia at 7.5 millimeters above the REJ.

To note, there are a few sites that do not have hypoplasia distribution charts made, due to a lack of defects present, or too small a sample size to construct a chart. The exempted sites include the first molar form both the Abydos Settlement Site and Tell el-Borg and the third molar from Old Kingdom Elephantine.

At this point, the results from the modern material only were plotted on to a schematic dental developmental graph (as discussed in Chapter 2) based on the developmental rates of pigs as described in McCance *et al.* (1961) and the known time of birth. An increase in the frequency of enamel hypoplasia is observed around the time of birth. On the second molar, there is a peak of enamel hypoplasia that occurs at about eight to nine months after birth and then drops sharply. A similar picture is seen with the third molar, as the number of defects peak between nineteen to twenty months after birth and again sharply drops.

At this point, dental developmental graphs will not be constructed for any of the archaeological populations, as their season of birth is unknown.

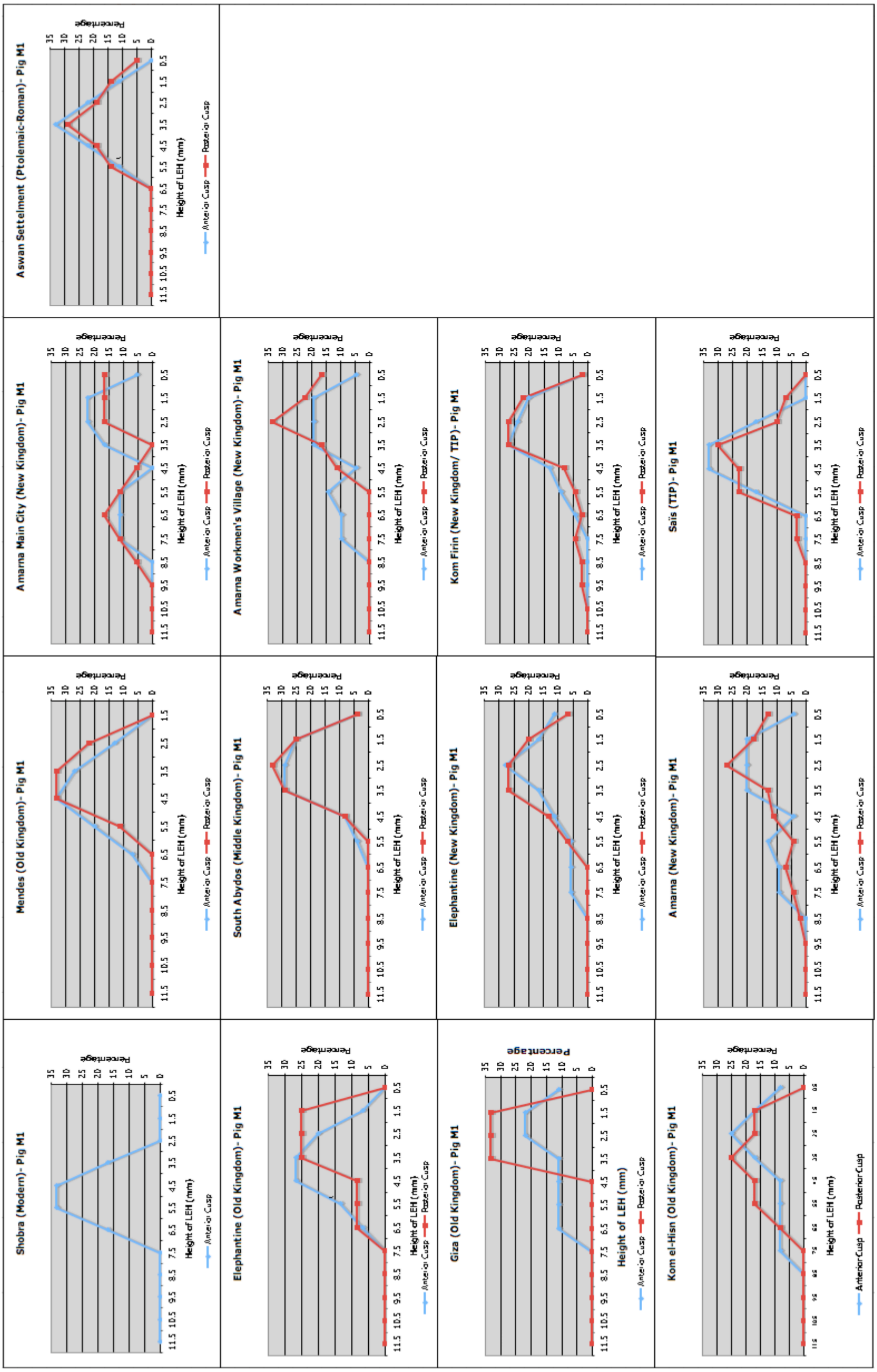

Figure 6.1: The location of hypoplasia on the tooth crown of M1 in the modern and archaeological pig material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

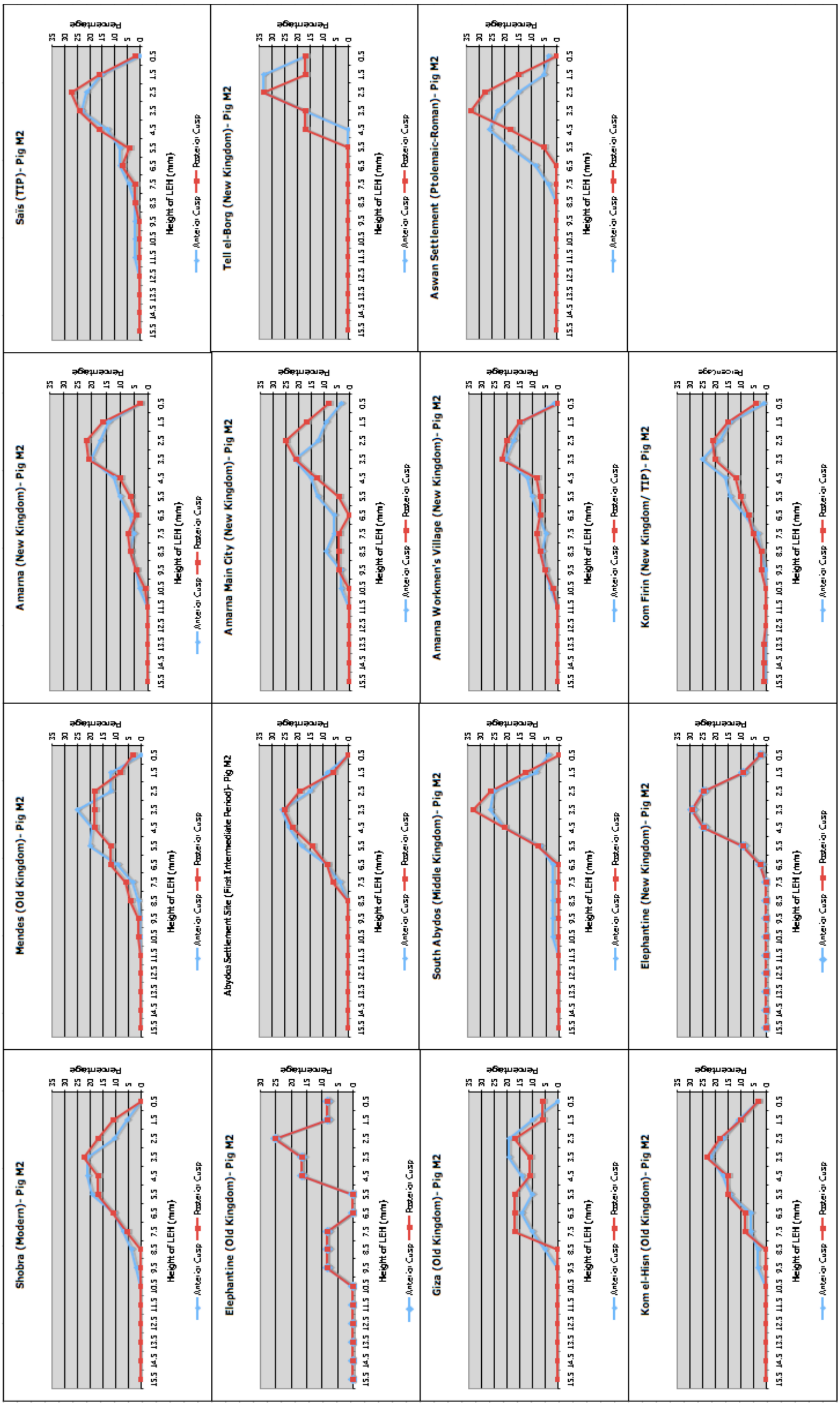

Figure 6.2: The location of hypoplasia on the tooth crown of M2 in the modern and archaeological pig material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

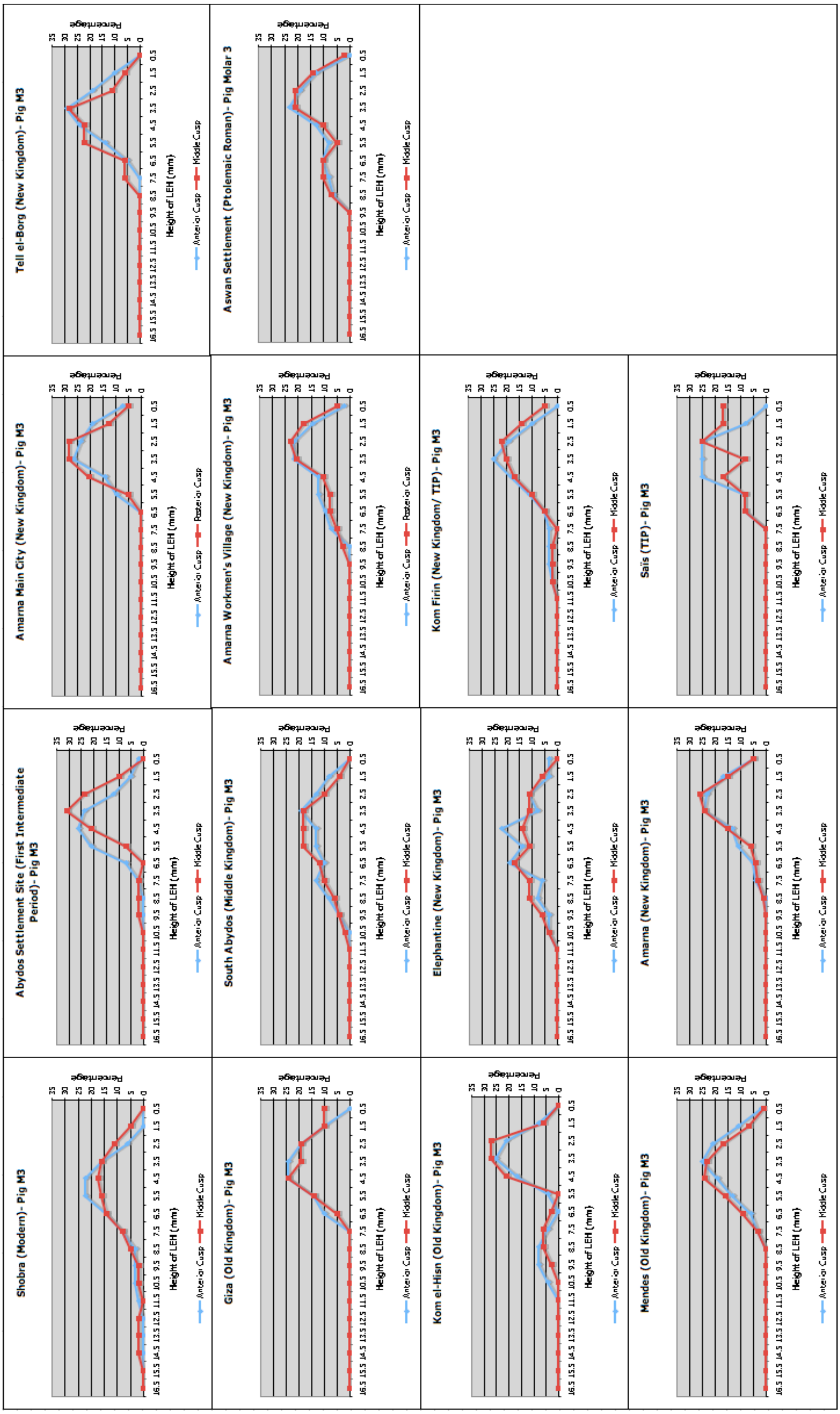

Figure 6.3: The location of hypoplasia on the tooth crown of M3 in the modern and archaeological pig material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

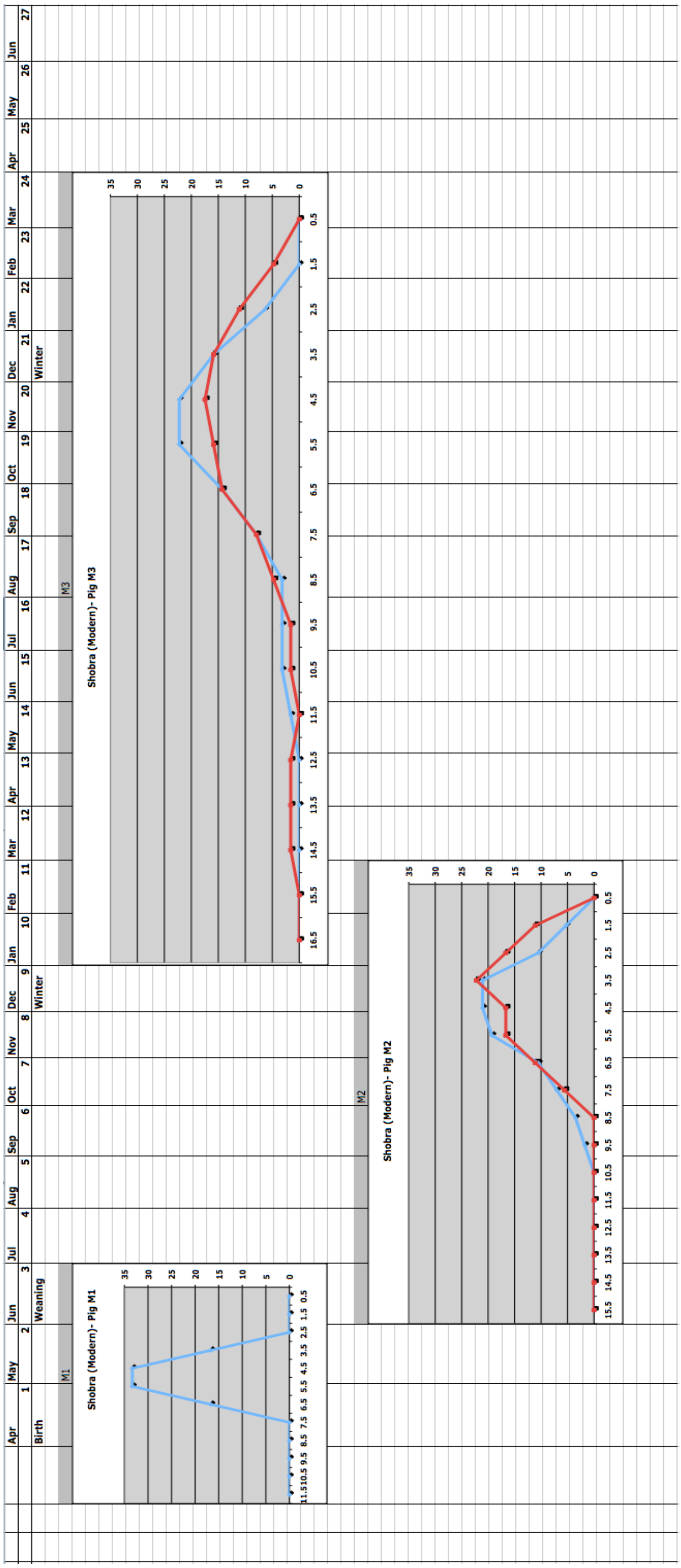

Figure 6.4: The modern Egyptian pig material plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

6.2.3 Interpretation of defect type and severity

Key Points

Teeth from all sites display a high percentage of severe defect types (such as lines), with very few showing low level defects, such as depressions.

Teeth from all sites display low severity score levels, although the Kom el-Hisn, Abydos Settlement Site, South Abydos and Kom Firin have a larger percentage of higher severity scores (levels 3 and 4).

Pits are the least common defect type to occur.

General Results

Tables 6.5 and 6.6 along with Figure 6.5 show the results of the analysis of the defect types and severity scores. Overall, linear defects are by far the most common, which all have very low severity scores (mostly one or two). The sites with the largest percentage of higher severity scores (levels 3 and 4) are the Kom el-Hisn (27% at level 3), Abydos Settlement Site (8% at level 3 and 10% at level 4), South Abydos (13% at level 3 and 3% at level 4) and Kom Firin (16% at level 3 and 2% at level 4).

As previously mentioned, the linear type of defect is by far the most common in all recorded Egyptian sites (both ancient and modern), with only two sites displaying moderate levels of the depression type of defect: Giza (24%) and the modern population from Shobra (23%). The pit type of defect is by far the least common, with the Tell el-Borg data (9%) displaying the highest percentage of pit type defects.

Site	% of linear type defects	% of depression type defects	% of pit type defects
Elephantine (Old Kingdom)	100%	-	-
Giza (Old Kingdom)	76%	24%	-
Kom el-Hisn (Old Kingdom)	79%	14%	7%
Mendes (Old Kingdom)	92%	8%	-
Abydos Settlement Site (FIP)	82%	18%	-
South Abydos (Middle Kingdom)	81%	19%	-
Elephantine (New Kingdom)	85%	15%	-
Amarna (New Kingdom)	89%	8%	3%
Kom Firin (New Kingdom)	85%	13%	2%
Saïs (TIP)	85%	12%	3%
Tell el-Borg (New Kingdom)	82%	9%	9%
Aswan (Ptolemaic- Roman)	84%	16%	-
Shobra (Modern)	77%	23%	-

Table 6.5: Comparison of enamel hypoplasia from all Egyptian sites.

Site/ Severity Score	1	2	3	4
Elephantine (Old Kingdom)	67%	33%	-	-
Giza (Old Kingdom)	15%	85%	-	-
Kom el-Hisn (Old Kingdom)	14%	59%	27%	-
Mendes (Old Kingdom)	23%	75%	2%	-
Abydos Settlement Site (FIP)	24%	58%	8%	10%
South Abydos (Middle Kingdom)	38%	46%	13%	3%
Elephantine (New Kingdom)	41%	48%	11%	-
Amarna (New Kingdom)	15%	77%	6%	2%
Kom Firin (New Kingdom)	23%	53%	16%	2%
Saïs (TIP)	30%	67%	3%	-
Tell el-Borg (New Kingdom)	55%	36%	9%	-
Aswan (Ptolemaic- Roman)	26%	70%	4%	-
Shobra (Modern)	63%	37%	-	-

Table 6.6: Comparison of enamel hypoplasia severities of line defects only for all Egyptian sites.

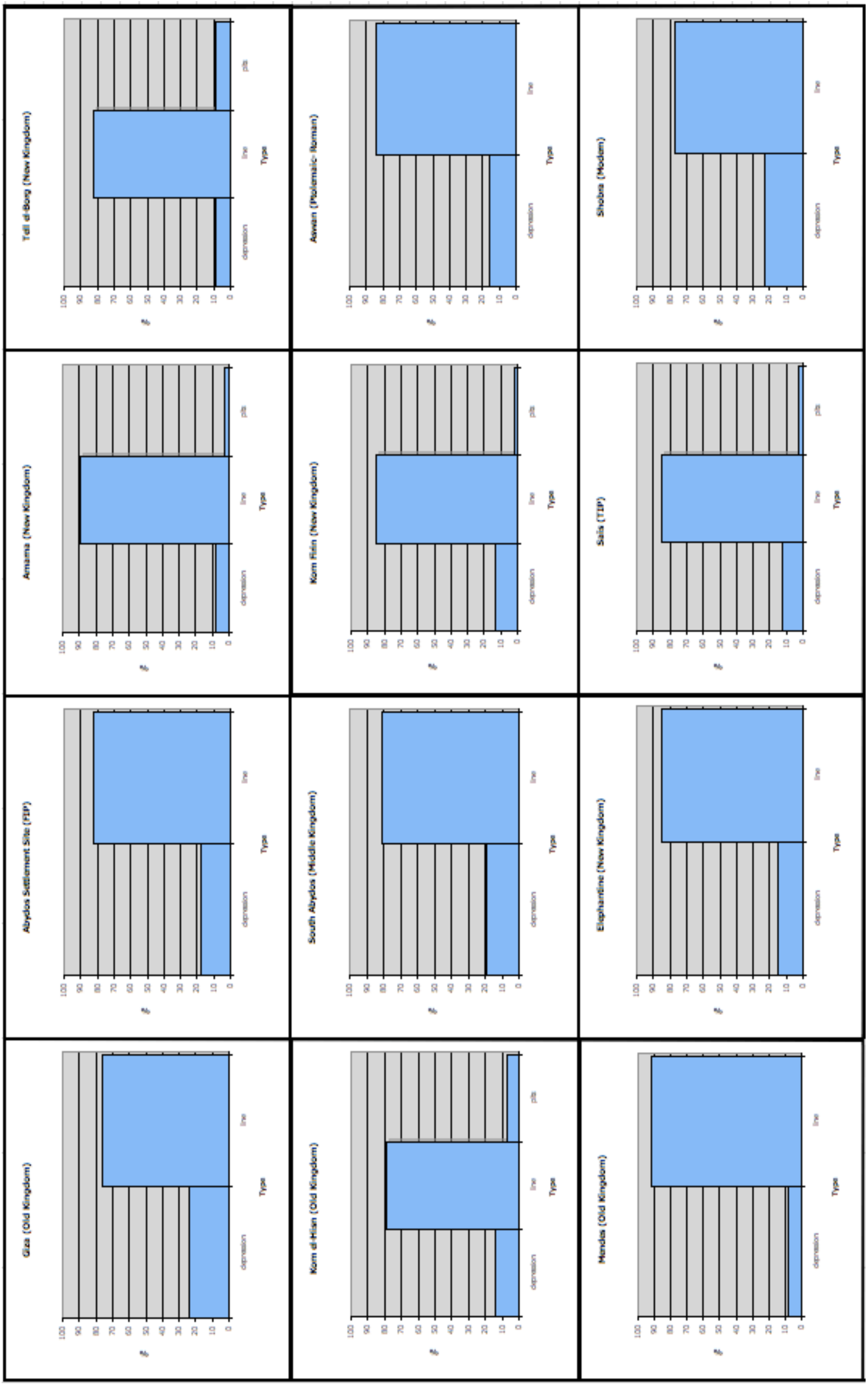

Figure 6.5: Comparing the percentage of different defect severity scored between the modern and archaeological populations.

6.3 Discussion

6.3.1 *Interpreting swine husbandry practices*

As all of the sites are from Egypt, it is highly likely that general animal management strategies may have been very similar throughout the country, despite the wide time range that the archaeological sites represent (c. 2686 BC- c. AD 400), and possibly even including modern populations. As seems to be the case in ancient Egypt, the two main types of swine management strategies are free-range and pens (Miller 1990: 126; Shaw 1984; Kemp 1991: 256). Management strategies along with the environment seem to be the two major factors in determining the frequency of enamel hypoplasia present.

The New Kingdom site of Amarna stands out from all the other sites as it has the lowest frequency (57%) of enamel hypoplasia as compared to all the other sites studied. The only site that has a similar frequency are the modern pigs from Shobra, of which 56% of all teeth studied displayed evidence of hypoplasia. This result is quite surprising at first, as, of all the sites studied in this dissertation, Amarna quite possibly has the harshest settlement environment, being located on the desert edge, in an area that is particularly exposed to the sun and the hot summer winds from the south with no natural shade (Shaw 1984: 49). However, Amarna is the only known ancient Egyptian site to date that has evidence for pig pens (Shaw 1984; Kemp 1991: 256). What is startling is that as discussed in section 4.1.5 is that typically pigs in confined spaces are more likely to be affected by various health-related conditions (such as respiratory diseases) as compared to free-rang animals. Taking this into consideration, it is highly possible that penning can cause a stress on the animals, be it a respiratory disease or even stress from overcrowding. However, the Amarna assemblage, which is known to have been penned, displays a considerably lower frequency of LEH. This is even in comparison to sites such as Elephantine and Mendes that were most likely free range. Thus, it is highly possible Amarna swine husbandry was very good, resulting in fewer pigs having physiological stresses- even ones that can be related to penning. What stresses that would have been encountered were reduced in general and as a result, there was a lower LEH frequency. Furthermore, the percentage of first molars from Amarna that display evidence for enamel hypoplasia is the lowest at 33%, as seen in Table 6.2 (again with the exception of the Shobra pigs, of which 11% of first molars have LEH), possibly indicating that both Amarna and the modern Shobra pigs (which are also known to have been kept in pens) were not as heavily affected by early life stresses as compared to some of the other archaeological populations. This seems to suggest that penning provides a buffer for the pigs from the environmental factors that might otherwise produce enamel hypoplasia.

Although Amarna is the only known site with specific pig penning, as mentioned in CHAPTER 4, the Old Kingdom site of Kom el-Hisn also has evidence for pens, although the type of animal is unknown (Richard Redding, personal communication). However, like Amarna, Kom el-Hisn, also displays a fairly low frequency of teeth with LEH at 69% (as seen in Table 6.2). Furthermore, Kom el-Hisn also displays a low percentage of first molars showing evidence of LEH, at 36% (Table 6.2). Other sites that seem to show a similar pattern of low overall percentage of teeth with LEH along with a low percentage of first molars displaying the defect are: the Abydos Settlement Site (at 69%, with 11% of first molars showing LEH), Kom Firin (at 64%, with 35% of first molars showing LEH, and Aswan (at 67%, with 38% of first molars showing LEH). Although it is unknown if any of these sites may have had penning as well, it is highly possible that these sites at least had more intensive involvement in pig husbandry as compared to some of the other archaeological sites such as Elephantine, Giza, and Tell el-Borg. Although the environment at these other sites is one of either a floodplain or riverbank settlement as compared to the desert edge settlement at Amarna, what makes these sites similar is the likely heavy reliance on pig as a food resource. The reason is that these sites were of slightly lower status as compared to major cult centers such as Elephantine (Khnum cult center) or South Abydos (mortuary cult of the King Senwosret III) or even royal centres such as Malkata (Ikram 1995: 213). At these lower status sites, pigs were a locally maintained, inexpensive food resource that individuals reared either as the primary or supplementary source of protein (Redding 1991: 28).

An analysis was also made of the sites and the modern material with similar frequencies of LEH to compare the cusps of the same tooth to see if there are any notable differences (Figure 6.6). In fact, all of the tooth cusps have fairly similar patterns. The only exception is the anterior cusp of the third molar at Kom el-Hisn, which has a slightly lower percentage of LEH as compared to the middle cusp, and to the third molar from all the other sites. The results could possibly be due to the methodological problem of the ascending ramus of the lower jaw obstructing the observation and measurement of any hypoplasia present, as discussed in Chapter 2. The third molar on the modern population also has a significantly lower frequency of tooth/cusps showing LEH. One possibility for this low percentage is a methodological problem, as in few instances, particularly with a few mandibles from the Amarna and modern sample, the bone was so thick, it was impossible to drill out the third molar, thus obscuring the visibility of LEH. A more likely reason, however, for the decrease is the younger overall age of the population at Kom el Hisn and the modern dataset, thus causing a number of the third molars to either be not fully formed or even erupted in some cases.

On the other hand, the Old Kingdom population from Elephantine displays the highest frequency (88%) of enamel hypoplasia as compared to all the other sites studied. As this is a riverside settlement, it is highly possible that the pig management strategy here was free-ranging, unlike at Amarna where pigs could not survive independently in the desert environment. Furthermore, it is possible that the impact of the Nile flood may have had an affect on these pigs as well, due to the location of the settlement on an island in the middle of the Nile, which, when the Nile flooded, may have limited the pigs normal environment. This is an issue that will be discussed further in the next section.

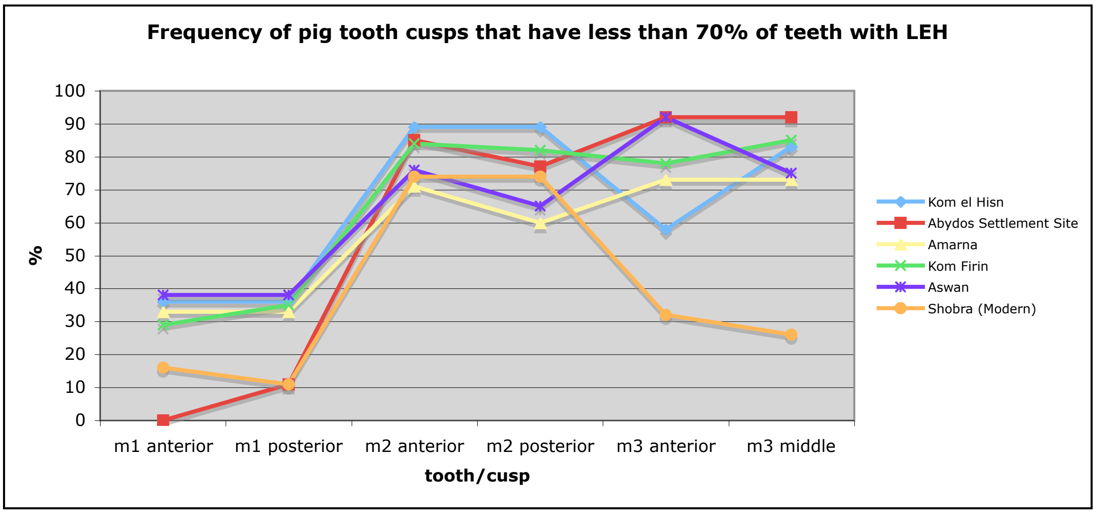

Figure 6.6: Frequency of the five sites that have pig tooth cusps with less than 70% of teeth with LEH and less than 40% of first molars with LEH.

Elephantine also displays the highest percentage of first molars (at 100%) that have evidence of LEH. This is the complete reverse of the five previously discussed sites. This almost certainly because the Old Kingdom Elephantine pig sample is very small, which could be skewing the data and creating a curve that may not be representative of the whole sample. The only other site that displays a similar pattern is that of South Abydos, which also has a fairly high percentage of teeth with LEH at 75%, and the second highest percentage of first molars displaying evidence of LEH at 62%. What is similar between these two sites is that these are sites where pigs are of fairly low status as compared to other animals (Angela von den Driesch, personal communication about Elephantine material; Rossel 2007: 191- 192 on South Abydos) that are more predominantly consumed such as cattle, caprines, and even fish. Thus, it is unlikely that there was a heavy emphasis on pig husbandry and care for these animals, exposing pigs to increased physiological stresses, and a resulting increase in the presence of LEH.

Other sites that display a high percentage of teeth with LEH include Giza at 79% and Tell el-Borg with 78%. Although both these sites in comparison have significantly lower percentages of first molars with LEH (as seen in Table 6.4), this is entirely due to the small sample size, as, aside from the Old Kingdom Elephantine sample, these two sites represent the smallest pig teeth assemblages discussed in this dissertation. These two other sites, however, are also similar in that pig remains are also not prominently represented in the overall faunal assemblage, indicating that there were not as commonly consumed as other animals (Redding In Press; 2007: 265).

6.3.2 Understanding seasonality and physiological impacts: Physiology and animal husbandry

Compared to Europe or America, modern Egypt does not have nearly as intensive a pig breeding regime. In America, under extremely intensive breeding regimes, pigs can be weaned as early as fourteen days. In Europe, however, EU legislation forbids the weaning of pigs before '28 days of age unless the welfare or health of the dam or the piglet would otherwise be adversely affected' (EU Council Directive 2008/120/EC- http://europa.eu/legislation_summaries/food_safety/animal_welfare/sa0009_en.htm). In modern Egypt, pigs are weaned naturally around 2 months (Mr. Magdy, personal communication), similar to the North African wild boar, which also is usually weaned by 2 months (Haltenorth and Diller 1980: 31). Thus, simply from the normal stress associated with weaning, it is possible that, although weaning is at a slightly later age as compared to European and American pigs, Egyptian pigs will still be affected by weaning. The remainder of this section will examine the question of whether the physiological events of weaning along with birth and other nutritional stresses can be identified in the Egyptian pig material as they have been elsewhere (Dobney and Ervynck 2000: 603; Dobney *et al.* 2004: 197). Furthermore, the chapter will discuss the issue of whether such stresses can be used to reveal differences between animal husbandry regimes used at the different sites.

<u>Birth</u>

As discussed in section 6.2.2 relating to the dental development graph (Figure 6.4) for the modern Egyptian pigs, a peak of enamel hypoplasia is identified between 3.5 to 6.5 millimeters, which, according to the chart, seems to be around the time of birth. Because of the moderate sample size (N= 19) and as was discussed in sections 6.2.1 and 6.3.1, only 2 teeth (11%- as seen in Table 6.3) have any evidence of LEH, this is not large enough to be statistically valid. Furthermore, it is highly possible that due to the slightly more advanced wear stages of the first molars, evidence of enamel hypoplasia may have been lost. Otherwise, the modern population did not seem to have experienced much early life stress. However, looking at the archaeological populations, there are a number of sites that also have defects occurring in the range between 3.5 to 6.5 mm (as seen in Figure 6.4), including: Old Kingdom Elephantine, possibly Giza, Kom el-Hisn, and Amarna (both in the Workmen's Village and Main

City populations). Thus it is possible that Egyptian pigs, both ancient and modern, may have encountered some physiological stress from birth, despite the low frequency of its presence in the modern population.

Weaning

With the exception of the modern Egyptian pigs, in all the archaeological populations (as seen in Figure 6.4), a significant peak of enamel hypoplasia is recorded in the cervical half of the first molar (between 2.5-3.5 millimeters). When this data is related to the chronology of dental development, this peak of LEH must be related to a stress occurring after birth, but before the animal has reached four months of age, when the development of the first molar is completed. Such a conclusion is based on a normal, well-nourished population, although development of the first molar can take up to seven or eight months in an under nourished population as described in Mc Cance *et al.* 1961: 220. Thus, it is most likely that weaning and the associated physiological stresses that are connected with this period are responsible for this peak of hypoplasia.

As this peak that is located between 2.5-3.5 millimeters, this range may possibly indicate a difference in the timing of weaning at different sites. In an attempt to see if there is a correlation between possible timing of weaning, geographical context, or if it was a site that likely had more intensive pig husbandry, no patterns were found. The vast majority of the sites that were discussed in the previous section as being likely to have intensive pig rearing (Amarna, Kom Firin, Abydos Settlement Site, Kom el-Hisn, and Aswan) has some peaks at 2.5 millimeters on the first molar (Kom el-Hisn and Amanra), while others had a peak at 3.5 millimeters (Kom Firin and Aswan). Sites that, perhaps, may not have has as intensive pig rearing have similar peaks as well, for example South Abydos at 2.5 millimeters and the Old Kingdom Elephantine population has, what seems to be, a peak at 3.5 millimeters. Thus pig husbandry does not seem to have been responsible for this particular hypoplasia peak. Geographical context does not seem to reveal any patterns either as, although most of the desert edge sites such as Amarna and South Abydos peak at 2.5 millimeters and the riverside New Kingdom Elephantine settlement has a peak at the same height as well. The other floodplain sites (Kom el-Hisn, Kom Firin, and Saïs) along with the riverside settlement of Aswan instead peak at 3.5 millimeters. Although this is a very small discrepancy, and since there seem to be no obvious patterns, this most likely suggests that weaning was occurring naturally, likely between two to three months after birth, was a stressful event that most pigs encountered, and seems to be the most common stress encountered during the development of the first molar. Hypoplasia peaks on the second and third molar can have more variation, and will be discussed in the next section.

6.3.3 *Understanding seasonality and physiological impacts: Seasonal Environmental Factors*

Upex (2010: 216) states that if some stress episodes are connected to the seasonal deterioration of environmental conditions, then a distribution of hypoplastic defects that reflect that particular seasonal cycle should be expected. It is further noted that in order for seasonal patterning to be identified, then there needs to be a known season of birth to ensure that seasonal events affect all animals when they are at a similar age. There is no exact season of pig birth in modern Egypt, as modern practice is to have continuous breeding that result in five litters every two years. The data from modern pig population that was collected, however, has a known season of birth and time of death, which will provide the base for comparison of the archaeological material.

<u>The modern and ancient seasonality in Egypt and its impact on birthing seasons</u>

As discussed in Chapter 3, the single most important seasonal factor in Egypt is the annual flooding of the Nile, which is the country's lifeline. However, the construction of the Aswan dam in the 1960's completely stopped the annual flooding north of the dam. Despite the absence of the annual flood, Egypt is still said to have three main seasons: inundation (mid July-October), winter (mid November- February) and summer (mid March-June). Inundation was the time when farmers prepare their fields, followed by winter when crops are planted, and summer when they are harvested and the temperature is at or reaching its peak. However, in modern day Lower Egypt (and possibly during Ptolemaic-Roman Egypt as well), some slight change is seen due to the constant water supply that has resulted in two growing seasons: planting in October, harvesting in April; planting again and harvesting in September (Penelope Wilson, Personal Communication).

The absence of the flood, however, may make it easier on both the animals and their herdsman and allow for the continuous breeding of pigs, as they do not have to deal with possible displacement and, depending on the level of the flood, possible parasitic infection. Thus, the absence of the flood may allow for easier pig rearing and thus results in there being no specific birthing season.

As the annual flooding was the most important climatic factor in ancient Egypt, it likely had a large impact not only for the preparation of planting crops, but on the animals as well, possibly causing some seasonal stress. However, it is unknown at this point if it was the actual flood, or the repercussions of the annual flood, such as water logging of the soils, that had a greater impact on the animals themselves.

As discussed in Chapter 3, the flood levels consistently varied throughout dynastic Egypt, with some years being uncontrollably high, while others were dangerously low, ultimately resulting in drought. Thus, it is this flood level variation throughout dynastic Egypt that will be explored in the next sections.

Modern Seasonality

Although there are Arabic words to describe all four seasons: *shita (*winter*) rabia (*spring*), seif (*summer*), and kharef (*fall*),* modern day Egypt in reality has only two seasons, which are winter and summer. Winter lasts typically from November-March followed by a brief *khamsin* hot wind in April *(*Wilcocks and Craig 1913: 304) before the start of summer lasting through October.

The modern pig material, as seen in Figure 6.4, shows hypoplasia peaks that are most likely explained by birth (note that month of birth was calculated from both a known age and time of death as discussed in section 5.2 and 5.4.1), that occur at roughly 4.5 millimeters. On the second molar, there is a single peak that occurs at 3.5 millimeters. This peak falls at about eight to nine months of age, or at about the beginning of winter. The third molar also has only one peak that occurs at 4.5 millimeters. This peak occurs between nineteen to twenty months of age, also at about the beginning of the second winter in the animal's life, at a time when temperatures in Cairo decrease.

Archaeological Seasonality

As it is not completely known when and if there was a specific season of birth for ancient Egyptian pigs, in order to construct a possible model for ancient seasonality, one must use the modern material as a base, and therefore construct some working hypotheses/models for the archaeological material. Thus, we will look at the two possible birthing seasons of April (summer) and November (start of winter), as it is highly unlikely that animals were born during the flood season, and how they might be reflected in LEH occurrences. Then, the two scenarios will be used to investigate whether there are changes that may reflect environmental occurrences such as varying flood levels and if they occur throughout dynastic Egypt.

To begin with, as there are twelve archaeological pig samples that are discussed in this thesis, a dental developmental graph will not be constructed for each site to avoid redundancy. The site of Amarna was chosen to compare the two possible seasons of birth (*i.e.* summer versus winter), as it represents a known husbandry regime, has the largest sample of teeth and its enamel hypoplasia pattern is similar to that at other sites. Furthermore, it has a similar LEH pattern to that which is seen in the modern sample.

The Amarna LEH distribution (Figure 6.7) shows some similarities to the modern material (Figure 6.4), with the exception of additional peaks on both the first and second molars. Whereas the modern material displays only one peak on the first molar between 3.5 to 6.5 millimeters that likely represents birth, the Amarna material displays two peaks — a large one at 2.5 millimeters, and a second smaller one at about 5.5 millimeters. Putting aside the issue of seasonality at birth, the first larger peak, falls at about two months after birth, and thus is likely to have been the result of weaning. The second smaller peak, parallel to that in the modern material falls at about the time of birth. Obviously, the pig population that displayed LEH was more affected by the stress of weaning as compared to birth.

The second molar at Amarna also displays two peaks: a large one at 2.5 millimeters and a second smaller peak at about 7.5 millimeters. The first larger peak falls at about eight to nine months after birth, where as the second smaller peak falls at about six to seven months after birth. This is where the issue of season of birth becomes important.

Figure 6.7 shows the Amarna material with the two birth scenarios of a summer and winter birth. If the pigs experienced a summer birth in April, the larger peak at about eight to nine months would fall at the time of winter, as with the modern material. The second possibility of a winter birth in November instead places this second peak at the time of the flood. Although both scenarios could make sense, as both the winter and flood had the potential to cause stress for the animals, when considering the geographical context of the site on the desert edge, the likelihood that the flood is the cause of the peak becomes slim. Despite the fact that the Amarna assemblage consists of material from both the Workmen's Village, Stone Village, and the Main City, it is highly possible that the pig material in the Main City and Stone Village originated in the Workmen's Village and was redistributed from there. The Workmen's Village, however, is quite a long distance away from the floodplain, so the likelihood that the flood was the contributing factor becomes very small, especially in terms of animal displacement.

The flood is thought to affect food production in general and so, it is possible that the flood could affect the animals through the food they consumed- or lack of it. However, considering the intensive rearing regime that was in place at Amarna, the pigs experienced a combination of being fed, as evidenced by the stone troughs that were excavated in the pens (Shaw 1984: 47) and foraging at the nearby garbage heaps for organic refuse. Thus, a lack of food as a result of the flood was less likely to have been a problem

For these reasons, the possibility of winter being the causing factor of the LEH peaks is more likely. This is further supported when considering that the temperatures can drop dramatically during winter months at this site (modern temperatures are known to drop as low as 9.3C/49F in the winter as discussed in Section 3.3), in addition to the decrease in food availability, as this is the planting season when food sources would have been low. The factors of food lack and temperature stress could therefore have resulted in the LEH peak. Another possibility is that since the data (along with all the other archaeological sites) is pooled, these peaks could but do not necessarily represent the same individual. Although these double peaks on the second molar could represent tow different physiological events another possibility is that they represent two different birthing seasons. As Amarna is known to have the most intensive pig breeding regime for all the ancient Egyptian sites recorded, this is a strong possibility, especially when considering the fact that having pigs being born more than once a year would create a greater turnover of pigs all year round so supplies are not interrupted which would result in preserving their meat. Furthermore, as seen in Appendix 2, although there are some individual second molars that do display two occurrences of LEH, most display only one. This further seems to support the likely hood of at least two pig populations born at different times throughout the year.

The pattern seen on the third molar displays only one large peak at 2.5 millimeters, about twenty-one to twenty-two months after birth. Following the summer birth scenario this also would fall during winter, whereas following the winter birth scenario, this would occur during flood season. Again, if the pigs were born in the winter, it is possible that the decrease in food that results from the flood is a possible cause. However, considering the intensive rearing regime in place at

Amarna, and the significant distance of the site away from the flood plain, this proves to be a slim possibility. Rather, the dramatic decrease in temperature that occurs during the winter months combined with the possibility of even fewer food resources available further supports a spring season of birth.

Despite the fact that at Amarna, the site context seems to suggest the likelihood of a summer birth, the possibility still remains that pigs could have been born in the winter, and the flood could have a strong affect on the formation of LEH. To test this possibility, the site of Elephantine was chosen as being a riverside settlement at the southernmost border of Egypt that was likely to have been more affected by the flood as compared to some other sites. As two data sets were available from Elephantine (Old and New Kingdom), both samples are analyzed in Figure 6.8.

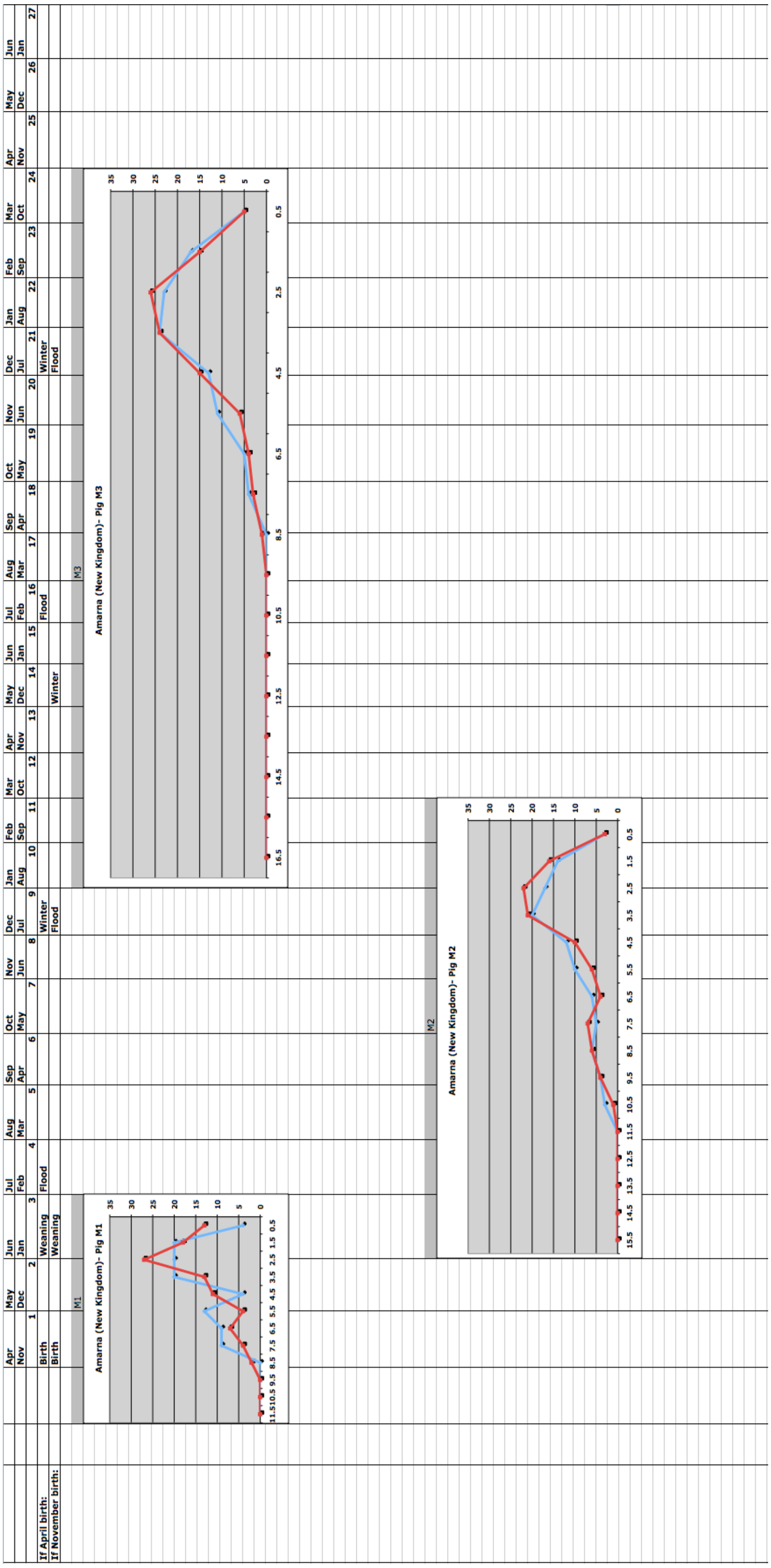

Figure 6.7: Showing the pig material from Amarna plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

Both the Old and New Kingdom samples at Elephantine seem to have a peak on the first molar at about 3.5 millimeters, about two months after birth, probably the result of weaning. Although both samples also seem to show some evidence of LEH as the result of birth, the Old Kingdom sample seems to be slightly more affected by birth than the New Kingdom population, as seen by the slightly larger peak at about 6.5 millimeters. The second molar, however, seems to show a bit more variation.

Looking at the distribution of LEH on the second molar, the Old Kingdom sample shows two discrete peaks: one at 2.5 millimeters at about nine months after birth, and a second smaller peak at 8.5 millimeters at about six months after birth. The New Kingdom sample only shows one peak at 3.5 millimeters at about 8 months after birth. If these two populations were born in the summer, then the larger peak seen in both samples occurs during winter, with the second smaller peak seen on the second molar occurring during the flood. But why is there a second peak on the Old Kingdom sample and not New Kingdom sample?

As mentioned earlier, before the First Intermediate Period, the island of Elephantine would have split into two parts (Franke 2000: 465) when it was inundated during the annual flood that began in July, and not did recede until September (Baines and Malek 2002: 15). However, during the First Intermediate Period, the river level sank, and the swamp between the two islands was filled in, forming one larger island (Baines and Malek 2002: 15; Moeller 2005). If there were indeed a summer season of birth, then the flood covering the island, splitting it in two would explain the second smaller peak on the second molar as a result of stress from displacement. However, in the New Kingdom when the island was unified and not as drastically affected by the flood, the pigs would not have been as adversely affected, as this second peak on the second molar disappears. This could not be tested on the third molars, as none were available for analysis from the Old Kingdom sample. However, if the pigs were born in the winter, then another possibility arises.

If the Elephantine pigs were born in November then the larger peak on the second molar for both Old and New Kingdom populations occurs at the time of the flood. The second smaller peak on the Old Kingdom population would then occur right at the beginning of summer, when Aswan can reach temperatures of over 120 Fahrenheit (over 49 Celcius), thus the extreme heat could be a factor is this second peak. However, aside from the fluctuating Nile flood levels the general climate did not change that much between the Old and New Kingdom in Egypt. Thus, the possibility of a summer birth is more plausible than a winter birth, because if extreme heat is the cause of the second smaller peak, then it should show up in the New Kingdom material as well.

Although there is no third molar data for the Old Kingdom populations, again, the possibility of a summer birth fits in better with the LEH distribution seen in the New Kingdom Elephantine population, as the larger peak at about 4.5 millimeters occurs during winter. If the population were born in the winter, then this larger peak would occur before the flood. As previously discussed with reference to the second molars in the Amarna sample, these peaks could but do not necessarily represent the same individual. In the case of the Old Kingdom Elephantine material all the second molars have LEH representing both peaks, so this does in fact represent two different physiological impacts which are likely the result of nutritional stresses form winter and the annual flood.

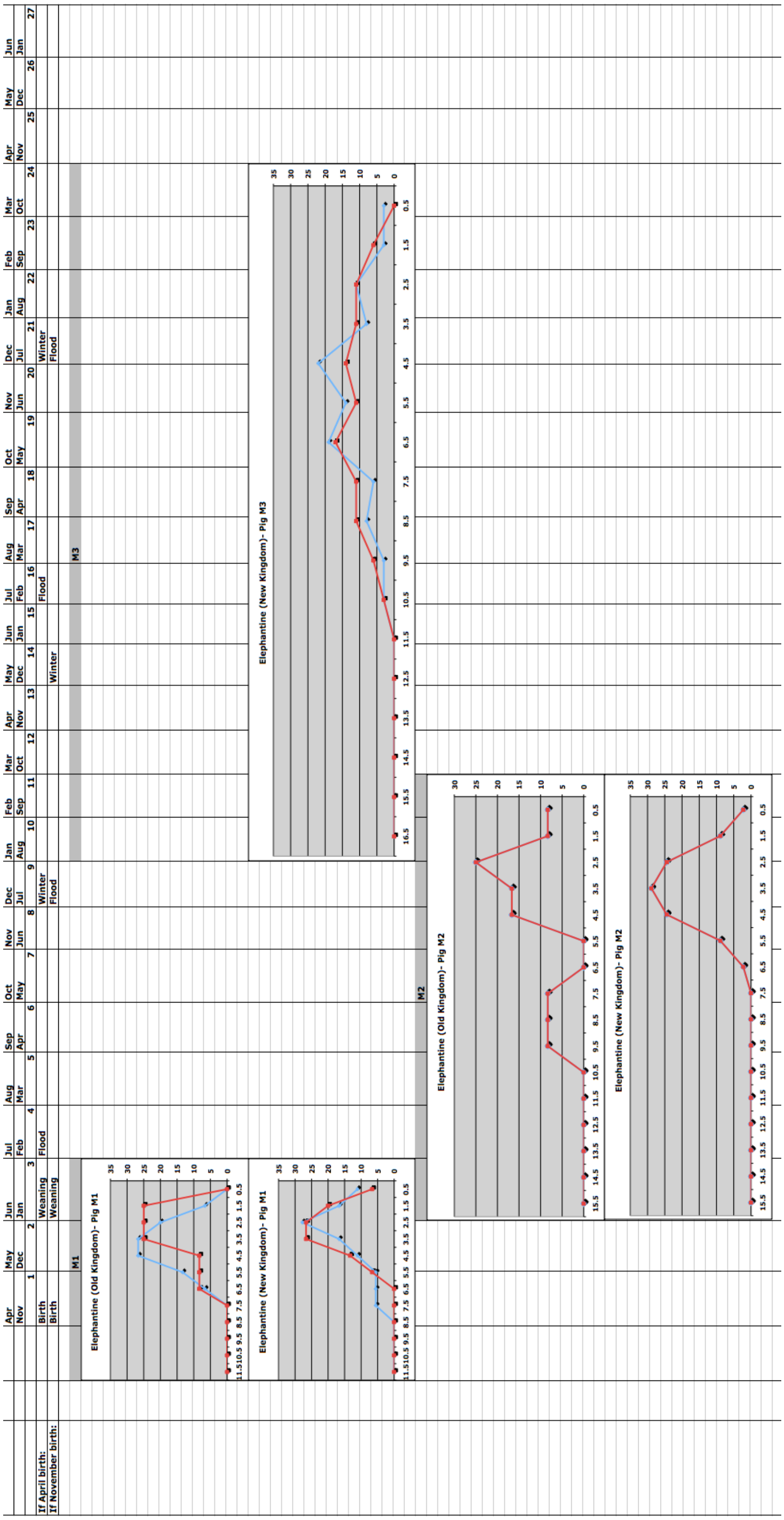

Figure 6.8: Showing the pig material from Old and New Kingdom Elephantine plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

Following the effect of the flood on the Elephantine material, as discussed in section 3.2, after the First Intermediate Period flood failures, a dramatic increase in flood levels is seen in during Middle Kingdom (Seidlmayer 2001: 73-80; Said 1993: 145-6; Bell 1975: 238-245). In an effort to see if this change had any effect on the pigs, the Abydos material can be looked at, as there is data from both the First Intermediate Period (Abydos Settlement Site) and the Middle Kingdom (South Abydos) at this one site.

Comparing these two sites, as seen in Table 6.2, the frequencies of LEH at these two sites are fairly similar, although South Abydos (75%) seems to have a slightly higher percentage than the Abydos Settlement Site (69%). Figure 6.9 displays both data sets and the two possible seasons of a summer or winter birth.

Comparing the first molars, the Abydos Settlement Site had no data available. As discussed in sections 5.3.1 and 5.4.1, both data sets have similar age distribution, although the Abydos Settlement Site is slightly older, which could explain the absence of first molars.

The second and third molars both have similar patterns, although the third molar displays a slightly different pattern. As seen in Figure 6.9, both assemblages third molar display a peak at about 3.5 millimeters (about 21 months after birth). If the pigs had a spring birth, this peak would occur right during winter. However, if the pigs were born in winter, this peak would occur right about the time of the flood. However, due to the low flood levels of the First Intermediate Period, it is doubtful that the flood would have cause this peak in the Abydos Settlement Site sample.

The South Abydos third molar assemblage, however, displays a second peak at about 7.5 millimeters (about 18 months after birth). This peak can also have two different explanations. If a summer birth, then this peak would occur right around the time of the flood. A winter birth, however, would put this peak right during the *khamsin* season/start of summer. As there is not much evidence for the effect of the *khamsin* during antiquity it is doubtful that this could explain the peak. Another possibility if the pigs were born in the winter is a prolonged stress due to the water logging of soils from the high floods creating parasites that might have been consumed by the pigs. Taking these possibilities into consideration, the most likely explanation is the flood, especially when taking into account the high flood levels of the Middle Kingdom. However, looking at the individual teeth (Appendix 2), only three third molars have two occurrences of LEH on the same tooth. This seems to suggest more likely that while some pigs may have been affected by different physiological stresses, more likely this second peak represents two birthing seasons. More work, however, needs to be done to confirm this possibility.

There are other causes of hypoplasia that could contribute to some of the peaks observed in the different pig samples such as infection, short-term nutritional deficiency, or even a sporadic metabolic dysfunction (Dobney, Ervynck, and LaFerla 2002: 40). Looking at pig populations from Egypt, infections could have been rather common, especially during periods of increased Nile flood levels, like that during the Middle Kingdom when long-term water logging of soil took place, as previously discussed. The extra water would have increased soil parasites that were likely to have been consumed by animals along with endangering crops through rot and vermin (Butzer 2000: 550; 1984:105; Seidlmayer 2001: 73-80; Said 1993: 145-146; Bell 1975: 238-245). However, this is an area that would require future study with larger sample sizes, particularly from the Middle Kingdom, as the one sample from South Abydos is not enough to see if is this the cause of hypoplasia peaks or not. The data would also need to be tested against environmental sampling of the soils and sediments from drill augering.

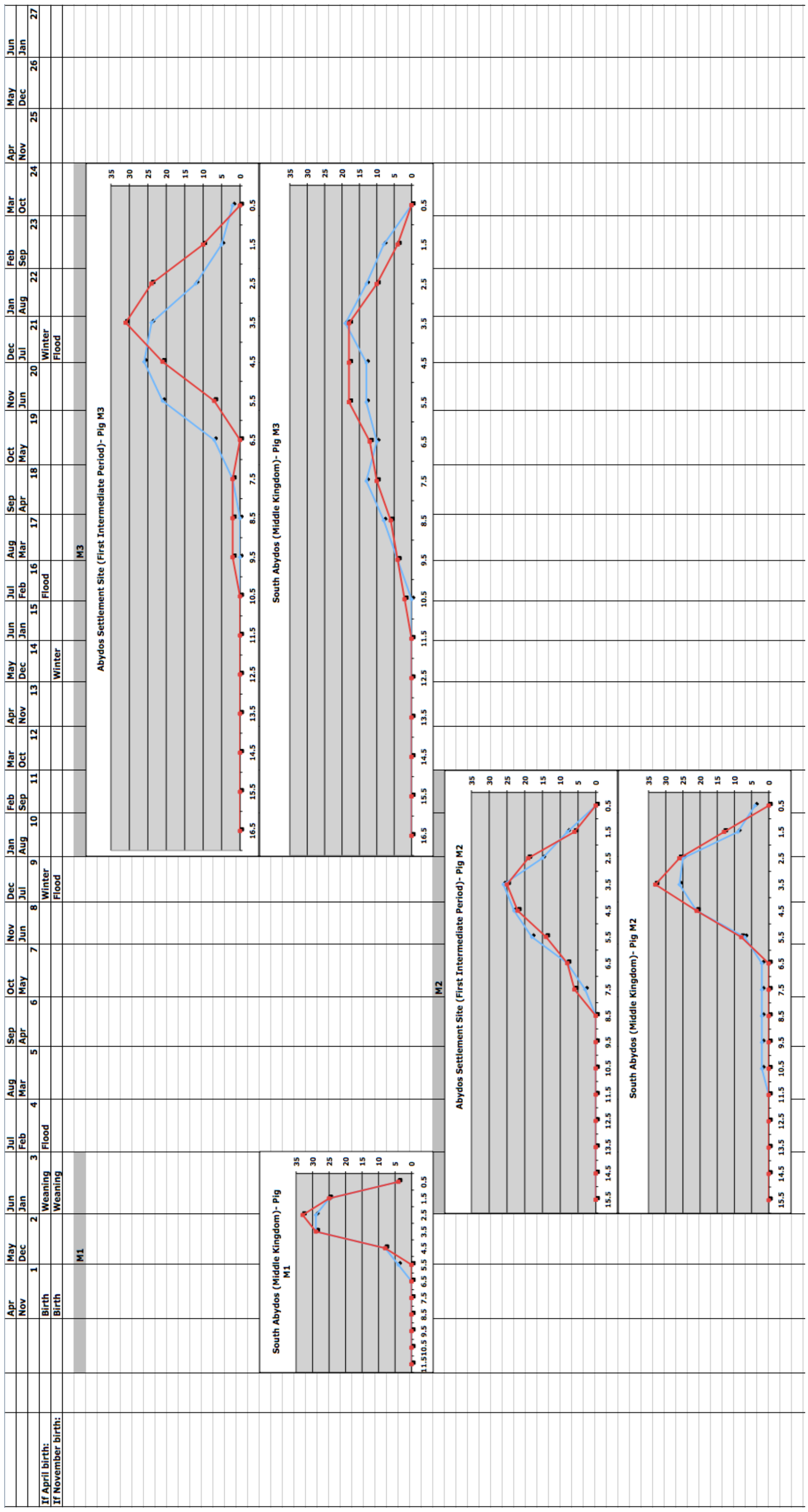

Figure 6.9: Showing the pig material from the Abydos Settlement Site and South Abydos plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

6.3.4 *Interpretation of defect type and severity*

As demonstrated by Witzel *et al*. (2006) and reiterated by Upex (2010: 158), different forms of enamel hypoplasia can be related to different types of stress events occurring in the lives of pigs. Depression-type events were a marker of longer lasting but low intensity periods of stress, whereas linear defects are caused by severe stress impacts caused within a short time duration (Witzel *et al*. 2006: 108).

Although describing sheep data, Upex's (2010: 158) archaeological data seems to support the likelihood that increased frequency of enamel hypoplasia is a reflection of harsher environmental and dietary conditions, as environment and diet are intrinsically linked. Without isotopic analysis, however, it is difficult to ascertain what the animals ate and it is highly possible that since all the Egyptian archaeological sites reveal a high frequency of severe defect types, such as lines, as seen in Figure 6.5, they are likely to have been due to the harsh environment of the desert. None of the archaeological sites or modern material has a large percentage of depression or pit-type defects, although they do occur in very small numbers, surprisingly at the sites as discussed in section 6.3.1 that may have had more intensive pig rearing such as at Amarna, Kom Firin, and Kom el-Hisn.

Defect type

As most of the sites did not have a large enough number of depression-type defects to provide a statistically valid sample (as seen in Figure 6.5, where lines are far more common), in order to compare the different defect types, an analysis was made on the type of defect from all the archaeological sites in comparison to the modern material. The distribution of lines and depressions (pits were not common enough to be included in this analysis) are shown plotted against a seasonal calendar (Figure 6.10) in an attempt to investigate if there is any link between the different types of defects and different seasonal events. For the purpose of this analysis (and to avoid redundancy), only the distributions on the anterior cusps are plotted, but this does not affect the data in any way for, as demonstrated in Figures 6.1-6.3, the distribution of defects on the anterior and posterior cusps are almost identical.

Figure 6.10 shows the distribution of the types of defects recorded for both the modern and archaeological Egyptian pig material in relation to the seasonal and physiological events occurring during the period of tooth development, based on a spring season of birth, which is confirmed for the modern pig population, and as discussed in the previous section, it most likely the case for the archaeological material as well. Concerning the modern first molar material, however, as only one linear type defect was identified along with one depression type defect, no chart was made.

As linear type defects are the most common type of hypoplastic defect in all the Egyptian (modern and archaeological) pig populations, these dental defects clearly map onto the peaks of hypoplasia relating to key physiological and seasonal events as discussed in the previous section. Overall the linear and depression types surprisingly seem to follow the same pattern. However, the modern population, on both the second and third molar, display a slightly different distribution pattern between the linear and depression type defects, although it does not seem significant enough to be a cause for concern. Overall, as seen in Figure 6.10, there is no significant difference between the occurrence of different defect types and seasonal events in the Egyptian pig material.

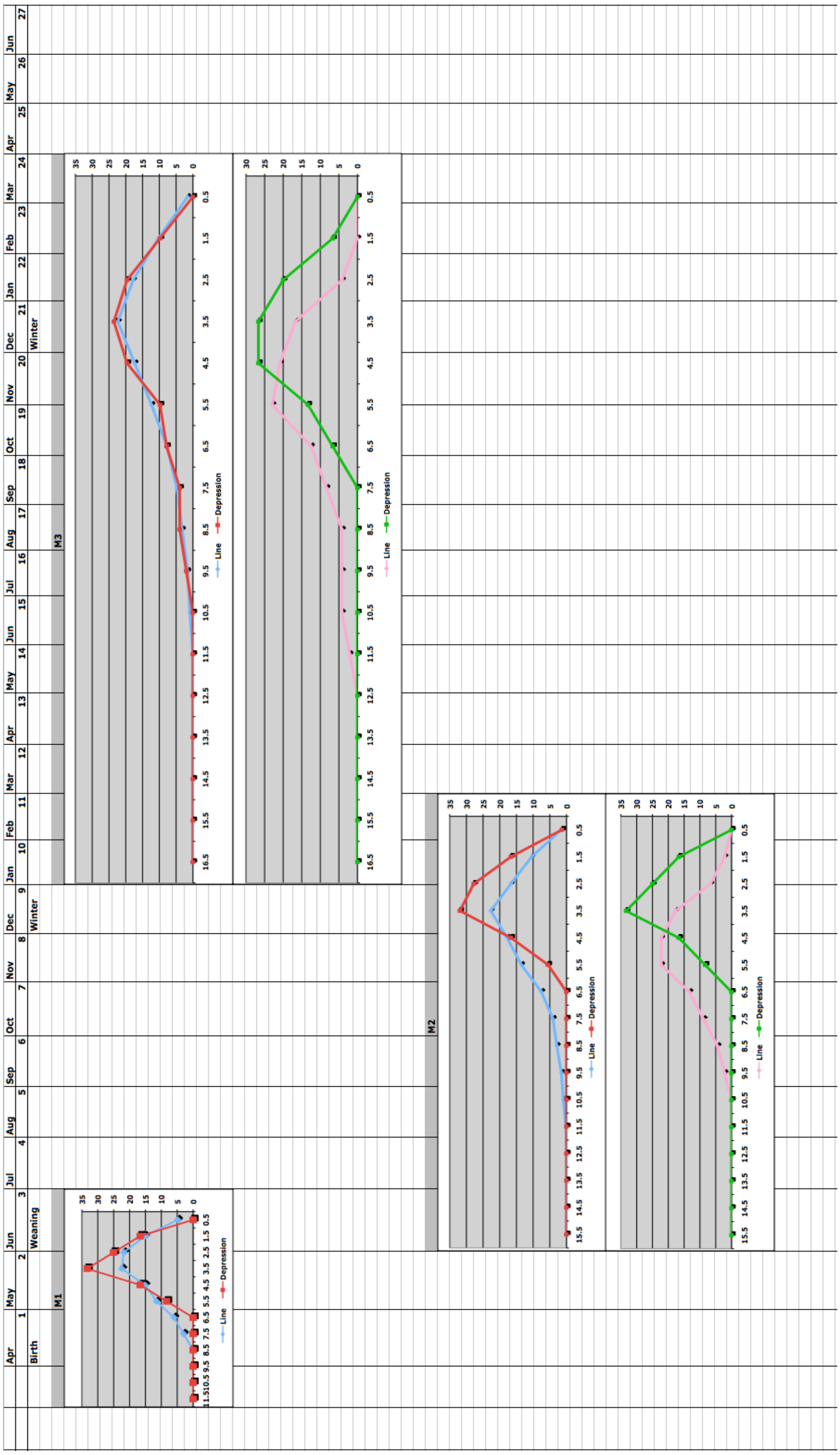

Figure 6.10: Showing the defect types from the all combined archaeological sites (top charts) as compared to the modern pig population (bottom charts) plotted as percentage running means onto a chart of tooth development rates based on a summer season of birth. Months after birth and physiological stressors are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

Defect severity

The previous section combined all of the archaeological data, since a number of sites did not have enough depression-type defects to provide a statistically valid sample. A similar situation is seen when looking at the degree of defect severity of linear type hypoplastic defects. As seen in Table 6.6, very few sites have defects with a severity score of three or four. Thus, the only sites chosen for defect severity analysis are the site of Kom el-Hisn, Abydos Settlement Site, South Abydos, Amarna, and Kom Firin, as these are the only sites that have a significant percentage of defects with severity scores at all four levels as described by Upex (2010: 94). Coincidentally, these sites are also the five sites, except for Aswan where all the sampled teeth had severity scores of one or two, except for one tooth with a score of three, that are likely to have more intensive pig rearing practices as compared to the other sites analyzed. Although this might seem slightly contradictory at first, as the overall percentage of teeth with hypoplasia is significantly lower than the other sites, analysis of when particular degrees of severity occurred might help to create a link between severity levels and specific events in the animal's life.

As with the analysis in the previous section, the height of the different severity scores per molar are plotted as relative frequencies of the total number of hypoplasias observed on each molar as seen in Figure 6.11. The distribution of severity scores represents the anterior cusps only as, again, the distribution of defects on the anterior and posterior cusps are almost identical.

The previous section shows that there seems to be no difference between when specific types of hypoplasatic defects occur. Although the defect severity scores for linear type defects also seem to follow a similar pattern (as seen in Figure 6.11), there are some slight differences. The archaeological data seems to indicate that more severe hypoplasias are present in later developing teeth (second and third molar), with no severe enamel defects (score three or higher) found on the first molar. Defect scores of four are only identified in the second molar. The modern material, however, seems to have slightly less severe defects occurring in the second and third molar, with scores of only one and two present. Furthermore, birth seems to be slightly more stressful on pigs at the five archaeological sites, as the severity score of two displays two peaks at both birth and weaning, where as the severity score of one has a peak only at weaning. Only one first molar in the modern population had a linear type defect, thus was not a statistically valid sample for analysis.

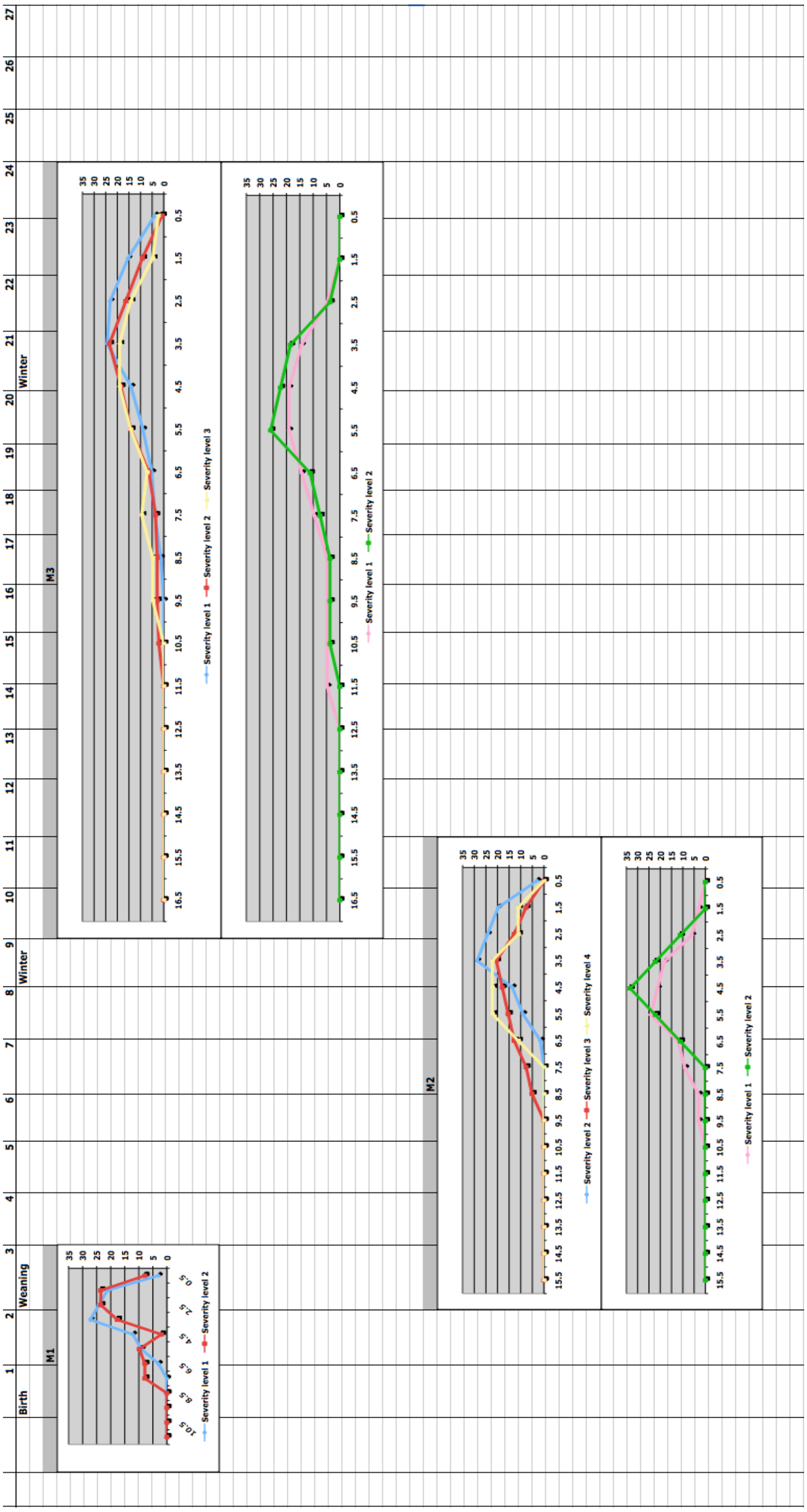

Figure 6.11: Showing the severity scores of enamel hypoplasia for the all combined archaeological sites (top charts) as compared to the modern pig population (bottom charts) plotted as percentage running means onto a chart of tooth development rates based on a summer season of birth. Months after birth and physiological stressors are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

6.4 Conclusions

6.4.1 Interpreting swine husbandry regimes

The site of Amarna stands out from the other archaeological assemblages as it has a considerably lower level of enamel hypoplasia, which is only mirrored by the modern hypoplasia frequency. It is likely that at most Egyptian sites, pigs were free-ranging. However, in environments where pigs would have not otherwise survived, such as at Amarna, other husbandry regimes were necessary, such as penning. Although Amarna is the only known site to date with a different pig regime, it is possible to postulate that other sites may have had at least more involvement in pig rearing. These sites include Kom el-Hisn, Abydos Settlement Site, Kom Firin, and Aswan in addition to the modern material. One last comparative way to look at differences in husbandry regimes is to look at the overall frequency index of pig teeth with enamel hypoplasia.

Figure 6.12 shows the total frequency index for all Egyptian sites studied with pig enamel hypoplasia in comparison to a number of Neolithic European sites (European data courtesy of Keith Dobney). The error bar around the averages per site represents the mean plus or minus the standard deviation. It is interesting to note that overall Egyptian sites have a significantly higher frequency index as compared to the European data sets. The only comparable European site with a high frequency index is the Bercy domestic population, which seems to support two conclusions about the Egyptian material. Firstly, that by the Old Kingdom, Egyptian pigs were fully domesticated as supported by both the high frequency index and size of tooth as discussed in the Chapter 5. Secondly, that the high frequency of Egyptian pig enamel hypoplasia also seems to be indicative of the more harsh and difficult environment of Egypt for pigs compared to that of Europe. The heat and lack of year round food resources in addition to the possible displacement that some animals may have experienced at sites such as Elephantine during the Old Kingdom as a result of the flood, may have been particular problems. The natural conditions seems to be counteracted, however, at sites where intensive pig rearing took place, such as Amarna, where the enamel hypoplasia frequency is comparable to modern pig populations. This suggests that Egyptian swineherds were aware of the effects of environment on their pigs and took measures to rear them more effectively.

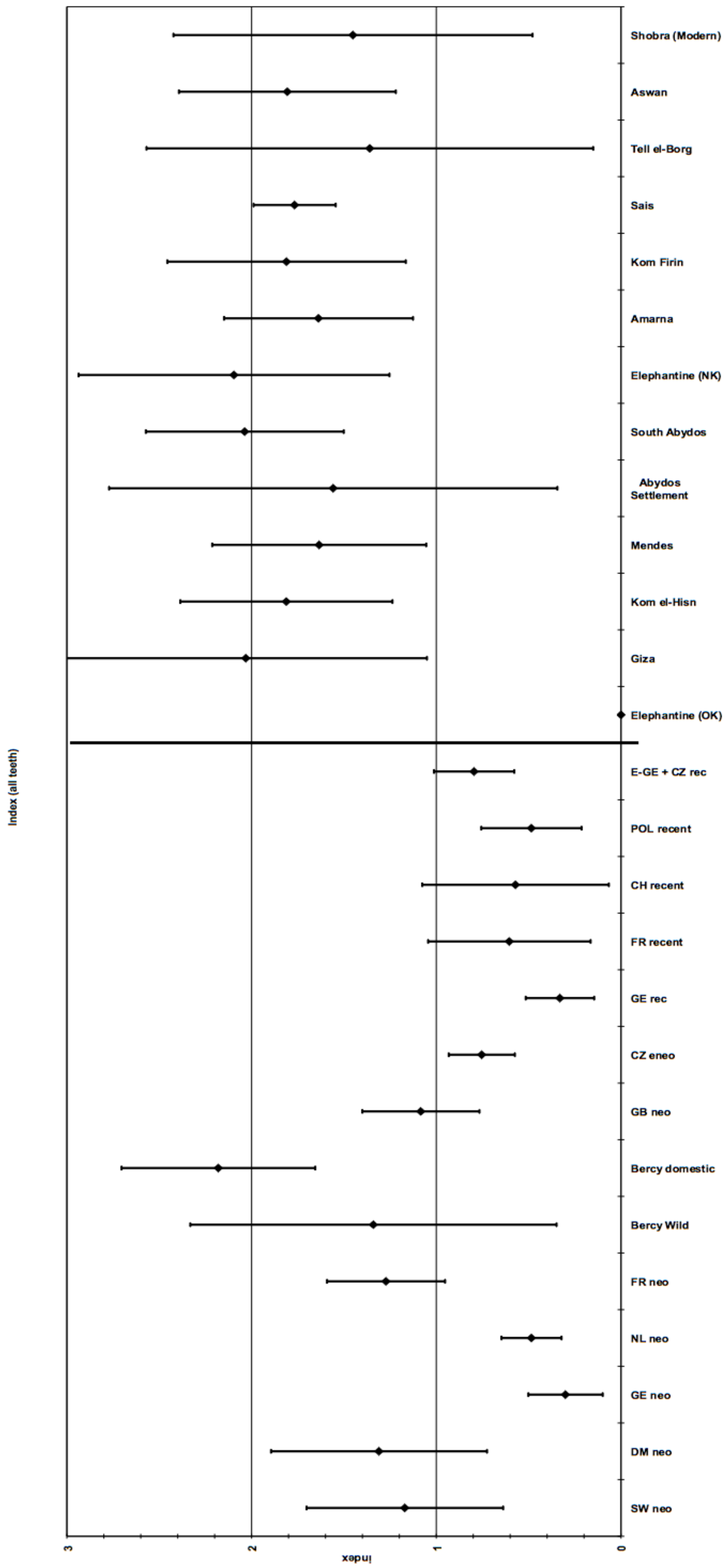

Figure 6.12: Index comparing the average frequency of LEH for all the archaeological and modern Egyptian pig assemblages (to the right of the bold line) and European data (European data courtesy of Keith Dobney), calculated for all molars combined. The error bars represent the mean plus or minus the standard deviation.

6.4.2 Understanding seasonality and physiological impacts

The distribution of hypoplasia on the tooth crown seems to have little difference between all the sites (both archaeological and modern) with the majority of enamel hypoplasia being located in the cervical portions of the tooth crowns. As previously suggested (Dobney and Ervynck 2000: 603; Dobney *et al.* 2004: 197) and confirmed with both the archaeological and modern Egyptian material, peaks of enamel hypoplasia on the first molar are related to both birth and weaning.

In the later part of dental development, environmental events such as winter with the onset of both decreased temperatures and likely decrease in food availability as this is the planting season immediately following the flood recession, along with the occurrence of the flood itself seem to be the cause of the peaks occurring in the hypoplasia distribution of the second and third molars.

There are, however, some interpretational difficulties that need to be considered, namely the difficulty in establishing the seasonal conditions of ancient Egypt and a typical season of birth for pigs. However, ancient Egyptian records provide a window at least into changing Nile flood levels, thus giving some idea as to the ancient seasonal conditions. Furthermore, in testing the two possible birthing seasons for pigs in ancient Egypt, at this point the summer season seems to be the more likely time, as there would be no impact from the annual flood and environmental challenges would be minimal, aside from the extreme heat encountered in Upper Egypt. However, there seems to be reasonable evidence for more than one birthing season in a number of Ancient Egyptian assemblages-notable including Amarna, South Abydos, and Kom el-Hisn, which is likely due to an intensive pig rearing regime. Sites like Elephantine (Old Kingdom), and Aswan (Ptolemaic-Roman), however display two peaks in their LEH distribution (see Figures 6.1-6.3), but when looking at their individual teeth (Appendix 2), most teeth display at least two different occurrences of LEH on the same tooth which likely represents different physiological impacts, most likely the nutritional stresses from winter and impact of the annual flood.

6.4.2 *Interpretation of defect type and severity*

LEH defects are by far more common in both the Egyptian archaeological and modern material, than in European material. Perhaps this reflects the harsher environmental conditions of Egypt. Even when plotted against the chronology of tooth crown development, there are no significant differences of the frequency distribution between lines and depressions on any of the molars. This may indicate that even though different types of stresses can cause different types of defects to occur (linear versus depression, Section 2.2), this did not happen in large enough of numbers (or is because the sample size was to small) to allow the observation of differences in the frequency distribution of lines versus depressions on any of the molars. Furthermore, sites which perhaps had a more intensive pig rearing regime have a greater frequency of higher defect severity levels, particularly in the second and third molars, representative of increased stress likely due to the winter conditions of temperature change and decrease of food availability, in the final months of dental development. However, teeth with higher severity scores are in very small numbers (as seen in Table 6.6), in addition to the fact that all the sites that probably had more intensive pig rearing have the lowest overall frequency of enamel hypoplasia. At this point, more work is needed to confirm if it is the environment or some other stress that is a result of a particular rearing regime causing a higher severity score of the linear-type defect.

7 The Sheep and Goat in Ancient Egypt

Caprines have been a major source of subsistence in the Middle East and Egypt since their domestication almost 11,000 years ago (Redding 1981: 1; Schaller 1977: 37; Bruford and Townsend 2006: 306). The importance of caprines is seen not only by their predominance in archaeological faunal samples, but also in the textual, artistic, and religious record from ancient Egypt. Their taxonomy and nomenclature, however, are very complicated, especially with regard to sheep, as there are more than forty identified wild breeds alone (Clutton-Brock 1987: 52-3).

This section of this thesis (chapters 7 to 9) will combine the data from sheep and goats due to the difficulties of distinguishing between their teeth in the archaeological record. It is important to note, however, that a number of highly effective (although not uniformly accepted by all zooarchaeologists) criteria have been developed to distinguish between the post-cranial elements of sheep and goat (Boessneck *et al.* 1964; Boessneck 1970; Hole *et al.* 1969; Prummel and Frisch 1986; Balaase and Ambrose 2005) and some of those criteria are used throughout this study, and are addressed in chapter 2. Recently, Zeder and Pilaar (2010) published tests of all published criteria for distinguishing sheep from goat teeth and mandibles. They found that the only reliable criteria were those relatd to whole mandibles.. Although this method is applied to the modern sample (discussed in chapter 8), it was published after the archaeological material had been studied. Additionally, much of the archaeological material consisted of incomplete mandibles rather than a complete articulated group that could be assigned to either sheep or goat.

7.1 Natural History of Egyptian Caprines

7.1.1 Taxonomy, Distribution, and Appearance of Caprines throughout Egypt (Order: *Artiodactyla* Family: *Bovidae*)

Sheep:

There is no animal that has more confusion surrounding its taxonomy than the sheep, as there are almost as many systems of its classification as there are sheep varieties. With respect to the wild sheep breeds, many authors have identified as many as one to nine species in both Eurasia and North America (Lydekker 1913; Nasonov 1923; Haltenorth 1963). In the Eurasian region, early authors (Lydekker 1913; Nasonov 1923) have recognized three species of wild sheep, which are the Moufflon (*Ovis musimon*), Urial (*Ovis orientalis*), Argali (*Ovis ammon*). The Argali has contributed to the domestic stock of India and the Far East, while the moufflon is generally believed to have not produced any domestic sheep (Zeuner 1963: 158). The Urial, however, is generally believed to be the ancestor of the largest number of domestic sheep breeds (Zeuner 1963: 159; Redding 1981: 57). The Urial or *Ovis orientalis* (Figure 7.1) is a dark colored sheep with a small body, long legs and short tail. Their horns are smaller and less twisted than other groups of wild sheep (Clutton-Brock 1987: 57; Brewer 1994: 91).

Figure 7.1: Image of Wild sheep (*Ovis orientalis*) (http://www.biolib.cz/IMG/GAL/23358.jpg)

However, more recent work on wild sheep shows the presence of two wild sheep species, which are differentiated based on their chromosome numbers rather than their morphological traits (Valdez, Nadler, and Bunch 1978; Nadler, Lay, and Hassinger 1971; Rezaei *et al.* 2010). In Iran, there are two cytologically distinct populations with diploid (2N) chromosome numbers of 58 in northeastern Iran and 2N= 54 in northwestern Iran. These two breeds overlap in the Elburz Mountains in northern Iran where hybrids display intermediate chromosome numbers between 54 and 58 (Valdez, Nadler, and Bunch 1978: 56; Nadler, Hoffmann, and Woolf 1974: 744). Although this is the classification that has been adopted as the current reference by the International Union for the Conservation of Nature and Natural Resources (IUCN) (Shackleton and Lovari 1977), since no genetic work has been done on any sheep in Egypt, for the purposes of this paper, only morphological traits as identified by Lydekker (1913), Epsetin (1971), Lortet & Gaillard (1907), Ryder (1983), and Zeuner (1963) will be addressed and used to differentiate sheep. This is due to the fact that zooarchaeologists working in Egypt are not allowed to do genetic analysis work on animal bone remains. Thus, we are forced to rely only on morphological differences in the bones.

Due to an absence of skeletal evidence from early sites (before 5000 BC) there is no evidence to indicate what specific species of sheep first reached Egypt. We must therefore resort to artistic evidence in order to discern what possible breeds were present at this time. Although illustrations of sheep have not been found before the Predynastic (c.4000 BC) period, by the Old Kingdom (c. 2686 BC) sheep are seen in wall decoration, knife handles, slate palettes, and even associated with a number of gods (Ryder 1983: 105; Ikram 1995: 17).

The earliest identified sheep based on ancient Egyptian artistic representations is the *Ovis longipes paleoagyptius* (Figure 1.2), although it is possible that earlier types of sheep may have reached Egypt in the fifth millennium BC or even before that (Zeuner 1963: 178). Although the Egyptian varieties of sheep appear to have longer legs than the ones depicted in Mesopotamia (Ryder 1983: 107), this is the feature that caused Lortet and Gaillard to name it *Ovis longipes paleoagyptius* (1907). This breed is also distinguished by its loosely spiral corkscrew horns seen on the backside of the Libyan (Cities) Palette (Figure 7.2) as early as the Naqada II/Gerzean period (c. 3500 BC). This breed, however, seems to disappear in art by the Middle Kingdom, although it does continue to exist in outlying districts. A close relative of the *Ovis* *longipes paleoagyptius* are the Bishari sheep of Upper Egypt and the Nigerian long leg Hausa sheep (Zeuner 1963: 181; Lydekker 1912: 224).

Figure 7.2: Libyan or Cities Palette, Egyptian Museum, Cairo (http://xoomer.virgilio.it/francescoraf/hesyra/palettes/tehenu.jpg)

In the Middle Kingdom, the *Ovis longipes paleoagyptius* seem to be replaced with the more traditional 'Amun' horned sheep, which Lortet and Gaillard named *Ovis platyara aegyptiaca* (1907: 107). Images of this newly introduced sheep begin to appear around the twelfth dynasty (c. 1985 BC) (Ryder 1983: 107), although the physical evidence for it is minimal. The first definitive depictions of this sheep come from the New Kingdom (Figure 7.3).

Figure 7.3: Statue of Amun, Louvre Museum, Paris (Personal Photo)

The *Ovis platyara aegyptiaca* is also represented archaeologically by the many horn cores recovered at Abusir and by the mummified sheep at Saqqara (Ryder 1983: 107). This woolly sheep with a convex nose also seems to be the same sheep that became to symbol of the god Amun, hence the term to describe the shape of the horns which curve down and forward (Smith 1969: 308). Its fleece is long and bushy, ranging in colour from black to brown, to yellow, and even white, which can even be seen in some mummified sheep remains (Ryder 1983: 109).

The fat-tail sheep represent the third type of sheep from ancient Egypt. Like the *Ovis platyara aegyptiaca*, pictorial evidence for their existence from the Middle Kingdom is inconclusive. As the name of this type of sheep would indicate, their tails were so large that the animal seems to have suffered as a result of its length as Herodotus describes (III: 113):

"They have moreover two marvelous kinds of sheep nowhere else found. One of these has tails no less than three cubits long. Were the tail to trail after them, they would suffer hurt by the rubbing of the tails on the ground; but as it is every shepherd knows enough of carpentry to make little carts which they fix the tail of each several sheep on its own cart."

The fourth type of ancient sheep is the Amun horned sheep with an extra pair of horns, also referred to as the four-horned sheep as seen in Figure 7.14. Although some four-horned are known, such as the Piebald sheep in England, it is unlikely that this type of sheep existed in ancient Egypt. This combination of the two sets of horns, along with a goat beard, may in fact simply represent the divine essence of the ovid-caprine group of animals, and is most likely the syncretization of the gods Amun and Khnum (Zeuner 1963: 184; Ryder 1983: 108).

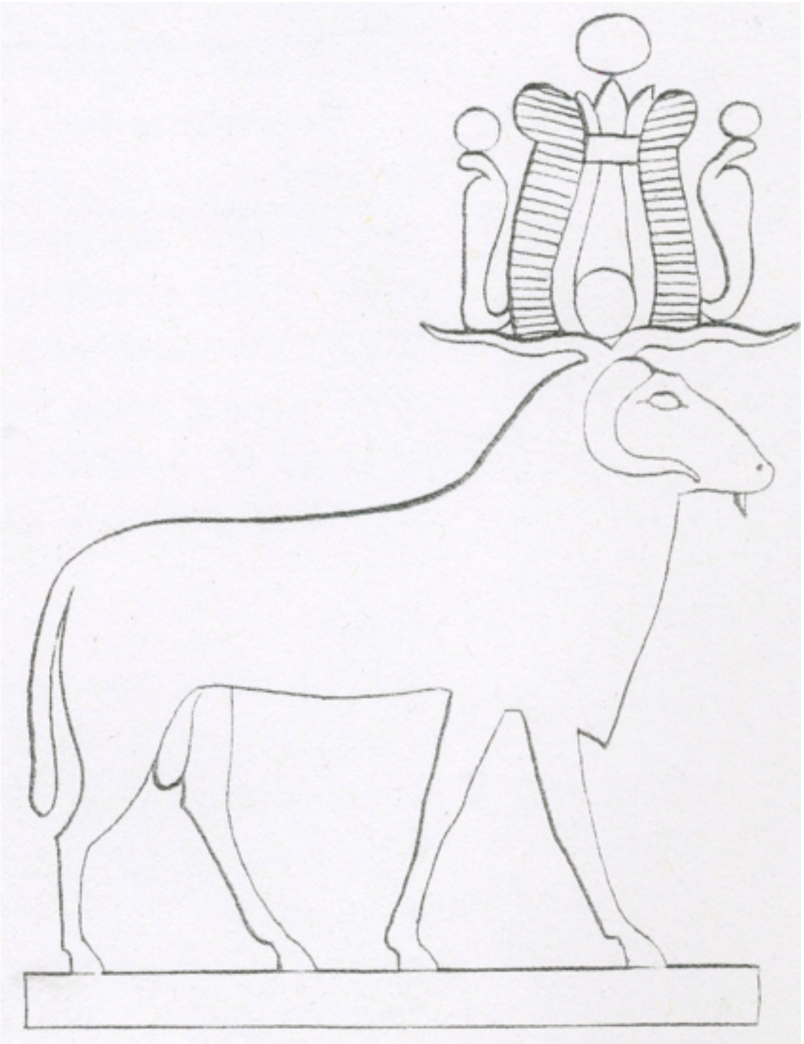

Figure 7.4: Four-horned sacred Egyptian ram dating to the New Kingdom (Zeuner 1963: Figure 7.17)

The last type of ancient sheep is that of the wild Barbary sheep (*Ammotragus tragelaphus*). The Barbary sheep is a very unique species in that it shares sheep and goat characteristics in both the skull and horns, resulting in some identification as sheep and others as goat. Ultimately it has been classified separately from both sheep and goats, and it is the large size of the horns particularly in the female that set this species apart from any other sheep or goat (Anderson 1902: 335; Osborn and Helmy 1980: 521). However, its diploid chromosome number is 58, similar to wild sheep (Schaller 1977: 43; Nadler, Hoffmann, and Woolf 1074: 744).

From both historical and modern times Barbary sheep are known to inhabit the eastern desert in the Wadi Asyuti and Wadi Mellaha, and the western desert in the rugged areas of Ain Dalla and Gebel Uweinat (Manlius 2009: 119-120; Hendrickx *et al.* 2009: 190). The majority of the known rock-art representations of the Barbary sheep come from the Kharga Oasis where at least twelve rock art examples have been counted ranging in dates throughout the Pharaonic period, with some possibly being modern and other examples originating in the rock art of the eastern desert (Salima Ikram, personal communication).

Goats:

Compared to the sheep, goat taxonomy is more straightforward, despite the fact that the goat may have been domesticated before the sheep (Clutton-Brock 1987: 59-60). Live *Ovis* (Sheep) can be distinguished from *Capra* (Goat) morphologically by the presence of pre-orbital glands, inguinal glands, pedal glands on all feet; and by the absence of a callus on the knee, potent body odor, and a beard on the males. Goats are bare underneath, and the horns of females tend to be larger in goats as compared to sheep (Schaller 1977: 22).

Unlike sheep, all goats, both domestic and wild, have a chromosome number of 2N= 60 (Nadler, Hoffmann, and Woolf 1974: 744). Despite this genetic similarity, morphological differences are the main criteria by which goats are classified, with horns being the main taxonomic character used for classification (Schaller 1977: 23). The number of goat species is still under debate, but estimates range between six to nine species (Schaller 1977: 23; Shackleton and Lovari 1997: 12-13). Wild goats are highly sexually dimorphic, including five adult male horn (Figure 7.5) morphotypes (Pidancier *et al.* 2006: 740; Schaller 1977: 26-27).

Figure 7.5: Heads and horns of several *Capra* goats. 1:Bezoar, 2:Ibex, 3:Markhor, 4:Spanish Ibex, (Schaller 1977: Figure 6).

The most common type of wild goat is the Ibex (*Capra ibex*), which includes the Alpine, Asiatic/Siberian, Nubian, and Walia. Their horns are scimitar-shaped although the anterior surface is relatively flat and broken by prominent transverse ridges (Pidancier *et al.* 2006: 740; Schaller 1977: 26). Comparatively, the Spanish

Ibex (*Capra pyrenaica*) has horns that are curved like a lyre, turning out, and have a triangular cross-section (Pidancier *et al.* 2006: 740; Schaller 1977: 27).

Another type is the eastern tur (*Capra caucasica*) found in the eastern half of the Caucasus Mountains of Eurasia between the Black and Caspian Seas. They have heavy, almost round horns that curve out, up, back, inward, and are somewhat like that of the Spanish goat (Pidancier *et al.* 2006: 740; Schaller 1977: 27). The Markhor (*Capra falconeri*) found in north-east Afghanistan and central Pakistan is rather different, having somewhat laterally compressed spiralling horns that twist into an open or tight spiral (Pidancier *et al.* 2006: 740; Schaller 1977: 27).

The last type is that of the Bezoar (*Capra aegagrus*) found in the mountains of the Asia Minor and extend across the Middle East, which like the Ibex, has scimitar-shaped horns, although they are laterally compressed and are teardrop- shape in cross-section (Pidancier *et al.* 2006: 740; Schaller 1977: 26).

Whereas all the wild goats are a product of the sheep/goat divergence that took place no later than the early Pleistocene (Nadler, Hoffmann, and Woolf 1974: 744; Hartl et al. 1990: 181; Zeuner 1963: 131), the domestic goat (*Capra hircus*) came into existence sometime between 7000-5000 BC (an issue that will be discussed in further detail in the next section), derived from the Bezoar, becoming the dominant breed in the region (Zeuner 1963: 132-133; Bruford and Townsend 2006: 306; Naderi *et al.* 2007, 2008).

Although domestic goat remains have been found in Egyptian archaeological contexts from the Predynastic period onward at sites such as Merimde and the Fayum, it can be assumed that both the domestic sheep and domestic goat entered Egypt at about the same time (Ikram 1995: 18-19; Brewer 1994: 91). Like the sheep, most of our knowledge about the breeds present at the time is from the artistic representations that have survived in the dynastic period.

The types of goats in Egypt include the scimitar-horn goat (*Capra hircus*), which is seen as early as the predynastic period on slate palettes, notably one from Hierakonpolis (Ikram 1995: 18). Although images of this type of goat are seen throughout the Old Kingdom, it seems to disappear by the Hyksos period (Zeuner 1963: 138-139).

The second type of domestic goat seen in Egyptian art is the ‘corkscrew’ horned goat (*Capra hirca girgentana*) (Zeuner 1963: 139; Ikram 1995: 18). It has also been noted that foreign corkscrew goats were introduced into the country during dynastic times, such as the Libyan goat brought to Sahure in Dynasty 5 as seen in his Pyramid valley temple (Ikram 1995: 18).

Other types of goats in Egyptian art include the dwarf goat (*Capra hircus reversus*) that is also pictured on the Hierakonpolis slate palette, the Syrian/Mamber goat (*Capra hircus mambricus*), and the Theban goat (*Capra hircus thebaicus*) (Zeuner 1963: 139; Ikram 1995: 19; Epstein 1971: 299).

Figure 7.6: Image of a Nubian goat (http://www.dairygoatjournal.com/goats/pix/nubian-03.jpg)

7.1.2 Domestication of Egyptian Caprines

Both the genus *Ovis* and *Capra* are found within the subfamily Caprinae of the family Bovidae. The divergence of Caprinae from Bovidae is estimated to have occurred during the Pleistocene (18 million years ago- 10,000 years ago) at c. 11 million years ago, based on the molecular studies of mitochrondrial rRNA genes

(Allard *et al.* 1992: 3972-3973). *Capra* and *Ovis,* as previously mentioned, are thought to have diverged c. 5-7 million years ago, with most of the subsequent diversification with in these genera taking place during the Pleistocene (Bruford and Townsend 2006: 306; Kurtén 1968; Geist 1971). Domestication, however, can be looked at, like taxonomy, in one of two ways: genetics and morphology, of which archaeologists have more commonly used the latter.

Recent studies on genetics of Caprines have looked at the polymorphism of mitochondrial DNA (mtDNA) to clarify taxonomical and phylogenetical relationships of sheep and goats (Buford and Townsend 2006; Takada *et al.* 1997; Nadler, Hoffman, and Woolf 1974; Wall, Davis, and Read 1992). These recent studies seem to confirm that the domestic sheep (*Ovis aries*) is most closely related to the Urial (*Ovis orientalis*) (Bruford and Townsend 2006: 313; Rezaei *et al.* 2010: 315) and the domestic goat (*Capra hircus*) to the Bezoar (*Capra aegagrus*) (Takada *et al.* 1997: 321; Pidancier *et al.* 2006: 746).

However, since there is no study of the genetics of Egyptian caprines yet, we must therefore rely on morphology to look at domestication.

***Sheep**:*

Archaeologists have more traditionally relied on morphological characteristics along, with human-oriented markers to differentiate wild from domestic stock. With respects to sheep, domestic animals can be differentiated from wild based on the following eight characteristics, which can sometimes be seen in ancient Egyptian artistic representations (Zeuner 1963: 162-167):

1. Wool (domestic breeds tend to have a thick coat);
2. Long Tail (in domestic breeds);
3. Fat Tail (in domestic breeds sometimes even with fat);
4. Lop-Ear (whereas wild species have small and stiff ears);
5. Convex Nose (though this is not a characteristic that is entirely confined to domestic breeds);
6. Colour of hair and wool;
7. Horn Shape (horns are smaller in domestic breeds and tend to drop away to the side instead of rising due to a weakening at the horn base);

8. Hornless females. This characteristic should be used with caution as this is a trait that can occur in a small proportion of wild female sheep (Hesse 1978: 184; Zeder 2006a: 183).

However, the two main morphological characteristics that are used to differentiate wild and domestic sheep from archaeological assemblages are that of the horn shape and bone size (Reed 1959: 1632). Other human-oriented markers such as zoogeography, abundance and demographic factors can also be used to differentiate between domestic and wild populations from the archaeological record (Zeder 2006a: 185-189).

It is possible that the earliest evidence for domestication, or at least the first recognizable stages of domestication date to the late Epi-Paleolithic period (c. 8000 BC). Despite the presence of domesticates, people still continued to hunt, with the chief game being gazelle and wild cattle, along with the occasional wild sheep and goat. However, with the onset of the Pre-Pottery Neolithic period in the Near East (c. 6000-5000 BC), the percentage of identified sheep remains greatly increase, mostly being made up of immature individuals (Zeuner 1963: 171).

Zawi Chemi Shanidar is an Epi-Paleolithic site located in North-eastern Iraq whose carbon-14 dating puts the site at 10,870 +/- 300 BP or c. 8,920 BC (Perkins 1964: 1565). As the site is located on the valley floor of the Baradost Mountains with steep cliffs on either side, sheep are actually quite scarce in the region (Perkins 1964: 1566). What becomes puzzling is what then accounts for the high percentage of sheep remains in the faunal assemblage? Perkins maintains that the increase in sheep exploitation in an area that he felt was unsuitable for wild sheep supports his claim that the sheep at this site may have been domestic. He further supports his claim by emphasizing an increased percentage in immature sheep identified remains, indicative of intensive breeding (Perkins 1964: 1566). Nevertheless, it can be assumed that regardless of whether the sheep at this site are domestic or not, Zawi Chemi Shanidar represents the first stages of sheep domestication.

A second site with possible early evidence of domestic sheep is Jericho. Located near the Jordan River in the West Bank of the Palestinian Territories, continuous occupation of the site of Jericho began in the Natufian Period (c. 10,000 BC) and continued through the Neolithic Period (c. 5000 BC) and even through the Bronze Age and Byzantine Period (Kenyon 1957, 1964). Because of the difficulties of differentiating sheep from goat bones, only a total of 14 sheep bones have been identified at the site dating to the Pre-Pottery Neolithic period (c. 6000-5000 BC) (Clutton-Brock and Uerpmann 1974: 262). It is possible that these remains could represent domestic sheep, but since there are so few remains identified, it is difficult to reach any firm conclusions (Clutton-Brock and Uerpmann 1974: 273).

The only other early Neolithic site with possible domestic sheep is Belt Cave in northern Iran. Despite the fact that Zeuner (1983: 171) states that Belt Cave is the earliest site that has produced domestic sheep, the sheep remains that were found and identified do in fact date to the Neolithic period, with the bones of sheep and goat displaying a high ratio of immature specimens making up 25% in the pre-ceramic (c.5840 BC) levels and 50% in the ceramic (c.5330 BC) levels. This seems to be indicative of domestication. The earlier level dating to the lateest Epi-paleolithic (c. 6620 BC) seems to contain mostly gazelle remains (Coon 1957: 150, 166). However, by 5000 BC, domestic sheep are found at all Near Eastern sites (Zeuner 1963: 172), including Egypt.

Although the date of the introduction of sheep into Africa is debatable, the earliest evidence for possible domestic sheep in Africa comes from the site of Haua Fteah in Libya. Dating to c. 6000-5000 BC, the Haua Fteah remains are, as at most sites, complicated by the difficulty of differentiating sheep from goat, in addition to the presence of Barbary sheep (*Ammotragus tragelaphus*). In fact, Higgs states that the decision was made to group all three species together in the analysis of faunal remains (1967: 165-166), making it impossible to look at any species-specific percentages. Higgs does state that the domestic sheep and goat was in Africa before 4800 BC, but likely no earlier than 6450 BC (1967: 169). If this were correct, that would put the introduction of domestic sheep and goat into Africa (and Egypt) at c. 6000 BC, and it is possible that the animals were herded in stages across the Sinai and the northern coast of Egypt into Libya, moving up and into the Nile valley at the same time (Reed 1969: 372). The sites in Egypt with the earliest evidence for domestic sheep are the Fayum (Kom W and K) and Merimde Beni Salame (Caton-Thompson and Gardner 1934; Midant-Reynes 1992: 111).

Excavated between 1924 and 1928 by Caton-Thompson and Gardner (1934), the Fayum sites of Kom W and K, as labeled by the excavators, are located on the northern end of lake Qarun. Dating to c. 5200- 4500 BC, most of the faunal remains from the site consisted of elephants, hippopotami, crocodiles, fish, and freshwater mussels from the lake. There was, however, a small presence of supposedly domesticated goats, sheep, cattle, and pigs, showing that this site was indeed fully Neolithic. This, with the exception of the pig, was confirmed by Polish excavators in 1981 (Midant-Reynes 1992: 103-4).

Merimde Beni Salame also exhibits domestic animal remains. Beginning with the first stratum (Level I/*Urschicht*), which dates to c. 5000-4600 BC, sheep remains are the most prominent followed by cattle, pigs, and in very small proportions, the goat (von den Driesch and Boessneck 1985; Midant-Reynes 1992: 111). The animal remains from Level II are quite different from Level I, as domesticated cattle become more common and continue to increase in number throughout each of the different occupation levels (von den Driesch and Boessneck 1985; Midant-Reynes 1992: 113). Of note, no radiocarbon dates have yet been obtained for Level II, but this phase likely dates to c. 4300 BC (Midant-Reynes 1992: 108)

Another early site, which may actually show the approximate time that caprines were introduced- or at least became more prominently used at the site is that of Saïs. As mentioned earlier, at this time there are three identified prehistoric phases: Saïs I, the early Neolithic dating to c. 5000- 4800 BC; Saïs II, the late Neolithic dating to c. 4500-4300 BC; and Saïs III, the Buto-Maadi period dating to c. 3500 BC (Wilson 2006: 83). Phase I is dominated mostly by fish remains (Linseele, In Preparation) followed by a very small percentage of pig remains (NISP=8), one identified cattle element, one donkey element, and no identified caprine remains (Bertini, Ikram, and Linseele, In Preparation). Comparatively, pig remains dominate Phase II, totaling 52% of the identified elements, followed by cattle (45%) and then Ovis/Capra (3%). Of the Ovis/Capra remains, only one element could be confirmed as goat and four as sheep (Bertini, Ikram, and Linseele, In Preparation). Although this is a small number, there is a possibility that this is when caprines could have been introduced at Saïs dating to c. 4500-4300 BC. This is not indicative as to when caprines were introduced into Egypt, but is possibly when they became more prominent at Saïs. The Phase III remains are again still largely pig (31%) followed by cattle (2%). Only seven Ovis/Capra elements were identified, again too small of a sample to make any accurate conclusions (Bertini, Ikram, and Linseele, In Preparation).

It is difficult to conclude as to when sheep entered Egypt (and Africa). However, when noting the early presence at sites such as Haua Fteah in Libya at c. 6000-5000 BC, and at sites such as the Fayum, Merimde Beni Salame, and Saïs in

Egypt dating to c. 5200-4300 BC, coupled with the definitive presence of domestic sheep in the Near East at sites such as Jericho by c. 7000 BC, it can be assumed that sheep entered Africa c. 6000 BC and were spread throughout Egyptian settlements by 4500 BC.

***Goats*:**

Although there is some evidence from radio-carbon dating that the domestication of sheep preceded that of goats, analysis of remains from many sites in the Near East show that the goat was more commonly kept as a supplier of meat during c. 8000-7000 BC as compared to sheep (Clutton-Brock 1987: 59-60).

Like sheep, archaeologists have typically relied on morphological characteristics along with human-oriented markers to differentiate wild from domestic goats. There are three animal-oriented markers that can be used to differentiate wild sheep from goat: change in horns, bone structure, and size reduction, along with the two human oriented markers of zoogeography/abundance, and demographic factors (Zeder 2006a: 181-189). However, a change in horn morphology is one of the most distinctive morphological differences between wild and domestic goats.

Domestic goats have a considerable amount of medial flattening, especially when viewed in a cross-section, along with varying degrees of helical twisting. Domestic goat horns are also considerably smaller than those of wild goats (Zeder 2006a: 181). However, as the cross-section of the shape of a horn core can vary over the length of the core coupled with the fact that often what is recovered archaeologically is typically in fragmented condition, making accurate conclusions about a specimen can be difficult (Zeder 2006a: 183).

A second way to differentiate wild from domestic goats is by bone structure or the "blue-rim phenomenon." This theory states that when viewed through cross-polarizers, the bones of domestic animals show strong blue or yellow interference colours on all articular surfaces. This is said to be a response to stress in the weight-bearing bones of the bodies of domesticated animals, which through a lack of exercise, poor nutrition, or genetic deterioration, lacked sufficient material in their bones to form the sturdy bones characteristic of wild animals (Drew, Daly, and Perkins 1971: 282). This theory, though, as explained by Watson (1975) argues that this pattern could be caused by post-depositional taphonomic factors, not by domestication. As a result of this debate and the fact that no further work has been undertaken to try and resolve this debate, this "blue-rim phenomenon" is no longer considered a viable marker of domestication (Zeder 2006a: 184).

The last animal-oriented marker of domestication that can be seen in both goats and sheep is that of size reduction. Beginning in about 7,500 BC both sheep and goat limb bones tend to show a rather marked reduction in size, with sheep showing this change somewhat later than goats (Uerpmann 1979; Clutton-Brock 1987: 60). This could be caused by climatic conditions, although the more likely explanation is that of domestication. Meadow (1989) argues that the body-size reduction in domesticates was likely due to overall lower levels of nutrition and early weaning in animals under human care. Despite Bökönyi's (1976) estimate based on modern animals undergoing domestication experiments, that it takes about thirty generations for definitive morphological changes to take effect, no actual rate of size reduction as a result of domestication has been established (Zeder 2006a: 185). As mentioned earlier, human-oriented markers such as zoogeography, abundance, and age/sex profiles can also be used to differentiate wild from domesticates (Zeder 2006a: 185-189).

The site with the earliest confirmed evidence for domestic goats is that of Jarmo, located in the highlands of Iraq. Dating to c. 6550 BC, the Jarmo goats are distinguished from the wild type based on the shape of their horn, which in some cases displays a slight twisting of the horn. In contrast, the horns of the wild goats are curved over the animal's back and are not twisted (Reed 1959: 1634).

Similarly at Jericho, changes in the cross-sections of goat horn cores are noted, indicating the presence of at least some domestic goats at the site around 7000 BC (Zeuner 1955: 132; Clutton-Brock and Uerpmann 1974: 261).

7.1.3 Herd Structure

In order to understand how sheep and goats were used in the past, it is essential to understand their herd structure and its possible variations. The three parameters that can be calculated and are typically reported by zooarchaeologists are the sheep/goat ratio, age distribution, and sex ratio (Redding 1981: 1; 1984: 223). As discussed by Redding (1981: 2), these three parameters, however, are dependent on the optimal foraging theory, which is based on the assumption that the foraging behavior of an animal is associated with its fitness within environmental constraints.

Thus, the two main factors that will affect herd structure (management strategy) are the environment and the goals of the herder/population demands (Redding 1981: 3). The environment can affect the behavioral, productive, and reproductive characteristics of sheep and goats mainly through the quality of the physical environment in terms of sheep and goat requirements.

Herd structure is also affected by the goals of the herd/demands of the population that should reflect their estimate of the best tactics to be used in order to attain their objective (Redding 1981: 23). The two main variables that need to be considered with respect to herd structure are the degree of reliance on sheep and/or goats for subsistence, and the degree of herded involvement in production for a market (Redding 1981: 13). Less involvement in herding is needed for an economy that is more reliant on agricultural products compared to pastoral groups that exclusively rely on sheep/goat products for subsistence (Redding 1981: 13-15).

A secondary factor that may affect herd structure is the behavioral differences between sheep and goat. Although some authors (Hafez and Scott 1969: 328-329) contend that the behavioral patterns of sheep in goat are similar, others (Nicolaisen 1963: 46; Shahrani 1979: 90; Behnke 1980: 71) contend that since goats are more mobile than sheep, the inclusion of goats in flocks of sheep will keep them moving.

Although reports on modern herds maintain that goats and sheep are herded together (which can be seen in present-day Egypt) possibly because sheep are less intelligent than goats who lead the flock (Nocolaisen 1963: 46), there is no solid evidence that sheep can not be effective leaders, or that flocks of sheep must be lead by goats. Goats may simply stimulate the sheep to greater activity and mobility (Redding 1981: 121).

Hole *et al.* (1969: 342-365) note that domestic goats originally dominated the early cultural phases of the Deh Luran plain in Iran, but by c. 5000-4500 BC, domestic goats and sheep were herded in equal numbers. However, by c. 4100-3700 BC, domestic sheep began to outnumber goats (Hole *et al.* 1969: 342-365; Bökönyi 1977: 10).

Figure 7.7: Goats from the tomb of Akhethotep, Louvre Museum, Paris (Personal Photo)

Comparing this to the ancient Egyptian evidence, looking at artistic representations of sheep and goats, there are many examples of sheep (Tomb of Khnumhotep III at Beni Hassan) and goats (Tomb of Akhethotep at Saqqara), although at this point no representations of both species together have been noted (Salima Ikram, personal communication). Furthermore, when sheep are represented, they are most commonly depicted in treading scenes in a flock, which consists of between four to seven individuals (Evans 2010: 64, 92) or as tribute. Goats, however, are rather depicted browsing, including nibbling on both short and tall grasses and feeding on trees as seen in Figure 7.7 (Evans 2010, 90). Despite not being represented together, it is possible that they may have been herded together, based on the fact that often their remains are found together in Egyptian faunal assemblages. Most likely, herd differences were due to the site environment and the goals of the herder and population needs. However in terms of artistic representation, it may have been important to show them as distinct species so that they could be accurately identified, so they would not be shown in 'real-world' situations, that is in mixed herds.

7.1.4 Reproduction

Similar to the effect of the environment upon herd structure, the breeding season of caprines was also affected as well. There is much debate as to whether sheep and goats breed all year round, particularly in the Near East/ Africa, or are seasonal breeders, giving birth only once a year during a restricted lambing season. The possible explanations for this are the variables affecting breeding time and frequency, namely the amount of daylight at the animal's location, which is in direct relation to its latitude, breed, nutrition, and human interference.

Yeates (1949) demonstrates that the breeding season of sheep is controlled by change in day length, of which the amount of daylight is in direct proportion to the latitude location of the animal, as a decrease in daylight can trigger oestrus in ewes (Hafez 1952: 195). The response of sheep to seasonal changes decreases towards the equator, therefore sheep have a less restrictive breeding season, and have the potential to breed at any time during the year (Hafez 1952: 196). Comparatively, sheep and goats at higher latitudes will have a seasonal restriction on breeding (Redding 1981: 53).

The second variable that can affect sheep and goat reproduction is that of the breed, suggesting that its ability to reproduce at any point during the year is under genetic control (Devendra and Burns 1970: 71). However, there is also a strong relationship between diet and the length of reproductive inactivity. As the quality of the diet deteriorates seasonally, the period of inactivity can vary from one to six months (Smith 1965: 100). Domestication can also have an affect on the breeding season or rather spread–it out over the year. This is mainly due to the artificial selection under conditions of shelter and better nutrition (Hafez 1952: 192).

Redding (1981: 55) reports that there is data available on the reproduction of five Middle Eastern sheep breeds: Awassi, Bakhtiari, Karakul. Mehrban, and Naeini. As most of these breeds are located in Iran, they cannot really be compared to Egyptian breeds. The Awassi, however, are the predominant breed in Israel, Iraq, Jordan, Syria, Lebanon, and Turkey, which is closer in geographical location to Egypt. Under extensive husbandry, Awassi sheep in Israel breed only when the ewes are in good physical condition as the result of the spring and summer pasture, with oestrus lasting from June through September and birth occurring in December through February (Hirsch 1933: 24).

There is no data available for each specific breed of modern Egyptian sheep, although Aboul-Ela (1993: 71) notes that they can breed at any time throughout the year, which is an important characteristic of Egyptian sheep. Furthermore, with accelerated lambing systems, it is possible to have three mating seasons every two years (September, May, and January), with the highest reproductive performance in September (Aboul- Naga *et al.* 1987).

Unlike sheep, goat reproduction has not been extensively studied (Redding 1981: 58). Hirsch (1933: 58) does report that goats in Israel give birth only once a year, with the majority of births occurring in January and February. However, in south-east Turkey, goats are known to give birth twice a year (Salima Ikram, Personal Communication) and the author has observed spring birth as well in Jordan. Furthermore, Egyptian goats do have the ability to reproduce more than once per year (Aboul-Naga *et al.* 1987), as Delta and Nile valley goats are raised with a dual purpose for both reproduction and as household dairy animals. However, the growth performance for all three local breeds (Barki, Baladi, and Nubian) is rather low (Aboul-Ela 1993: 69).

As it is likely that the ancient Egyptians had not yet developed an accelerated lambing system, most of the sheep were likely born in either April or January, although most likely in April (Angela von den Driesch, personal communication; interview with various Egyptian sheep herders). This is an issue that will be returned to in Chapter 9.

7.2 Ancient Egyptian Sources on Caprines

Unlike pigs, which inspire much debate due to the limited number of textual and artistic references, sheep and goats played an important role throughout Egyptian history as a source of subsistence, along with its important religious role, which is seen not only in the archaeological record, but in artistic, textual, and religious references as well.

7.2.1 Artistic Representations

The earliest representations of caprines are actually of the ibex (*Capra ibex*) and the Barbary sheep (*Ammotragus tragelaphus*) that are seen in a number of Mesolithic/Neolithic and early Predynastic drawings on the cliffs along the Nile valley and along the trails between Egypt and Nubia, and in the Kharga Oasis (Hayes 1965: 73 and 102; Darby *et al.* 1977: 212; Salima Ikram, personal communication-Kharga Oasis examples; Ikram 2009).

During the dynastic period, caprines are typically depicted in one of six categories: as tribute, frolicking, being herded, slaughter, working in the fields, or as part of offering lists (Ikram 1995: 17). And within these scenes, as one of four different types of sheep (*Ovis longipes paleoagyptius, Ovis platyara aegyptiaca,* four horned 'sacred ram', or the fat tail sheep) or five different goat (the scimitar horn *Capra hircus*, the corkscrew *Capra hirca girgentana*, the dwarf goat *Capra hircus reverses*, the Syrian/Mamber goat C*apra hircus mambricus*, and the Theban goat *Capra hircus thebaicus*) (Zeuner 1963: 139,178,181,184; Ikram 1995: 18-19; Epstein 1971: 299; Ryder 1983: 107; Lydekker 1912: 224, 228; Darby *et al.* 1977: 212-213; Wilkinson 1992: 61). Sheep were also associated with a number of different gods including Khnum, the Ram of Mendes or *B3-nb-ddt*, and Herishef of Herakleopolis of which all three are depicted as *Ovis longipes paleoagyptius*), and Amun which is depicted as *Ovis platyara aegyptiaca* (Ikram 1995: 17; Redford and Redford 2005: 169; Germond and Livet 2001: 124; Smith 1969: 308; Wilkinson 1992: 61; 2003: 93-97, 192-195).

Although the goat was not worshipped or identified with any god per se, it is possible that the Mendes ram was later changed around the twenty-ninth dynasty

(Lloyd 1976: 191-192) into a goat either due to the process of pictorial confusion or to accommodate it into the Pan concept of late Greek residents where it is identified as a goat as described by Herodotus (II, 46):

"... The Mendesians hold all goats sacred, the male even more than the female and goatherds are held in especial honor: one he-goat is most sacred of all; when he dies it is ordained that there should be great mourning in all the Mendesian province. In the Egyptian language, Mendes is the name for both the he-goat and for Pan. In my lifetime a monstrous thing happened in this province, a women having open intercourse with a he-goat. This became publicly known."

7.2.2 Religious References

One of the earliest centers of ram worship was Elephantine Island where the god Khnum was venerated as the god of inundation/ creation, beginning as early as the Early Dynastic period (Darby *et al.* 1977: 215; Baines, Lesko, and Silverman 1991: 33; Wilkinson 2003: 195). Although a number of ram mummies have survived from the Ptolemaic-Roman period, little remains of the early cult structures. In fact, the best preserved temple dedicated to the god Khnum is actually at the site of Esna, about 150 kilometers upstream from Elephantine (Wilkinson 2003: 195).

The ram was also worshipped in Thebes, but as the god Amun, where ram statues line the mile long sacred way between the temples of Karnak and Luxor (Darby *et al.* 1977: 215). Although Darby *et al.* (1977: 215) state that Khnum was incorporated with Amun at Thebes, these two ram gods which both represent inundation/creation, are more likely the result of different cosmogonies, despite the fact that Khnum developed earlier than Amun (Baines, Lesko, and Silverman 1991: 33). Although the earliest textual reference to Anum is in the Pyramid Texts (Chapter 446), the cult of Amun did not seem to gain power until the Middle Kingdom (Drioton 1958: 37). Although Amun may have been a god native to Thebes (Daumas 1967: 203), another possibility is that Amun as a ram probably derived from a Nubian prototype (Valbelle and Bonnet 2003: 293- 297). Although the first definitive representation of Amun in Nubia dates to the New Kingdom, his cult may have been active since a considerably earlier date as attested by the many temples dedicated to him (Rocheleau 2005: 22).

A Herakleopolis, Herishef, "he who is upon his lake," again is also a creator god who, like Khnum, is said to emerge from the primeval lake waters. Gaining importance during the First Intermediate Period when Herakleopolis was the center for the rulers of the ninth and tenth dynasties, a temple (excavated by Edouard Naville in 1891-1892; Sir W.M. Flinders Petrie in 1904 and Jesus López in the 1970's) was constructed for the worship of Herishef where he was primarily depicted in his anthropomorphic form of the corkscrew *Ovis platyara aegyptiaca* head with a human body (Baines and Malek 2002: 129; Wilkinson 2003: 192).

Mendes is the site where the ram god *B3-nb-ddt* (the ba, lord of Djedet [Mendes]) was venerated. *B3-nb-ddt* was also identified with Osiris as mentioned on the only inscribed ram sarcophagus lid that has been found on site to date (Redford and Redford 2005: 165; de Meulenare and Mackay 1976: 213). As a result of the of the importance of the ram god (Khnum, Amun, or *B3-nb-ddt)*, many sacred ram sarcophagi (although with no mummies) have been found that are thought to have been worshipped at this site.

Although no actual mummy has been found to date, an extensive ram cemetery with many sarcophagi and an immense ram hypogeum has been excavated at Mendes (Redford and Redford 2005). This destruction of both the temple and cemetery along with the absence of ram mummies is likely due the Persian invasion and re-conquest of Egypt in c. 343 BC when the entire city of Mendes was destroyed (Redford and Redford 2005: 191).

Sacred animals were often identified early on and selected as a result of specific or unusual markings thought to represent the physical presence of a god, and were thus worshipped throughout their lifetime (Ikram 2005: 5). Burials of rams have been found at Kerma associated with the god Amun dating to the New Kingdom (Bonnet 1986: 46). Ram mummies have also been found at Elephantine, dating to the Ptolemaic/Roman period, and were likely worshipped as the personification of Khnum. Despite the fact that Khnum is represented with the loosely spiralled cork-screw horns of the *Ovis longipes paleoagyptius* breed of sheep, the three examples in the Egyptian museum (CG 29861, 29862, and 29863) all appear to have had their horns sawn off (Ikram and Iskander 2002: 35-36; Ikram, In Press a). Smith (1969: 308) and Keimer (1938: 315-316) state that when animal mummies were required in this later period, they were of the 'Amun' horn *Ovis platyara aegyptiaca* breed as the *Ovis longipes paleoagyptius* were extinct by the Middle Kingdom. Since the horns of many of these ram mummies were sawn off, and the animals provided with a gilded wooden crown in the form of the horizontally twisted corkscrew horns of the *Ovis* *longipes paleoagyptius*, this was likely to maintain the original sacred appearance of the deity.

7.2.3 Textual References

In texts, caprines, like pigs, are listed in offering/possession lists (as stated above), medical, and magical/mythological texts. One particular possession list that mentions caprines as part of temple property is the Harris papyrus, which lists the number of livestock given to temples at Thebes, Heliopolis, and Memphis for sacrifice by Ramses III. Sheep were counted together with cattle with numbers ranging from 10,000 given to the temple at Memphis to 421,000 given to the temple at Thebes (Ryder 1983: 104).

Caprines or specific parts of them are also mentioned in medical texts. Examples include goat blood, which is used in a prescription to prevent the re-growth of a removed eyelash (Ebers LXIII, 425) and goat bile in the dressing of human bites (Ebers LXIV, 433). The hair of a ram is also noted in another prescription to be placed on a burn (Ebers LXIX, 499).

The last category of texts in which caprines are mentioned are that of magic/mythological texts. As previously mentioned, sheep are an animal that had qualities highly valued by the ancient Egyptians, as seen by its association with the gods Khnum, Amun, *B3-nb-ddt*, and Herishef. Sheep are not specifically mentioned in magic/mythological texts as such, but are rather mentioned as a manifestation of a particular god.

7.2.4 Archaeological Sources on Caprines in Egypt

Sheep and goat are very prominent in the archaeological record in Egypt, occurring in the faunal remains from most settlement sites dating from the Predynastic Period onwards (Ikram 1995: 17). Sheep and goats can have many uses, notably meat production. However, they do not reproduce as rapidly as pigs, nor have as large a carcass as cattle (O'Connor 1998: 5). Milk production in both the sheep and goat industry is not significant, while wool production is more typically of secondary importance, as sheep are typically sheared twice a year in roughly April and September (Aboul-Naga *et al.* 1987). Furthermore, as caprines are easy to rear and were most likely done so by both elites and non-elites (Ikram 1995: 211), their remains should be a very prominent in the faunal assemblages of settlement sites. This can be seen in the selected settlement sites below, which total all sheep (*Ovis aries*), goat (*Capra hircus*) and Ovid-caprine remains:

Site	**Period**	**Number of Caprine Elements**	**% Caprine**	**Source**
Sais	Neolithic	44	6.7%	Bertini, Linseele, and Ikram, In Preparation
Hierakonpolis	Predynastic	2,750	55.6%	McArdle 1992
Ma'adi	Predynastic	2483	2%	Boessneck 1989
Kom el-Hisn	Old Kingdom	311	23.4%	Wenke *et al.* 1989
Giza	Old Kingdom	1,140	c. 68%	Redding 2007
South Abydos (*Wah-Sut*)	Middle Kingdom	1,546	29.6%	Rossel 2007
Amarna (Workmen's Village)	New Kingdom	671	33%	Hecker 1982
El-Hibeh	New Kingdom	12	2.1%	Redding 1984a
Kom Firin	New Kimgdom/TIP	227	11.4%	Bertini, In Press
Sais	New Kingdom/TIP	241	35%%	Bertini and Linseele, In Press
Tell el-Borg	New Kingdom	173	21.6%	Bertini, In Press
		98	8%	Loyet, In Press
Malkata	New Kingdom	80	10.2%	Ikram 1995
Zawiyet Umm el-Rakham	New Kingdom	204	55.7%	Bertini and Ikram, In Preparation
Sais	26th Dynasty	14	15.4%	Bertini, In Preparation

Table 7.1: Sites with identified caprine remains. Percentages calculated based on total number of identified species.

As can be seen, caprine remains are common throughout ancient Egyptian faunal assemblages. The few sites that have small percentages of caprine remains are either the early Neolithic/Predynastic sites (with the exception of Hierakonpolis, which will be discussed later) which date to around the time of (or just after) ~~of~~ the introduction of caprines into Egypt, or sites where not much archaeological investigation or zooarchaeological analysis has taken place. However, in order to get more information out of the faunal remains of sheep and goat, their ratios from the collected data should be examined. As discussed in section 7.1.3, the sheep to goat ratio can provide information on the herd structure, which is a direct response to both the site environment, and the goals of the herder (Redding 1981: 3; 1984: 223).

Site	Sheep: Goat	Sheep NISP	Goat NISP	Source
Amarna	*None listed, but stated to be mostly goat	0	671	Hecker 1984: 158-159
Abydos Settlement Site	0.5:1	-	-	Richard Redding, personal communication
South Abydos	1: 3.2	97	311	Rossel 2007: 182
Giza	1.3:1	118	92	Redding 2007: 265
Kom Firin	1:1	23	22	Bertini, In Press
Kom el-Hisn	1.2:1	43	36	Redding 1992: 102
Saïs (All time Periods)	1.6:1	14	9	Bertini, In Preparation
Saïs(New Kingdom/TIP)	1.3:1	9	7	Bertini and Linseele, In Press
Saïs (Neolithic)	4:1	4	1	Bertini, Linseele, and Ikram, In Preparation
Zawiyet Umm el-Rakham	1.6:1	47	29	Bertini and Ikram, In Preparation
Hierakonpolis	1:2	Only % listed	Only % listed	McArdle 1992: 53
Ma'adi	1:1	441	438	Boessneck, von den Driesch, and Ziegler 1989: 88)

Table 7.2: Sheep to goat ratios and NISP.

The above table lists the calculated ratios for most of the sites from which sheep to goat ratios are available and have enamel hypoplasia/ tooth biometrical data that will be discussed in the next two chapters. Of note, all of the above numbers were calculated before the publication of Melinda Zeder's (2010) article on differentiating sheep and goat teeth. Considering this recent publication, it is likely that these numbers could be inaccurate. The two additional sites of Hierakonpolis and Ma'adi are also provided, although only as a point for comparison.

As seen above, although most of the ratios are relatively equal, the sites of Giza, Zawiyet Umm el-Rakham, Saïs, and Kom el-Hisn all have slightly more sheep than goats. In Giza's Main Street Gallery III.4 faunal assemblage, sheep are seen to be more abundant (sheep to goat ratio 2:1) than goats in all the excavated units except for one area of collapse (Phase IIIc), where the sheep to goat ratio is 1:1 (Redding 2007: 265). These ratios would make sense as Giza is not a site that would have had extensive agricultural involvement, but rather was a state supported large-scale rationing program where food was brought into the site to feed the workforce. The Zawiyet Umm el-Rakham sheep to goat ratio of 1.6:1 also makes sense, as this is a fort site, likely with very little agricultural involvement. More probably at this site there was a heavier use of secondary resources from sheep such as wool production that can be confirmed by looking at the kill-off patterns, as the majority of animals are older than two years, a pattern more indicative of secondary product exploitation (Bertini and Ikram, In Preparation).

Saïs on the other hand has two different ratios. Although the sheep to goat ratio for the entire site is 1.6:1, this is not appropriate to use, as it represents many different occupational periods at the site with a time span from the Neolithic period through to the 26th dynasty and even into the Roman period. Thus, the only two occupational periods from which a ratio could be calculated is the Saïs Neolithic layer which dates to c. 4500-4300 BC (Wilson 2006: 83), where the sheep to goat ratio is 4:1 (based on the four sheep bones and the one identified goat bone) and the New Kingdom/TIP contexts where the ratio is 1.3:1 (based on nine sheep bones and 7 goat bones) (Bertini, Linseele, and Ikram, In Preparation). Although these are very small numbers, it is likely that if more of the site were excavated, thus revealing a larger faunal sample, the sheep to goat ratio would be very low as there was most likely not extensive involvement in agriculture in the early period. As this is also around or just after the time that sheep and goat were first introduced into Egypt and so there was most likely not yet a preference for either animal, or highly developed herd strategies.

In the subsequent periods at Saïs, there is a sheep to goat ratio of 1.3:1. Again, this ratio is based on a very small amount of identified bones. Although, like the site of Kom el-Hisn, which also has a similar ratio of 1.2:1 (Redding 1992: 102), this maybe evidence of an unusual pattern for both Egypt, and especially the delta, where sheep would be expected to be slightly more prevalent because of the secondary resources they provide (Redding 1985: 122).

On the other hand the two sites of Amarna and the south Abydos town of *Wah-Sut* (plus Hierakonpolis) support a preference for goat. At Amarna there are no reported sheep to goat ratios, as Hecker (1984) only states the presence of goat (*Capra hircus*) remains. Although it is likely that there are some sheep remains mixed in the assemblage, it can be expected that there would be a strong preference for keeping goats, given the desert edge location of the site with very limited pastoral area, which would be necessary for sheep. At *Wah-Sut*, a sheep to goat ratio is reported to be 1:3.2 (Rossel 2007: 182). What these two sites, along with Hierakonpolis, all have in common the fact that they are desert edge sites with little to no pasture area, thus making the location more ideal for goats.

The only site that has an equal sheep to goat ratio (1:1) is Kom Firin. This is based on twenty-three identified sheep bones and twenty-two goat bones). Again, like Saïs, these are small numbers that happen to equate to an equal ratio. Although it is possible that the ratio could support the notion of a low level of agricultural activity at the site, with more herders, it is also possible that this is due to the environment of the flood plain edge where there could be equal opportunities for sheep to graze and goats to browse. Furthermore, considering the kill-off patterns that the Kom Firin remains show, which peak at about twenty-four months, this likely supports a heavier reliance on secondary products (Bertini, In Press), a pattern that is more typical of a mixed strategy that is based on herding and semi-agricultural involvement (Redding 1984: 237). Comparing the equal ratio at Kom Firin to what also seems to be an almost equal ratio at Ma'adi (441 sheep fragments to 438 goat fragments, thus a 1:1 ratio- Boessneck, von den Driesch, and Ziegler 1989: 88), the statistic also seem to support the idea that there was a mixed economy of herding. As Maadi is also much earlier in date, the numbers of identified sheep and goats suggest the beginnings of intensive agricultural practices (Midant-Reynes 2006: 215).

Redding (1991: 24) suggests that as cattle became more important, the ratio of sheep to goat should decline because sheep compete more directly with cattle for food, where as goats can make use of plants in waste areas. Although this is possible, it may also depend on what specific secondary products are desired from the animals. Considering the large number of cattle remains identified in the faunal assemblage at Tell el-Borg (also a state supported site), and a likely heavy reliance on them, it is possible that goats were more prevalent at the site as unlike sheep, goats would not compete with cattle for food (Bertini, In Press). However, considering the defensive nature of the fort site and how Tell el-Borg, like Zawiyet Umm el-Rakham has a *ovid-caprine* kill off pattern peaking at about thirty-six months (Bertini, In Press), this scenario is possible, but is more likely a result of a need for secondary products. More work is needed to confirm this possibility.

Moving onto Mendes, the only publication with information on its faunal assemblage states that eight *ovid-caprine* bones were identified (Brewer and Wenke 1992: 196) with no sheep-goat differentiation. It is possible, however, that sheep were more common at the site, considering the trend at the two east delta sites of Kom el-Hisn and Saïs, along with the importance of the *B3-nb-ddt* cult at Mendes. As for

Aswan and Elephantine, work is currently being done at both sites, but no sheep to goat ratio is available at the present time.

Most likely, the general trend is that at sites that are near or on the desert edge, such as Amarna and the south Abydos town of *Wah-Sut*, goats are likely to be more prevalent, due to the limited area for sheep pasture. On the other hand, at sites where there was more space for pasture, such as in the delta, sheep are more common. However, one does need to take into consideration the function of the site/population demands and the need of specific secondary resources that will also affect the ratio of sheep to goats. At sites such as the Giza Workmen's village that had to accommodate a large population, and was a heavily state supported settlement, sheep would have certain advantages over goats as they provided more secondary resources. Of note, as animals at Giza were likely shipped in from farms, so the bones do not represent husbandry practices by themselves, but consumption and supply. This would also have been the case at fort sites such as Zawiyet Umm el-Rakham, and possibly Tell el-Borg.

7.3 Conclusions

Overall, sheep and goats played a very important role in the subsistence needs and religious observances of the ancient Egyptian population, which is attested in the zooarchaeological record, artistic, and textual sources. Sheep and goats were introduced into Egypt from the Near East sometime around 6,000 BC, and quickly disbursed throughout the Nile Valley. In the absence of DNA testing and sufficient numbers of horn cores, it is impossible to tell exactly which breeds were present at different sites and at different time periods, but from the pictorial evidence, it seems that there were three types of sheep: the *Ovis longipes paleoagyptius, Ovis platyara aegyptiaca,* the Amun horned and the four-horned sheep. These are now all seen as breeds of the domestic sheep *Ovis aries*. As far as goats are concerned there seem to have been two main types: the scimitar-horned goat (*Capra hircus*), and the 'corkscrew' goat (*Capra hirca girgentana*). Although both sheep and goat are differentiated in representations, their remains are often found together (or something), making actual identifications from bones difficult.

Although DNA testing is something that one can hope will be an area of future study, it is possible to look at differences of sheep and goats or at least differences between the many sites through biometrical analysis, and possibly changes in different husbandry regimes seen through the presence of enamel hypoplasia. This may confirm or refute the known sheep to goat ratios at different ancient Egyptian sites.

8 Age and Biometrical Data of Modern and Archaeological Egyptian Caprines

This chapter will examine two data sets of caprine remains: the first is a collection of modern caprines collected by the author from butchers throughout Cairo, Egypt and analyzed to act as a control group, and to create a standard to which the ancient Egyptian archaeological material can be compared. The second data set is a collection of thirteen archaeological sites spanning the time period of the Old Kingdom through the Ptolemaic- Roman period.

8.1 Introduction

As established in Chapter 5, the measurements of animal bones from archaeological sites can be an extremely valuable tool for the distinction of taxa, morphological types, sexes, and age groups (Albarella and Payne 2005; Albarella 2002; Boessneck and von den Driesch 1978). However, unlike pigs, biometrical work on caprine teeth has never been done before. Thus, this chapter will apply a new method derived from that of the pig measurements. It will record the posterior width of the first and second molar and the anterior width of the third molar on the bottom portion of the crown (length measurements are not taken as they are subject to dental attrition- see Section 2.5). I am not sure of this method will work on caprines as it does for pigs, so this chapter is purely experimental. The caprine measurements from all thirteen sites in this thesis, like the pig sample, are analyzed using the size index scaling technique (Meadow 1999), which relates the measurements to a standard measurement. The calculated mean of the collected modern Egyptian caprine sample will be the standard measurement to which all the archaeological data will be compared.

The relative size of each of the thirteen site's measurements in comparison to the modern standard is calculated as the decimal logarithm of the ratio between the measurement and its standard (Simpson, Roe and Lewontin 2003: 89-95). This method allows for direct comparison between different measurements, in which the distribution of the archaeological measurements are shown in relation to the "0" line provided by the modern standard.

The sites discussed in this section include almost all of those previously discussed in Chapter 3, including the Abydos Middle Cemetery and Zawiyet Umm el-Rakham. As the goal of this thesis is to look at possible changes in husbandry practices over time, the sites discussed in this section are arranged based on their time period of occupation, with four chronological groupings: Old Kingdom (c. 2686-2125 BC), First Intermediate Period/ Middle Kingdom (2160-1650 BC), New Kingdom/Third Intermediate Period (1550-664 BC), and Late Period/Ptolemaic-Roman Period (664 BC-AD 300), in addition to the modern data.

8.2 Modern Egyptian Domestic Caprines

As has been established for pigs (Albarella and Payne 2005), a standard set of measurements also has been created for sheep (Davis 1996). This baseline, however, does not include any dental measurements. Therefore, there was a need to create a standard set of measurements in order to establish both a standard against which to compare the Egyptian archaeological caprine teeth and also to establish a standard that is relevant to ancient Egyptian material.

Chapter 7 discussed the difficulties in distinguishing sheep from goat in the archaeological record and these problems extended to the modern material. The collected mandibles came from various butchers throughout Cairo and often the butcher did not know where the animal came from, and was not quite sure if it was indeed sheep or goat, although they said that the majority were sheep. It therefore becomes appropriate to apply Zeder and Pilaar's (2010) recently published criteria on separating the mandibules of sheep and goats to this assemblage. From the application of this technique to the modern material, it was discovered that, out of the twenty-eight mandibles, only four could be identified as goats. The rest of the twenty-four mandibles were identified as sheep, which fits with the modern preference for mutton. Although the majority of the modern material proved to be sheep, they will still be referred to as caprines. This is due not only to the presence of the few goats in the assemblage, but also the fact that despite the recent advances in criteria used to distinguish between the mandibules of sheep and goat, caution is still needed when identifying teeth in order to avoid biases caused by eruption and wear patterns (Zeder and Pilaar 2010: 241).

The sample of domestic caprines consists of twenty-eight mandibles collected from various butchers throughout Cairo in May 2009. The butchers did not rear the caprines themselves and stated that they were mostly raised in various locations throughout Upper Egypt. They had been usually fed a diet consisting of grains, emmer wheat, maize, and clover. No DNA analysis has been done at this point on the modern sample collected, but the sheep present in the sample are most likely to have been the Ossimi (*Ovis aries species*) breed, the most common throughout modern Egypt.

8.3 Results

8.3.1 Age and Sex of the Modern and Archaeological Egyptian Caprines

<u>Key Points</u>

There is no clear pattern in age distribution, but most caprines seem to be slaughtered between attrition stages E-G, two to six years.

Sexing was not possible due to a lack of methodology on caprine mandibles.

<u>General Results</u>

Figure 8.1 is a comparison of all the age distributions of both modern and archaeological caprine mandibles following Payne (1973) plotted as a running mean based on the number of mandibles that could have their attrition stages calculated (see Appendix 3). Although there is no clear pattern in age distribution, as most of the mandibles peak anywhere between attrition stages E-G (two to six years), almost all the sites still display a normal distribution. The only exceptions are the samples from Amarna and the modern caprine sample, which both display a bimodal distribution, peaking at attrition stages C (six to twelve months) and G (four to six years).

Sexing was not possible on any of the mandibles, as at this point no methodology has been developed to differentiate the two sexes.

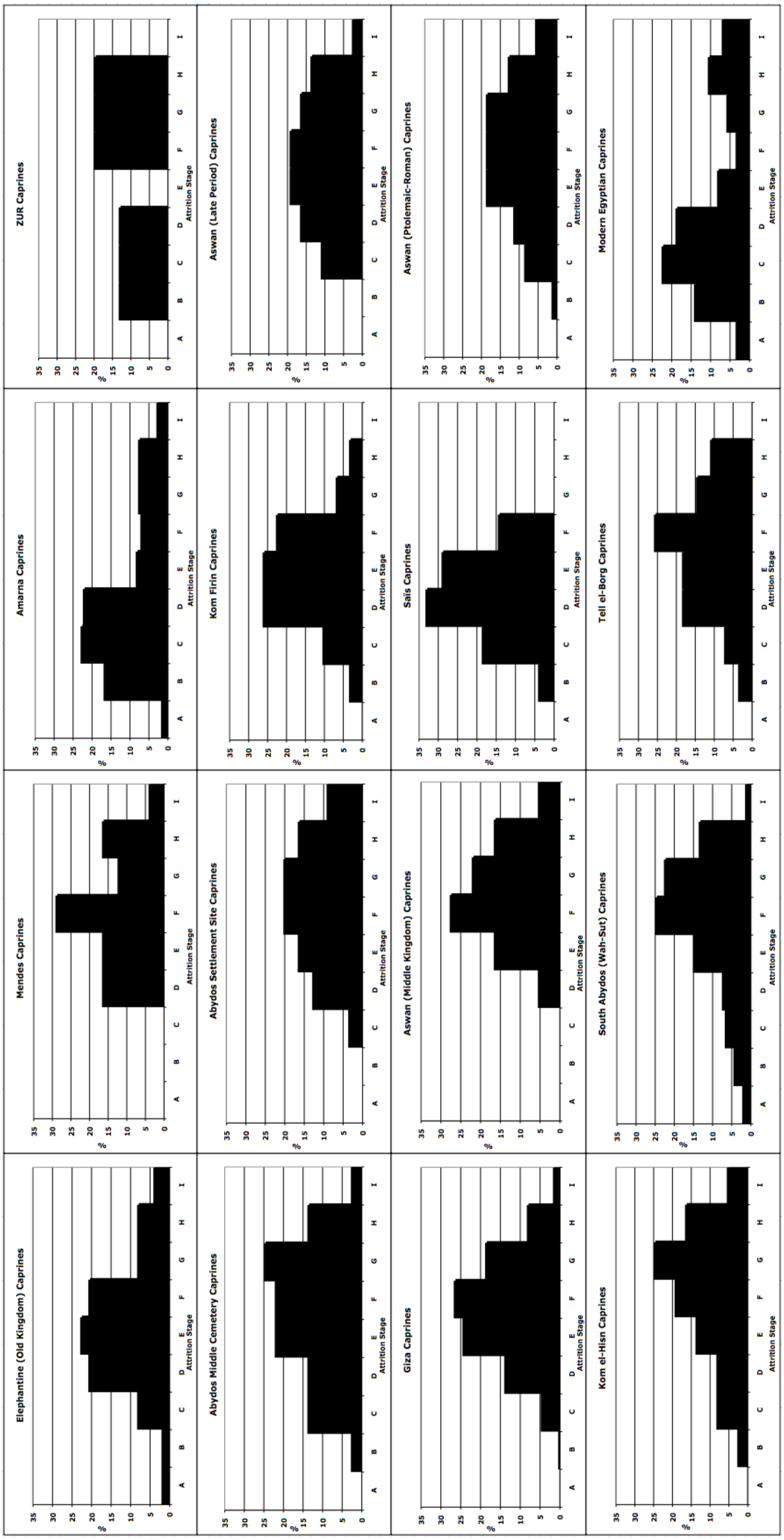

Figure 8.1: Comparison of age distributions for all archaeological and modern caprine populations

8.3.2 *Size of the Modern and Archaeological Egyptian Caprines*

Key Points

All the sites display a tight, normal distribution in size (based on tooth width), indicating a single, domestic population.

There is not much of a change in the size of caprines (based on tooth width) throughout dynastic Egypt, as most of the samples are about the same size as the modern Egyptian standard. First Intermediate Period and Middle Kingdom caprines, however, display a slight decrease in size.

General Results

Table 8.1 provides summary statistics for measurements of the first, second, and third molars from all sixteen caprine populations. Just as there are a varied number of teeth from each site, the mean, standard deviation, and coefficient of variation varies significantly between each caprine population. However, looking at the mean for each tooth type (and for the entire population which will be discussed in the specific site patterns section), the Lower Egyptian (delta) sites have slightly larger teeth than the Upper Egyptian sites.

Figure 8.2 a and b shows the width measurements combining all tooth types (M1, 2, and 3) for each of the sixteen caprine populations. Additionally, a breakdown is provided of the two different areas at Amarna and Giza from which caprine remains were collected using the size index scaling technique (Meadow 1999) as explained in section 8.1. As discussed in Chapter 5, combining different tooth types and measurements through log transformation allows for a larger sample size to be created in order to directly compare the archaeological caprine population to a standard value, that is, the modern Egyptian caprine standard. The chosen measurements were the posterior width of the first and second molar and anterior width of the third molar and they were selected because they are the dental measurements that are least variable and are less affected by age/occlusal wear.

All of the caprine assemblages show a ‘normal’ distribution. No bimodal distributions are observed. It is expected, however, that since males, females, sheep, and goats are all mixed together, extracting patterns will be difficult. However, the distributions from the two Middle Kingdom sites of Aswan and South Abydos along with Amarna (New Kingdom) are significantly skewed to the left, indicating that some individuals were significantly smaller than the modern Egyptian standard.

Specific Site Patterns

This section will briefly describe the size distribution patters based on the tooth width of the archaeological caprine assemblages in comparison to the modern Egyptian caprine standard as seen in Figure 8.2 a and b. Their results are discussed here and are organized by time period and site.

Elephantine (Old Kingdom)

Like the pig remains, the only caprine teeth remains that were available for analysis were those from the past three seasons of excavation at the site as previously analyzed remains were re-buried. A total of sixteen mandibles were examined, which consisted of forty-one teeth from which width measurements were taken. Unlike the pig remains, all the caprine mandibles date to the Old Kingdom levels of the Second and Third Dynasty (Dietrich Raue, Personal Communication). This moderate sample size displays a fairly tight, normal distribution (mean = -0.01), slightly smaller than the modern Egyptian standard.

Abydos Middle Cemetery (AMC)

The only non-settlement site in the entire Egyptian caprine assemblage, the Abydos Middle Cemetery faunal remains have never been formally analyzed, with the exception of the caprine teeth that will be discussed in this section. Analysis of the caprine teeth from this site was done for two reasons: firstly, the material was available for study, as it had not been re-buried. Secondly, analysis of a cemetery provides a unique point for comparison to see if there are differences (both in size and stress levels) between caprines from settlement sites as compared to cemetery contexts where animals were offered and might have been better cared for or from different herds.

The caprine tooth material comes from the excavated units of the remains of various elite Old Kingdom (c. 2494-2181 BC) tombs. A total of fourteen mandibles consisting of thirty-six teeth had their width measurements taken (mean = 0.02). They also display a fairly tight, normal distribution that is slightly larger than the modern Egyptian standard.

Giza

As noted in the Giza Workmen's Village pig biometry section, after analysis of the faunal material, the remains are re-buried. However, unlike the pig material, which was one of the smallest samples, there is an abundance of caprine material that was available for study, which was the largest caprine sample in this dissertation, consisting of seventy-six mandibles with one hundred and eighty-nine teeth.

The tooth material that was available for study came from two different areas of the Giza Workmen's Village all of which date to the Fourth Dynasty (c. 2613-2494 BC): the 'Buttress Building' and Main Street East. The vast majority of the caprine mandibles came from Main Street East (Figure 3.6), which was excavated in 2001 and is a boundary wall that most likely runs north-south creating a barrier between the Eastern Town and the EOG production area (Lehner 2007). The second area where caprine remains came from is the 'Buttress Building' (Figure 3.6). As discussed in the pig biometry section, the 'Buttress Building' that was excavated in 2006 seems to be some sort of large royal administrative building and storehouse (Lehner 2002).

The entire Giza sample displays a fairly tight, normal distribution (mean = 0.06) that is slightly larger than the modern Egyptian standard. However, when the sample is split into the two areas from where data comes, the material from the Buttress Building is slightly smaller (mean = 0.001) than the material from Main Street East (mean = 0.008). Furthermore, the data from the Buttress Building also has a few outliers that slightly skews the data to the left of the modern Egyptian standard possibly suggests a caprine population of smaller size as compared to the sample from Main Street East.

Kom el-Hisn

As also noted in the pig biometry section, all of the caprine remains that are analyzed in this dissertation were available for study courtesy of the University of Michigan Museum of Anthropology, as a large amount of the faunal assemblage that was originally excavated has since been reburied or kept in an inaccessible magazine in Egypt. Again, all of the caprine remains came from the floors and garbage deposits associated with the fifth and sixth dynasty residential structures (Redding 1992: 101).

A total of thirty-six teeth from twelve mandibles were measured (mean= 0.007) and also displayed a tight normal distribution that is slightly larger than the modern Egyptian standard.

Mendes

As noted with the pig material, all of the caprine material has been excavated since 1989, and again, despite the available faunal material representing dates from Old Kingdom through the Ptolemaic period, the caprine material also comes from the Old Kingdom levels, that is first to sixth dynasty (Matthew J. Adams, Personal Communication). Despite being the smallest Old Kingdom caprine sample size, consisting of eighteen teeth from eight mandibles (mean = 0.02), a very tight normal distribution is observed that is larger than the modern Egyptian standard.

Abydos Settlement Site

All the caprine teeth, like the pig teeth, were recovered from the one season of excavation at the Abydos Settlement Site in 1991. The caprine teeth sample consists of forty teeth from eighteen mandibles (mean= -0.02). A normal distribution is observed, which is slightly skewed to the left, indicating the presence of smaller caprines compared to the modern Egyptian standard.

Aswan (Middle Kingdom)

A small sample of Middle Kingdom caprine teeth were recovered from the Swiss Institute's salvage excavations of the Aswan settlement consisting of a total of eleven teeth from six mandibles (mean = -0.007), making it the smallest sample of caprine teeth discussed in this dissertation. A normal distribution is also observed that is skewed to the left, indicating the presence of smaller caprines.

South Abydos town of Wah-Sut

As all faunal material from South Abydos was saved, the material analyzed was from excavations at the site that took place between 1999-2004. From this material, the caprine sample consisted of eighty-nine teeth from forty-four mandibles (mean= -0.02), including some that had not been a part of previous analysis by Rossel (2007). A normal distribution is observed that is skewed to the left, signalling caprines with a smaller tooth size.

Amarna

The caprine assemblage from Amarna, like that of the pig, is quite a sizable one. It also comes from both the Workmen's Village and the Main City houses of Ranefer and Panehsy. The total Amarna sample consists of eighty-eight teeth from fifty-five mandibles (mean = -0.008) and display a normal distribution that is slightly smaller than the modern Egyptian standard. When broken down further into the two areas from which the teeth came, the Main City caprines, which consist of twenty-eight teeth from sixteen mandibles are slightly larger in size (mean= -0.007) as compared to the Workmen's Village caprines (mean = -0.01) representing fifty-nine teeth from thirty-nine mandibles.

Kom Firin

Much smaller than the pig sample, the Kom Firin caprine sample consists of twenty-five teeth from nineteen mandibles (mean =0.03). Again, dating to the New Kingdom/early Third Intermediate Period, the caprine teeth remains come from both the Citadel (a densely occupied settlement zone) and the buildings (most likely storage facilities) in addition to the temple (Spencer 2008: 24). However, since the caprine sample is not large enough to differentiate between the three areas, it is treated as one sample representing the entire site. Nevertheless, a normal distribution is observed that is slightly larger than the modern Egyptian caprine sample.

Saïs

The size of the Saïs caprines is also larger than the modern Egyptian sample (mean= 0.004), which was calculated from the sample consisting of thirty teeth from sixteen mandibles, and is consistent with that of the other delta sites. Only slightly larger than the modern Egyptian standard, the Saïs sample displays a wide, normal distribution.

Tell el-Borg

The Tell el-Borg caprine assemblage is a bit larger than the pig sample, consisting of eighteen teeth from nine mandibles. The size of the caprines is also larger than the modern Egyptian standard (mean= 0.02), and displays a tight, normal distribution.

Zawiyet Umm el-Rakham (ZUR)

Analysis of the ZUR faunal assemblage was undertaken by the author with Salima Ikram (Bertini and Ikram, In Preparation) from the University of Liverpool's excavation of the site in 1999. The smallest of the caprine teeth assemblages discussed in this dissertation, it consists of thirteen teeth from five mandibles (mean = -0.01). Although slightly smaller than the modern Egyptian standard, ~~still~~ a normal distribution is observed.

Aswan (Late Period and Ptolemaic-Roman assemblages)

Like the pig assemblage, the only Late Period and Ptolemaic-Roman caprine assemblage comes from the Aswan settlement. More substantial than the Middle Kingdom assemblage, the Late Period assemblage consists of nineteen teeth from twelve mandibles, and the Ptolemaic-Roman assemblage consists of fifty-five teeth from twenty-three mandibles.

The size of both the Late Period (mean= 0.03) and Ptolemaic- Roman (mean = 0.02) samples are both almost equal in size and are slightly larger than the modern Egyptian standard, having a tight, normal distribution.

First Molar Summary Statistics:

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine	17	6.5	8.55	7.62	0.55	7.22
Abydos Middle Cemetery	11	7.65	9.7	8.24	0.62	7.52
Giza	54	6.39	9.63	8.04	0.67	8.33
Kom El-Hisn	13	7.26	8.69	7.99	0.46	5.76
Mendes	6	7.03	8.62	7.99	0.84	10.51
Abydos Settlement Site	14	7.16	9.73	7.95	0.68	8.55
South Abydos	31	6.26	8.36	7.58	0.53	6.99
Aswan (Middle Kingdom)	3	6.41	8.46	7.63	1.08	14.15
Amarna	46	6.13	8.68	7.71	0.52	6.74
Kom Firin	13	7.55	9.51	8.42	0.54	6.41
Saïs	12	7.23	8.28	7.78	0.38	4.88
ZUR	5	6.97	8.36	7.77	0.54	6.95
Tell el-Borg	8	7.69	9.23	8.45	0.46	5.44
Aswan (Late Period)	4	7.64	8.95	8.41	0.56	6.66
Aswan (Ptolemaic-Roman)	21	7.42	9.43	8.32	0.60	7.21
Cairo (Modern)	28	7.06	8.55	7.91	0.40	5.06

Second Molar Summary Statistics:

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine	16	7.17	9.15	8.49	0.55	6.48
Abydos Middle Cemetery	14	7.46	10.36	9.04	0.76	8.95
Giza	77	7.23	10.27	8.63	0.60	6.95
Kom El-Hisn	12	7.67	9.93	8.49	0.73	8.59
Mendes	6	8.35	9.52	8.97	0.44	4.91
Abydos Settlement Site	14	2.6	9.05	7.81	1.57	20.10
South Abydos	32	6.71	9.53	8.18	0.62	7.58
Aswan (Middle Kingdom)	4	7.49	8.93	8.26	0.52	6.29
Amarna	24	6.45	9.26	8.41	0.66	7.85
Kom Firin	9	8.71	10.11	9.31	0.42	4.51
Saïs	11	6.61	9.65	8.71	0.93	10.68
ZUR	5	7.92	8.6	8.25	0.28	3.39
Tell el-Borg	7	7.09	9.16	8.42	0.78	9.26
Aswan (Late Period)	9	8.23	9.92	9.13	0.65	7.12
Aswan (Ptolemaic-Roman)	20	7.76	10.54	9.08	0.66	7.27
Cairo (Modern)	25	6.36	9.77	8.42	1.00	11.88

Third Molar Summary Statistics:

Site	N	Min.	Max.	Mean	Std. Dev.	Coef. Vari.
Elephantine	8	7.51	8.83	8.32	0.48	5.77
Abydos Middle Cemetery	11	8.55	9.88	9.25	0.48	5.19
Giza	58	6.61	10.29	8.84	0.61	6.90
Kom El-Hisn	11	8.29	10.86	9.19	0.78	8.49
Mendes	6	8.93	10.03	9.39	0.38	4.05
Abydos Settlement Site	12	7.68	9.24	9.29	0.49	5.91
South Abydos	26	7.22	9.51	8.54	0.59	6.91
Aswan (Middle Kingdom)	4	8.43	9.09	8.86	0.31	3.49
Amarna	17	7.36	9.24	8.42	0.50	5.94
Kom Firin	3	8.51	9.40	9.03	0.47	5.20
Saïs	7	7.96	10.32	9.24	1.19	12.88
ZUR	3	7.69	8.72	8.20	0.52	6.34
Tell el-Borg	3	9.01	10.18	9.56	0.59	6.17
Aswan (Late Period)	6	8.30	10.04	9.12	0.61	6.69
Aswan (Ptolemaic-Roman)	14	6.76	10.35	9.08	0.86	9.48
Cairo (Modern)	10	6.26	9.97	8.80	1.13	12.84

Table 8.1: Width Summary Statistics for all caprine populations

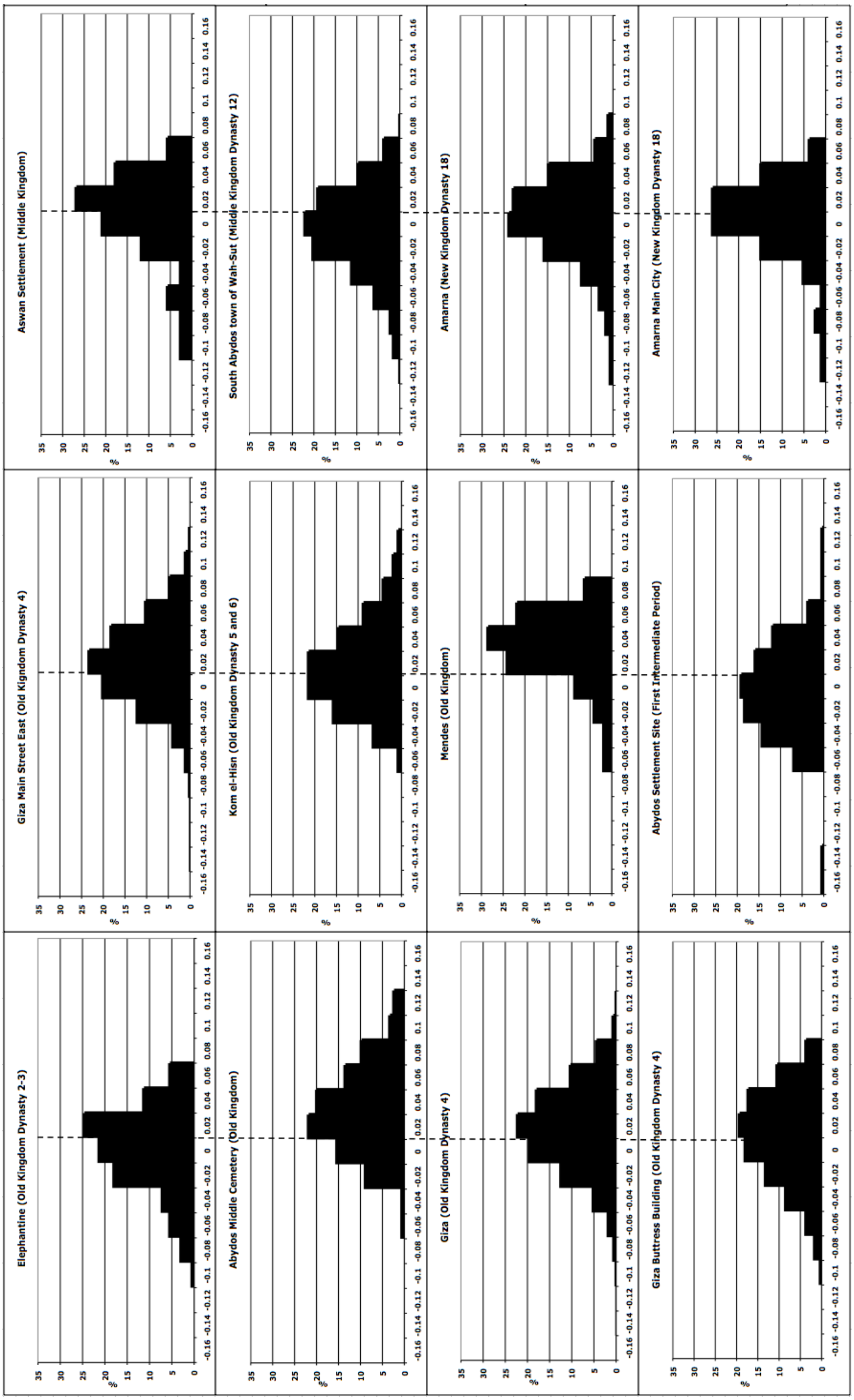

Figure 8.2a: Comparison of caprine lower tooth measurements from all Egyptian populations. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents modern Egyptian caprine standard

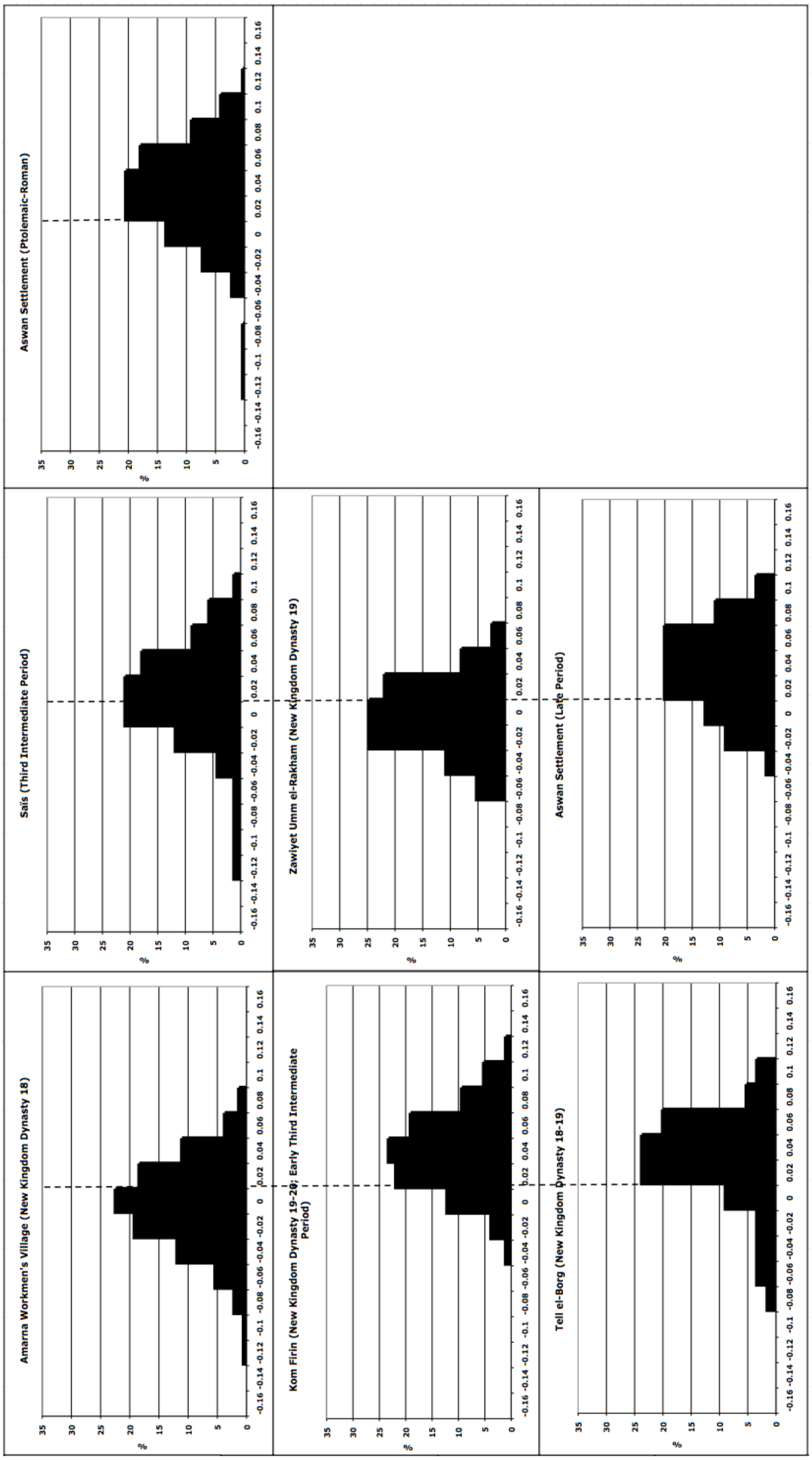

Figure 8.2b: Comparison of caprine lower tooth measurements from all Egyptian populations. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents modern Egyptian caprine standard

8.4 Discussion

8.4.1 Age and Sex of Modern and Archaeological Caprines

As stated in chapter 7, section 7.1.3 with respects to herd structure, caprines typically have three production products: meat, milk and wool. Determining which one, or combination of these products is required is key in archaeological assemblages, and can be ascertained from analysis of the age distribution of the animals at each site.

Starting with the modern caprine population age distribution (Figure 8.1), a bimodal distribution is seen with the majority of individuals being killed at around six to twelve months (stage C), with a second smaller peak at around six to eight years (stage H) based on the attrition stages (see Table 8.2) as established by Payne (1973). This coincides exactly with what was reported by the various sheep butchers throughout Cairo. This is not surprising given that these mandibles are coming from a butcher, whose primary concern is meat being sold for consumption. Thus, the figures provide a good model as to what might be the expected age distribution in a sheep husbandry regime whose primary goal is meat consumption.

Stage	Suggested Age
A	0-2 months
B	2-6 months
C	6-12 months
D	1-2 years
E	2-3 years
F	3-4 years
G	4-6 years
H	6-8 years
I	8-10 years

Table 8.2: Suggested ages for each of the attrition stages as provided by Payne (1973).

The modern age distribution, however, is quite different from the archaeological assemblages, with the exception of Amarna. Like the modern assemblage, Amarna displays a large peak at attrition stage C, six to twelve months, with a smaller peak around stages G/H, four to eight years. This suggests a primary goal of meat consumption.

If one considers the possibility that the central authority provisioned the inhabitants of the Workmen’s Village, similar to what was experienced at the Giza

Workmen's Village, then it is possible that the central authority was already providing for the secondary resources that might be obtained from keeping caprines to an older age. Thus, the inhabitants only needed to obtain their own meat. Although it is likely that pork was the most commonly consumed meat, it is probable that lamb was consumed as well, thus explaining the younger age pattern seen throughout the site, and particularly at the Workmen's Village. The few older individuals present are likely to have been those that were only kept for breeding purposes. As Hecker (1984) does not note any age distribution of the caprine remains, at this point there is no basis for age comparison.

The remainder of the archaeological assemblages, however, displays no clear pattern, with most assemblages peaking between attrition stages E-G (two to six years). Unlike Amarna and the modern caprines, this suggests a primary reliance on caprines for their secondary products such as milk and wool.

The Old Kingdom sites of Giza and Kom el-Hisn display interesting age distributions, both peaking at a late age, although the Giza caprines are slightly younger, peaking at stage F (three to four years), whereas the Kom el-Hisn assemblage peaks at stage G, (four to six years). With reference to cattle, Redding (1992: 105) notes that the cattle remains at Kom el-Hisn are significantly younger or older than the remains at Giza, supporting the fact that Kom el-Hisn was a cattle rearing centre supplying sites such as the Giza Workmen's Village, which were state supported. Although it is possible that caprines could have also been brought into sites such as Giza, given the fact that the Kom el-Hisn remains are slightly older than Giza, this may support the fact that they were reared elsewhere. At Kom el-Hisn caprines were maintained and kept on the periphery of the site (1992: 104). Nevertheless, both age distributions seem to indicate a reliance on the secondary resources of caprines, possibly with an emphasis on wool production due to the presence of significantly older individuals, which corresponds with Redding's conclusions (1992: 103).

Furthermore, comparing Kom el-Hisn (Old Kingdom) to Kom Firin (New Kingdom), as both are of similar geographical contexts in the western delta, although from different time periods, there are some slight differences. The Kom Firin assemblage peaks considerably earlier at stage D/E (one to three years) compared to Kom el-Hisn at stage G (four to six years). Although the pattern at Kom Firin seems to suggest a combined reliance on meat and possibly milk production in comparison to wool/hair production at Kom el-Hisn, it could also suggest a change in husbandry regime overtime. However, given the fact that the Kom Firin sample is fairly small (totaling twenty-five teeth from nineteen mandibles), one can only hope for future study to confirm this supposition.

The other two New Kingdom sites of Tell el-Borg (representing nine mandibles) and ZUR (representing five mandibles) in comparison to Kom Firin show slightly older individuals present. As these two assemblages are an even smaller sample size than Kom Firin, they do not provide statistically valid results to form any meaningful conclusion. The Third Intermediate Period site of Saïs does provide a similar age distribution to Kom Firin also peaking at stage D (one to two years), which is not surprising given that this too is a western delta site. However, if there was a change in caprine husbandry regimes between the Old and New Kingdoms, how do the First Intermediate Period/Middle Kingdom sites fit in?

Stine Rossel (2007: 190) states that the caprine slaughter age at the Middle Kingdom town of *Wah-Sut* at South Abydos peaks around thirty to thirty-six months, as the majority of mandibles analyzed (about twenty) are older than thirty months. Five mandibles were aged to around eighteen months and only a few were older than five years.

The author's analysis of the South Abydos teeth as seen in Figure 5.1 which peak at stage F (three to four years) confirms Rossel's conclusions, and although she does not discuss this, supports that caprines were most likely being used for their secondary resources such as milk and wool. Furthermore, given the larger presence of goats at the site, as the sheep to goat ratio is 1:3.2 (Rossel 2007: 182), this supports a more likely reliance on milk production rather than wool production. The same age distribution is also seen at the First Intermediate Period Abydos Settlement Site and the Middle Kingdom assemblage from Aswan. Furthermore, despite the time period change, the Late Period and Ptolemaic-Roman assemblages from Aswan also display similar age distributions to the Middle Kingdom assemblage, supporting a heavier reliance on the secondary resources from caprines. This seems to support the idea that there were no major changes in the age preference for slaughter throughout dynastic Egypt. Overall, all of the assemblages show the presence of older individuals that were utilized for their milk and wool.

8.4.2 Size of the Modern and Archaeological Caprines

As stated in section 8.3.2, the caprines from Lower Egyptian (delta) archaeological sites are on the whole larger than those from the Upper Egyptian archaeological sites. As was the case with the pigs (as in section 5.4.2), it is possible that this may be due to better food access in the delta. However, there are exceptions in the Abydos Middle Cemetery (AMC), and both the Late Period and Ptolemaic-Roman assemblages from Aswan, which all have the same mean (0.02). Larger than the modern Egyptian caprine standard, this is comparable if not slightly larger than a number of Lower Egyptian assemblages. What might account for this exception?

Being a cemetery context, it is highly possible that the remains from AMC represent funerary offerings of animals that may have been raised differently to the normal caprines that were raised in domestic contexts for consumption/secondary products. It is quite possible that animals that were reared by the state (temples, cemetery, or general administration) might have had better access to food and care than animals raised by individuals (Ikram 1995: 211).

The other Aswan assemblages from the Late Period and Ptolemaic-Roman contexts, are larger in size and are the only two settlement contexts from Upper Egypt that are larger than the modern Egyptian standard. It has been suggested that beginning in the Ptolemaic-Roman period there may have been an introduction of a second breed of sheep at Aswan (Johanna Sigl and Angela von den Driesch, Personal Communication). Although difficult to confirm without DNA testing, this could explain the slightly larger size of caprines at Aswan, especially when compared to the earlier assemblage from the Middle Kingdom. This larger size combined with the fact that the third molar coefficient of variation in the Ptolemaic-Roman assemblage is high (9.47), supports the hypothesis of the presence of two different breeds of sheep accounting for the larger size. Of note, at this point, there is no evidence to support a second breed in the Late Period assemblage, but due to the fact that the Late Period assemblage is considerably smaller than the Ptolemaic-Roman sample, future work is needed to confirm whether there was a second breed present during this period.

Comparison of the sites of Kom Firin and Kom el-Hisn is also interesting. It was mentioned in the previous section (8.4.1) that both sites are of a similar geographical location, although are from different time periods. The teeth in the Kom Firin sample, however, are slightly larger (mean = 0.03) than the Kom el-Hisn sample (mean= 0.007). When combining this data with their age distributions, Kom el-Hisn was found to have significantly older individuals (around four to six years at time of death) than Kom Firin (around one to two years at time of death). Thus, the difference in age at death may explain the slightly larger size of caprines at Kom Firin, since younger individuals would not have experienced as much attrition as the older individuals. However, the size difference is not great enough to provide a methodological issue, as it is known that tooth height is more greatly affected by age than tooth width.

Aside from these exceptions, overall there does not seem to be much variation is caprine size based on tooth width, which seem to reflect the idea that caprine husbandry remained a constant throughout dynastic Egypt. Another possibility for the lack of variation is not due to the husbandry regime, but the mixing of species and sexes. This is a problem of which there are ways to work around this. As Zeder and Pilaar's (2010) article was not published at the time of data collection, the application of this species differentiation may help to solve one of these issues. Future work on the separation of the sexes is needed, though.

Hecker (1984: 162) notes that given the desert edge settlement context of the site of Amarna, especially the Workmen's Village, it is likely that the remains are more likely to be goat than sheep. Furthermore, Hecker (1984: 159) notes that goats were likely to have been regularly kept in the open space at the south-west corner of the Workmen's Village (Figure 3.4), although some may have been penned in the individual workmen's houses. If goats were more common than sheep at Amarna, then this might explain the smaller size of the caprines, skewing the distribution to the left as seen in Figure 8.2. This could indicate that the distributions that are more skewed to the left could represent goats, where as larger ones could represent more sheep. Again, this is a conclusion that is not possible to confirm without DNA testing.

Again, referring back to the main goal of the dissertation, which is to look at changes in husbandry practices throughout dynastic Egypt, all sites were combined according to their time period as seen in Figure 5.3. This, as in Chapter 5, section 5.4.2, was done in order to calculate changes in the caprines' size over time. As no Neolithic data for caprines was available, analysis starts with the Old Kingdom, which displays a tight, normal distribution that is evenly spread. This is also seen from the New Kingdom onwards, although the Third Intermediate Period, Late Period and Ptolemaic-Roman age groupings all represent one site each, which are normal distributions that are all larger than the modern Egyptian standard. The First Intermediate Period (FIP) and Middle Kingdom assemblages also have normal distributions, but are slightly smaller than the modern Egyptian standard. Referring back to the Amarna sample which according to Hecker (1984: 158-159) is almost exclusively goat, this might mean that the FIP assemblage which solely represents the Abydos Settlement Site and the Middle Kingdom assemblages which are made up of the South Abydos town of *Wah-Sut* and the Middle Kingdom Aswan settlement (although the majority of Middle Kingdom teeth are from *Wah-Sut*) may have a majority of goat remains. This is further supported by the sheep to goat ratios at both the Abydos Settlement Site, which has a sheep to goat ratio of 0.5:1 (Richard Redding, Personal Communication) and *Wah-Sut,* which has a 1:3.2 ratio (Rossel 207: 182). No ratios are available as of yet for the Aswan material (Johanna Sigl, Personal Communication). Thus, it is more likely that goats may be smaller in size than sheep, and are thus represented by size-distributions skewed to the left of the modern Egyptian standard.

If there was a greater presence of one species over the other, or even a specific breed, the overall size of the teeth still would fall within the same size constant. This is around the modern Egyptian standard, suggesting that there was not much of a size difference between the caprine populations at different sites or between different species/breeds.

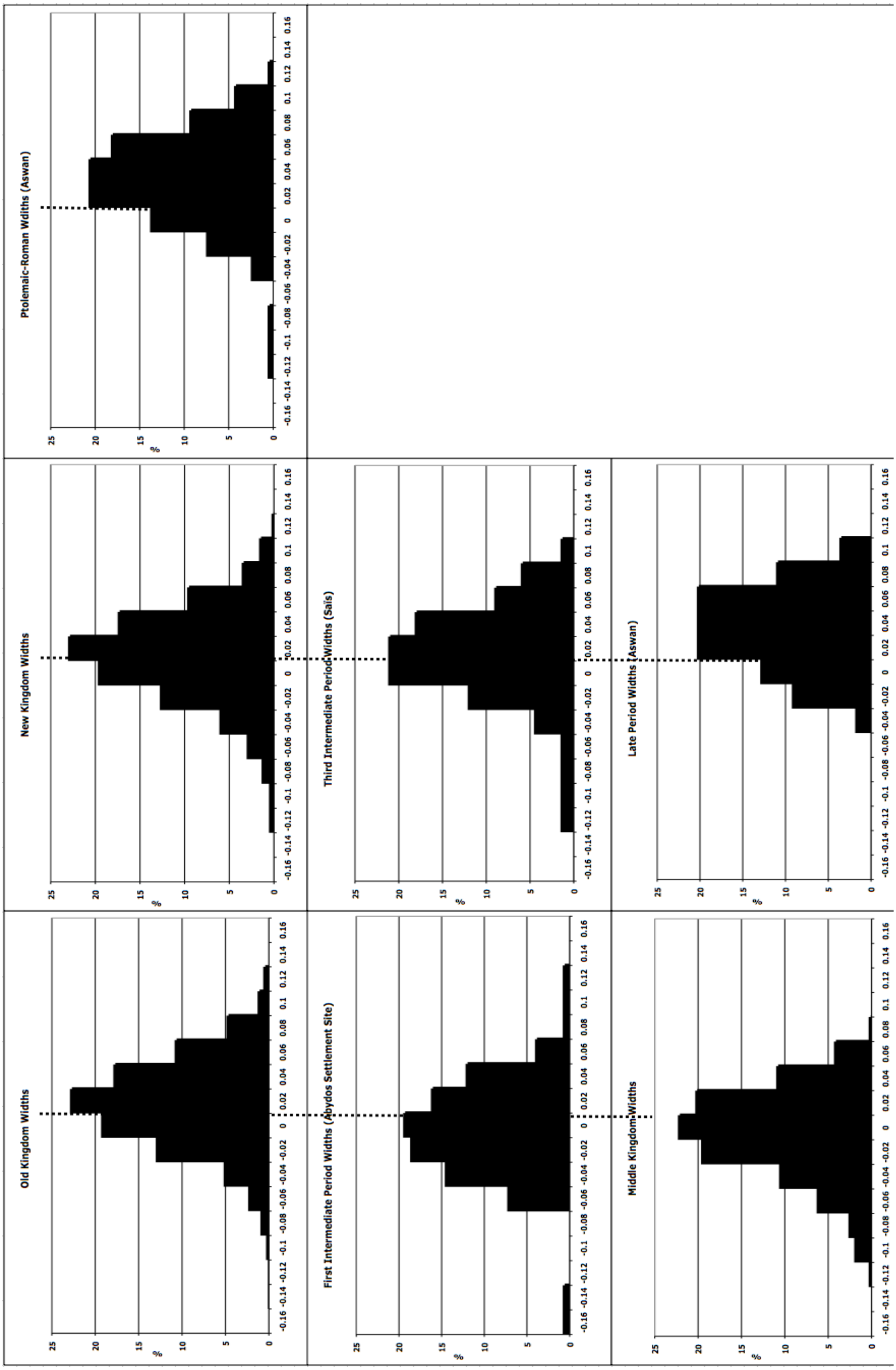

Figure 8.3 Comparison of caprine lower tooth measurements from all Egyptian populations based on time period. The posterior width of the first and second molar along with the anterior width of the third molar are combined using the log ratio technique (see text). The '0' line represents modern Egyptian caprine standard.

8.5 Conclusions

8.5.1 *Age and Sex of Modern and Archaeological Caprine*s

To summarize the age data, most caprines were slaughtered when they were quite mature at an older age between two to as much as six years, most probably to maximize secondary resources such as milk, and possibly wool. This is a pattern that is seen at most of the archaeological sites except for Amarna, where meat production was more likely the goal of the herds, as the kill-off pattern corresponds exactly to that of the modern population, derived from the butchers. The indicative pattern of meat exploitation peaks between six to twelve months of age at death, with a second peak around six to eight years, likely representing individuals kept for breeding purposes. The sex of the animals was not determined, as no methodology has as yet been developed for sexing caprine mandibles.

8.5.2 Size of the Modern and Archaeological Caprines

Overall the size distribution of the animals based on tooth width seem to indicate that caprine husbandry remained constant throughout dynastic Egypt and that despite differences in geography, age distributions, species, or breeds, no major variations in the animals was detected throughout Egyptian history. There are a few minor exceptions to this conclusion including the possible greater presence of goats at Amarna, the South Abydos town of *Wah-Sut*, and the Abydos Settlement Site. The presence of more goats might explain why some sites are smaller in size than the modern Egyptian standard. Furthermore, there may have been more than one breed of sheep at Aswan when the size distributions are combined with individual molar summary statistics. Although it is possible that goats could have had different husbandry regimes compared to sheep, which one might expect to manifest itself in different patterns, the caprine sizes still seem to fall within the same constant, resulting in a caprine populations that are all fairly similar in size. This study also points out the futility of using teeth measurements when you cannot sort out the sheep from the goats and the males from the females.

9 The Presence of Enamel Hypoplasia in Modern and Archaeological Egyptian Caprines

This chapter will examine further the two caprine data sets (modern and archaeological) discussed in the previous chapter through the study of enamel hypoplasia by applying the methodology discussed in Chapter 2. As for the pig section, the modern population with its known life history is crucial in this chapter for understanding the factors that can affect the presence of hypoplasia in the archaeological population. Thus, like Chapter 6, the three key research questions that will be discussed in this Chapter are: 1) interpreting caprine husbandry practices; 2) understanding possible seasonality; and 3) interpretation of defect type and severity.

9.1 Key Research Questions

As previously noted, three research questions will be addressed in this chapter:

1) Interpreting caprine husbandry practices

In this chapter, LEH will be used to interpret caprine husbandry practices throughout the history of dynastic Egypt. As there is no information available on the presence of enamel hypoplasia in either ancient or modern Egyptian caprines, this chapter will begin by using the modern Egyptian caprine data collected to establish general patterns of frequency and chronology of enamel hypoplasia from a sample with a known life history. This will then provide a baseline for understanding the influence of the environment and diet on the formation and severity of enamel hypoplasia, which can be compared the archaeological data. This section will also investigate whether coherent patterns do indeed exist in the archaeological material that may reflect ecological setting and/or husbandry practices. The issue of variability with diachronic change will also be addressed.

2) Understanding seasonality and physiological impacts

The theme of seasonal markers in both the past and present as indicated by the presence of enamel hypoplasia will be investigated. Two different aspects of seasonality will be discussed using the distribution of enamel hypoplasia on the tooth crown:

Physiology and animal husbandry: This section will investigate whether established physiological events such as birth and weaning (as discussed in Dobney & Ervynck 1998, 2000; Dobney *et al.* 2002; Ervynck & Dobney 1999, 2002; Ervynck et. all 2001; Arbuckle 2004; Upex 2010) can produce a marker within the distribution of enamel hypoplasia on the tooth crown. This section will also look at the established physiological markers in the thirteen archaeological caprine assemblages with semi-unknown management strategies.

Seasonal Environmental Factors: Again, as the Nile and its annual flooding is the major environmental factor in ancient Egypt, the second aspect of seasonality to be investigated is the possible impact of the annual flood on the frequency of hypoplasia. This unique environmental aspect of Egypt will be used to address the potential of enamel hypoplasia to be used as a marker for seasonal climatic changes in archaeological caprine populations.

3) Interpretation of defect type and severity

As noted previously (Upex 2010: 128), different types and severity levels of enamel hypoplasia can be related to different forms and severity of specific stress events. This section will investigate if specific events in the animal's life can be linked with specific hypoplasia types and severity levels.

9.2 Results

A total of 707 recordable caprine teeth were analyzed from all archaeological sites, along with 63 caprine teeth from the modern caprine mandibles (N= 28) collected, totaling 770 caprine teeth that will be analyzed in this study. An inventory of the material studied is represented in Table 9.1 below. It shows that all tooth types are sufficiently abundant in the study collection, and a large number of teeth were available from most sites. The fact that some tooth types are under represented at some sites is a combination of both taphonomic factors (such as preservation and recovery) and differences in age profiles of the slaughtered caprine populations represented.

SITE	TIME PERIOD	M1	M2	M3	Total Number of Teeth
Elephantine	Old Kingdom	17	16	8	**41**
Abydos Middle Cemetery	Old Kingdom	11	14	11	**36**
Giza	Old Kingdom	54	77	58	**189**
Kom El-Hisn	Old Kingdom	13	12	11	**36**
Mendes	Old Kingdom	6	6	6	**18**
Abydos Settlement Site	First Intermediate Period	14	14	12	**40**
South Abydos	Middle Kingdom	31	32	26	**89**
Aswan	Middle Kingdom	3	4	4	**11**
Amarna	New Kingdom	46	24	17	**87**
Kom Firin	New Kingdom	13	9	3	**25**
Saïs	Third Intermediate Period	12	11	7	**30**
ZUR	New Kingdom	5	5	3	**13**
Tell el-Borg	New Kingdom	8	7	3	**18**
Aswan	Late Period	4	9	6	**19**
Aswan	Ptolemaic-Roman	21	20	14	**55**
Cairo	Modern	28	25	10	63
TOTAL	**ALL SITES**	**286**	**285**	**199**	**770**

Table 9.1: Total caprine teeth from all sites.

9.2.1 Interpreting caprine husbandry practices

Key Points

The highest frequency of enamel hypoplasia (calculated using complete teeth) in caprine teeth is the New Kingdom sample from Tell el-Borg as compared to both modern and archaeological populations.

The Old Kingdom population from Mendes has the lowest frequency of caprine teeth with enamel hypoplasia (calculated using complete teeth), which is significantly lower than all other archaeological and modern populations.

When simultaneously compared, there is a significant difference in the frequency of hypoplasia between the caprine assemblages ($p \leq 0.0001$, Chi square test) and will be further discussed in section 9.3.1.

General Results

The data discussed in Table 9.1 and a comparison of the relative frequencies between all sixteen data sets is seen Table 9.2. Of the 707 recordable caprine teeth that were analyzed from all the archaeological sites in the study, 425 (60%) had evidence of hypoplasia and of the 63 modern teeth analyzed, 30 (48%) displayed evidence of hypoplasia as well. Thus, the total number of caprine teeth analyzed in this study amounts to 770 teeth, of which 455 (59%) have hypoplasia present. The defects affected 51% of all the first molars studied (both modern and archaeological), and 62% of both all the second and third molars studied. A breakdown of the analysis of modern verses archaeological teeth studies is seen in Table 9.3.

As there are sixteen different caprine populations, the percentage of enamel hypoplasia for each of the three molars per site is listed in Table 9.4.

SITE	TIME PERIOD	# OF COMPLETE TEETH	# OF TEETH WITH LEH	% OF TEETH WITH LEH
Elephantine	Old Kingdom	41	24	59%
Abydos Middle Cemetery	Old Kingdom	36	25	69%
Giza	Old Kingdom	189	111	59%
Kom El-Hisn	Old Kingdom	36	19	53%
Mendes	Old Kingdom	18	3	17%
Abydos Settlement Site	First Intermediate Period	40	33	83%
South Abydos	Middle Kingdom	89	65	73%
Aswan	Middle Kingdom	11	7	64%
Amarna	New Kingdom	87	38	44%
Kom Firin	New Kingdom	25	22	88%
Saïs	Third Intermediate Period	30	15	50%
ZUR	New Kingdom	13	8	62%
Tell el-Borg	New Kingdom	18	16	89%
Aswan	Late Period	19	9	47%
Aswan	Ptolemaic-Roman	55	29	53%
Cairo	Modern	63	30	48%
TOTAL	**ALL SITES**	**770**	**455**	**59%**

Table 9.2: Comparing archaeological and modern caprine populations in terms of frequency of enamel hypoplasia.

Tooth	Modern Population	Archaeological Population	Total Population
M1	64%	50%	51%
M2	28%	66%	62%
M3	50%	64%	62%

Table 9.3: Percentage of teeth affected by enamel hypoplasia.

Site	**Time Period**	**% of M1**	**% of M2**	**% of M3**
Elephantine	Old Kingdom	53%	69%	50%
Abydos Middle Cemetery	Old Kingdom	45%	79%	72%
Giza	Old Kingdom	48%	61%	64%
Kom El-Hisn	Old Kingdom	46%	50%	63%
Mendes	Old Kingdom	0%	50%	17%
Abydos Settlement Site	First Intermediate Period	57%	93%	75%
South Abydos	Middle Kingdom	52%	75%	96%
Aswan	Middle Kingdom	33%	75%	75%
Amarna	New Kingdom	48%	38%	41%
Kom Firin	New Kingdom	77%	89%	100%
Saïs	Third Intermediate Period	67%	63%	29%
ZUR	New Kingdom	80%	40%	67%
Tell el-Borg	New Kingdom	75%	100%	67%
Aswan	Late Period	25%	56%	50%
Aswan	Ptolemaic-Roman	33%	80%	43%
Cairo	Modern	64%	28%	40%
TOTAL	**ALL SITES**	**51%**	**62%**	**62%**

Table 9.4: Percentage of teeth by molar affected by enamel hypoplasia for each site.

9.2.2 Understanding seasonality and physiological impacts

<u>Key Points</u>

The majority of all occurrences of enamel hypoplasia in almost all sixteen caprine populations are on the cervical half of the tooth crown.

In the modern Egyptian population the number of defects peak when the caprines are: 5/6 months old; 9/10 months old; and 22/23 months old, based on the Weinreb and Sharav (1964) sheep development rates.

Based on age data from the modern Egyptian populations (section 8.3.1, 8.4.1) the average estimates as to the numbers of defects in the archaeological populations peak when the caprines are: 5/6 months old; 9/10 months old; and 21/22 months old, based on the Weinreb and Sharav (1964) sheep development rates.

<u>General Results</u>

The distribution of hypoplasia on the anterior and posterior cusp (along with the middle cusp for the third molar) of all the analyzed sites organized by molar is shown in Figure 9.1-9.3. As discussed in Chapter 2, calculations are based on the running means of the values of the individual tooth height classes recorded. The use of running means was chosen for the analysis in order to smooth variation and allow underlying trends to become more clearly visible (Dobney and Ervynck 2000: 601; Upex 2010: 109).

In the modern Egyptian caprine material, all occurrences of enamel hypoplasia occur on the cervical half of the tooth crown, with defects on the first and second molar peaking at 9.9 millimeters above the root enamel junction (REJ). The third molar, however, displays a slightly different pattern, peaking at 7.9 millimeters, and a second possible peak between 13.9 and 15.9 millimeters above the REJ.

The distribution of hypoplasia seen in the archaeological material (Figures 9.1-9.3) is slightly different; as the vast majority of sites seem to peak slightly later at 7.9 millimeters above the REJ on the first molar, although there are three sites that peak at about 9.9 millimeters. Furthermore, there are two sites (Old Kingdom Elephantine, Amarna) that seem to display two peaks in the distribution of enamel hypoplasia, although both are at varying heights above the REJ.

Second molar distributions seem to show a bit more variation, although the vast majority of defects for all archaeological sites do occur in the cervical 20 millimeters of the tooth crown. The only exception is the site of Saïs, where the distributions peak at 27.9 millimeters. Aside from Saïs, most sites seem to peak between 7.9-9.9 millimeters above the REJ, with three sites (Abydos Middle Cemetery, Tell el-Borg, and Aswan Ptolemaic-Roman) possibly displaying a second peak around 13.9 millimeters.

Third molar distributions also seem to occur within the cervical 20 millimeters of the tooth crown, with the majority of defects peaking roughly between 7.9-9.9 millimeters above the REJ. Like the second molar distribution pattern, there also are a few sites that seem to have a second peak present roughly between 11.9-13.9 millimeters above the REJ.

The results from the modern material only (as this is the only caprine population with a confirmed season of birth) were plotted on to a schematic dental developmental graph (as discussed in Chapter 2) based on the development rates of caprines as described in Weinreb and Sharav (1964) and Upex (2010) as seen in Figure 9.4.

Although the Weinreb and Sharav (1964) development rates on Awassi sheep are likely to be more appropriate to use for Egyptian caprines, a comparison is still done using the development rates on the modern Shetland sheep from Hoy following Upex (2010), which will be explained further in the discussion section.

Following the top portion of Figure 9.4,which is based on the developmental rates as described by Weinreb and Sharav (1964), an increase in the frequency of enamel hypoplasia is observed around the time of weaning at about five to six months. On the second molar, there is a peak of EH that occurs at about nine to ten months after birth and then drops sharply. A similar picture is also seen with the third molar, with a peak at about twenty-two to twenty-three months after birth. There is, however, a second peak a few months earlier, at about nineteen to twenty months after birth. Dental development graphs will not be constructed for any of the archaeological populations, as it is not known exactly when the animals' time of birth was.

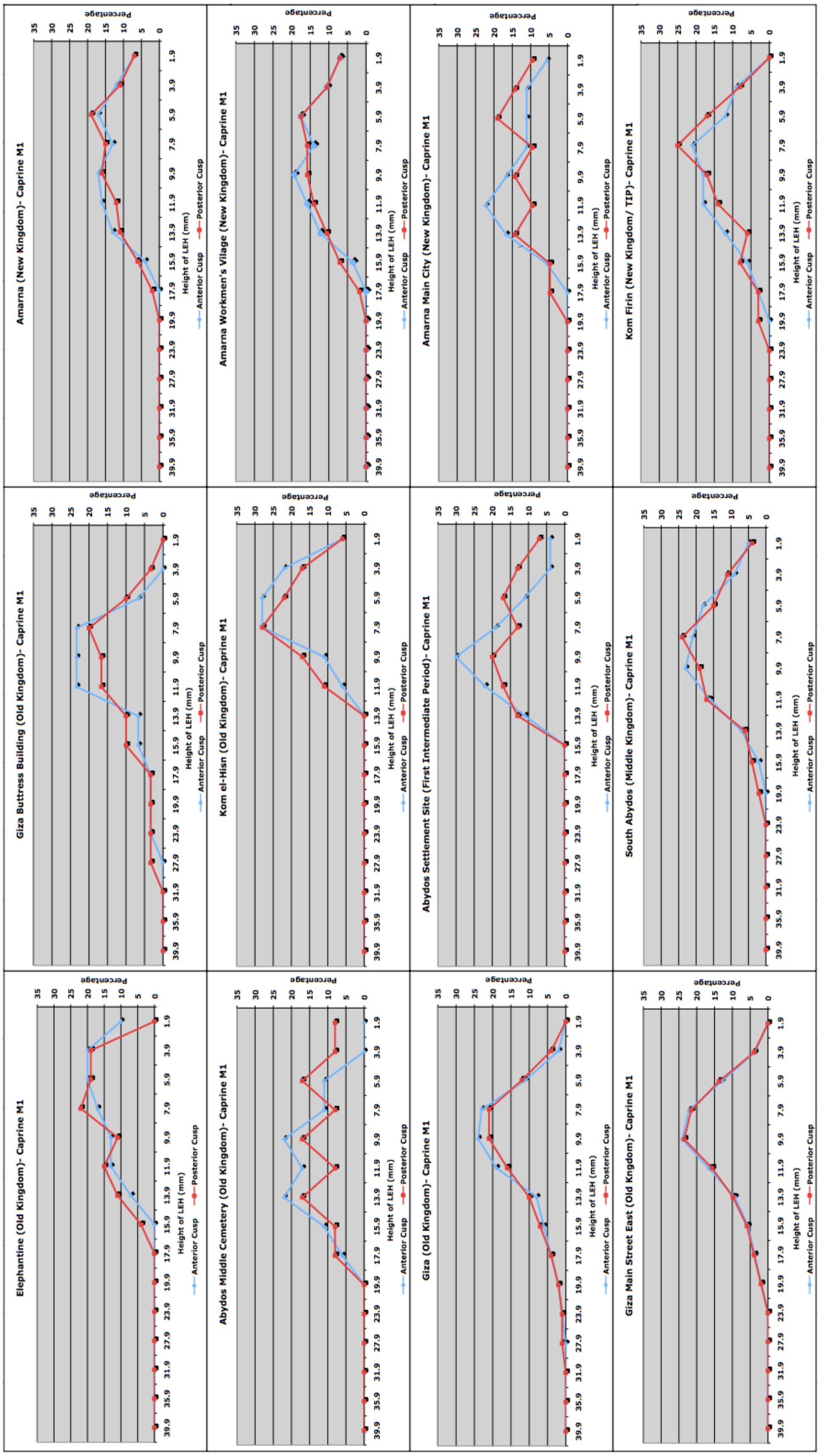

Figure 9.1a: The location of hypoplasia on the tooth crown of M1 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

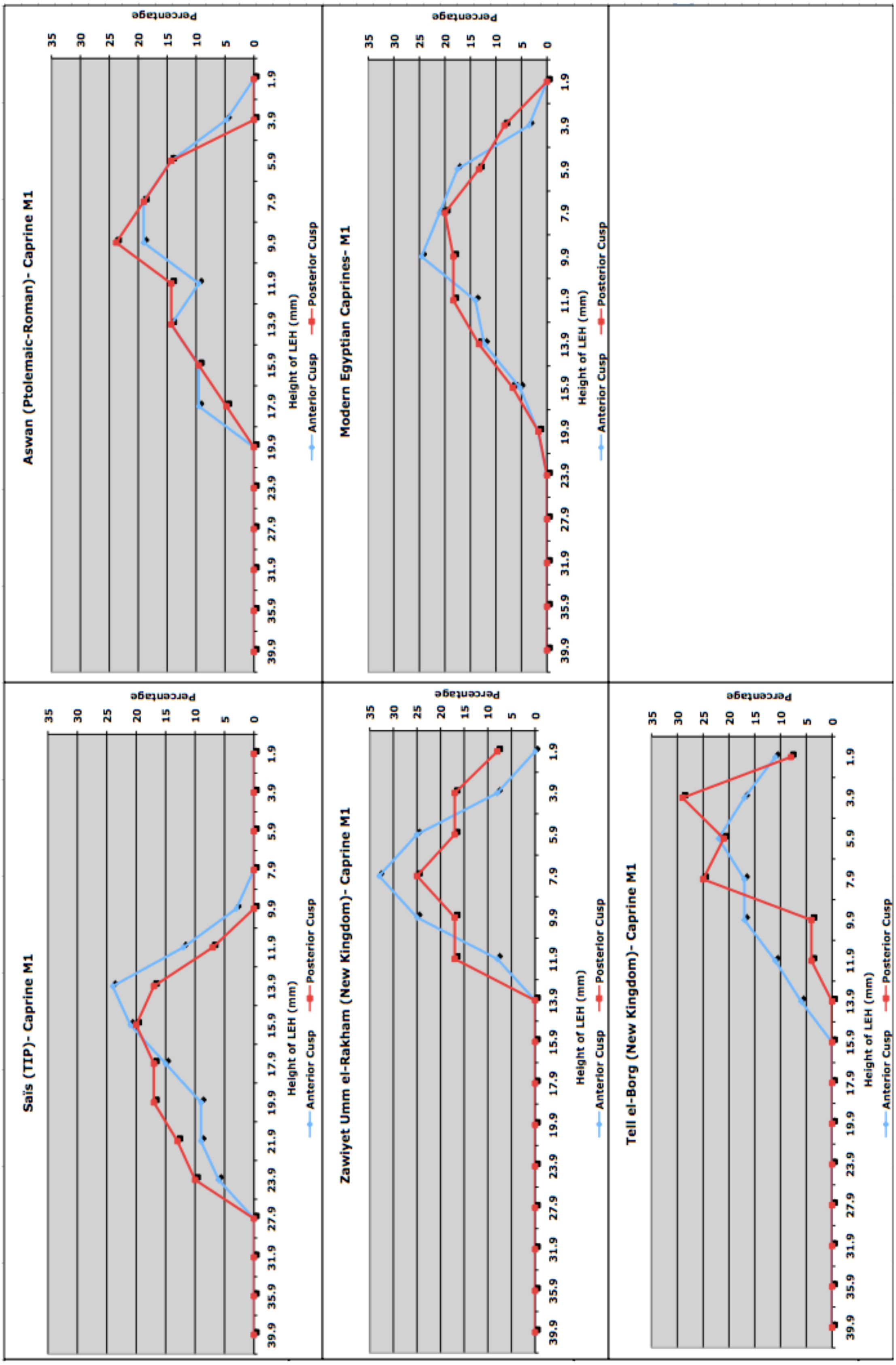

Figure 9.1b: The location of hypoplasia on the tooth crown of M1 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

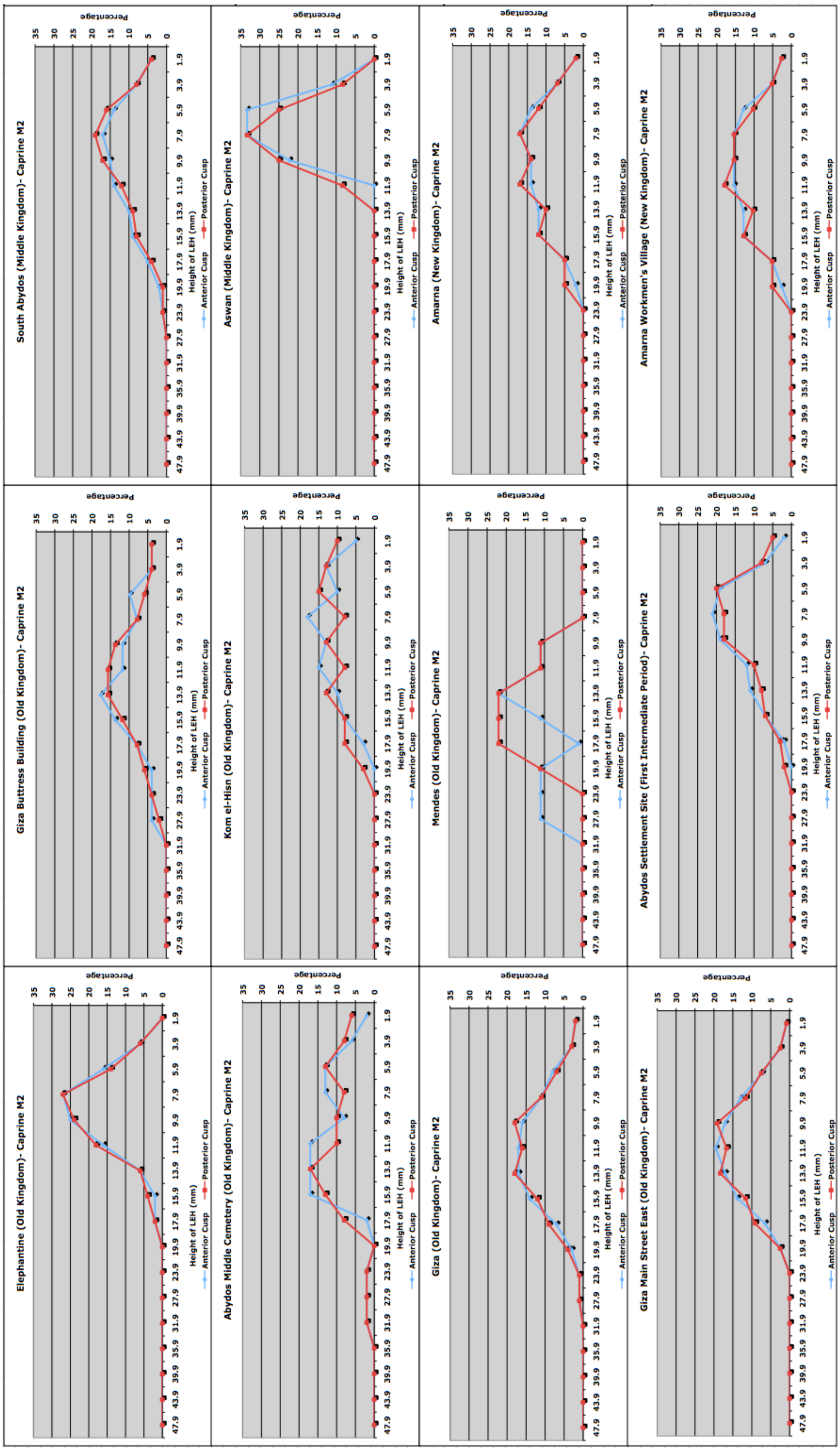

Figure 9.2a: The location of hypoplasia on the tooth crown of M2 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

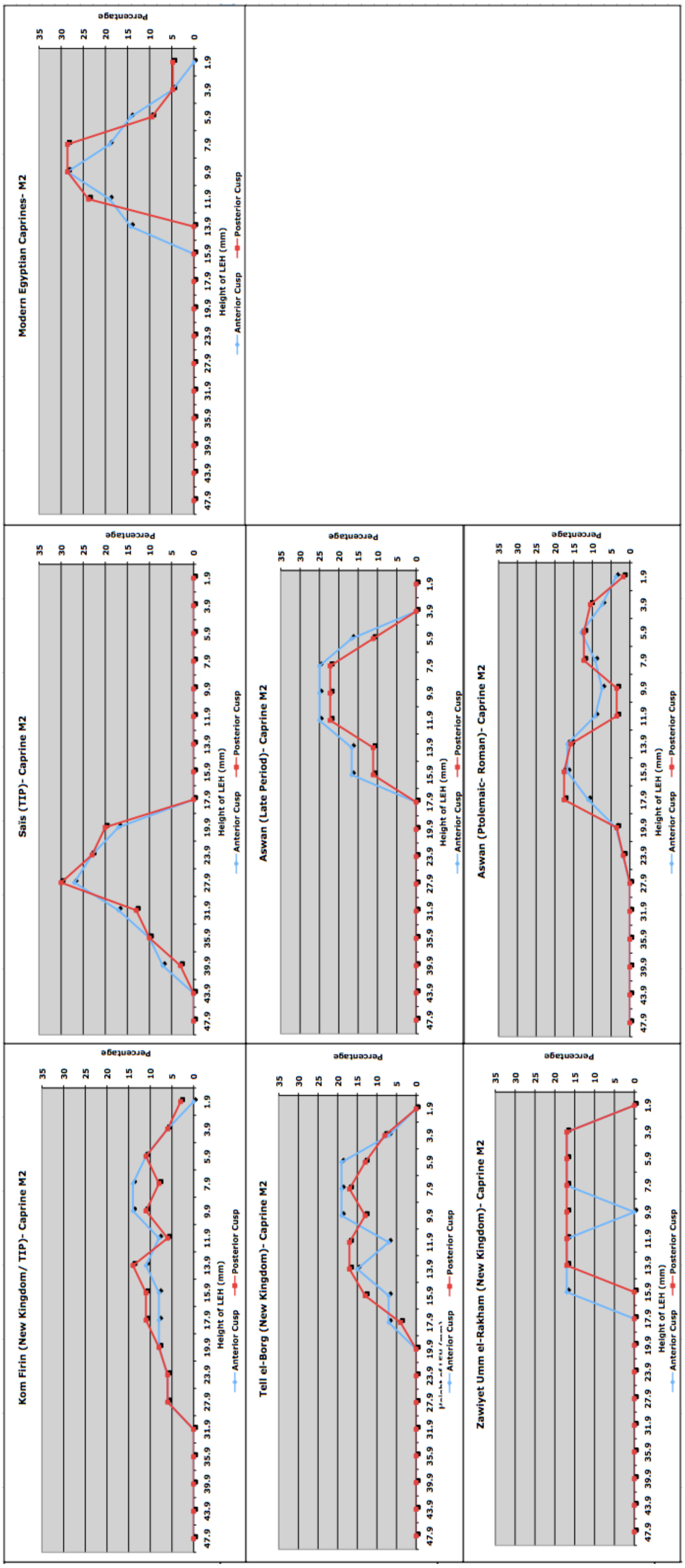

Figure 9.2b: The location of hypoplasia on the tooth crown of M2 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

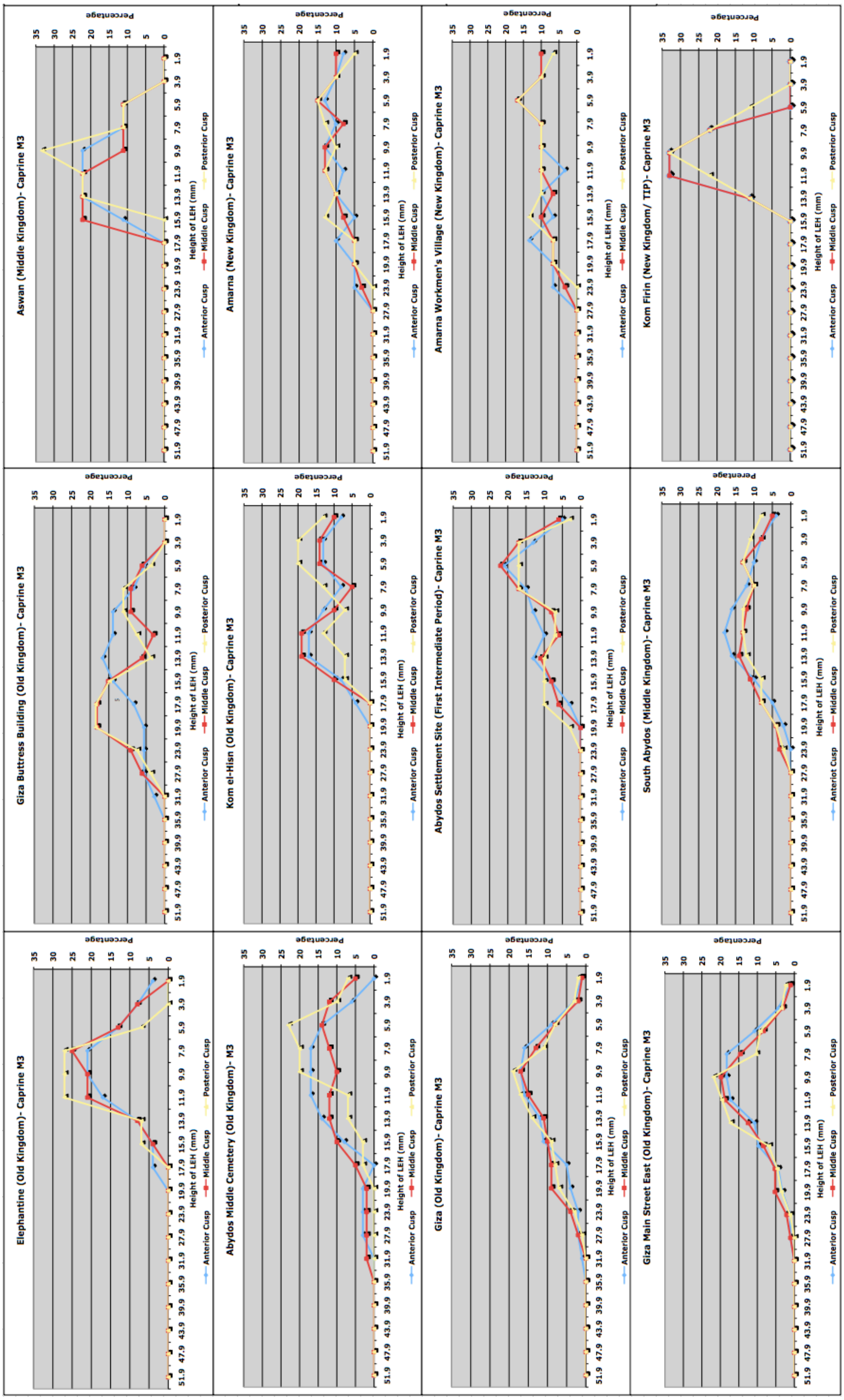

Figure 9.3a: The location of hypoplasia on the tooth crown of M3 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

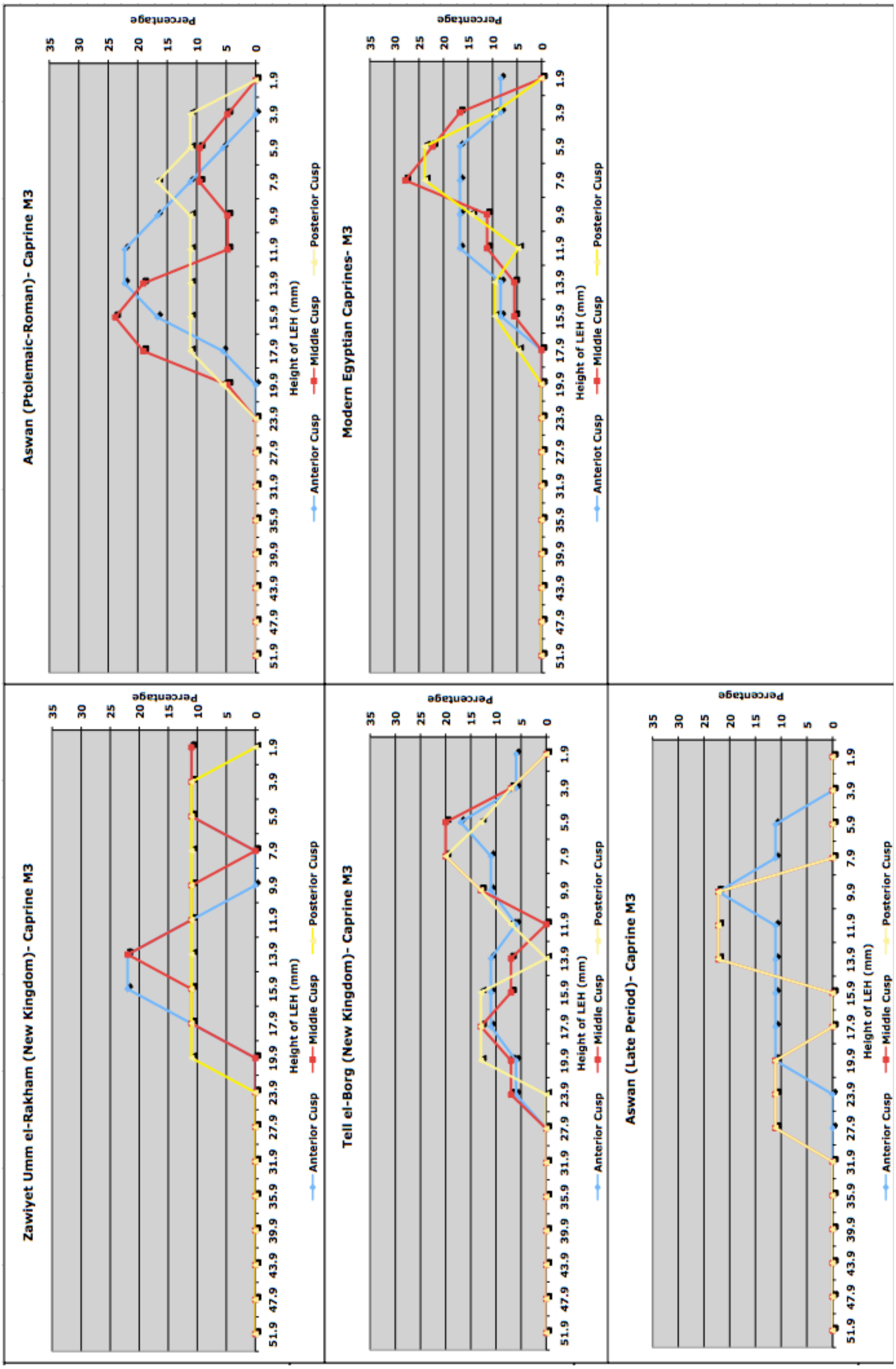

Figure 9.3b: The location of hypoplasia on the tooth crown of M3 in the modern and archaeological caprine material, plotted in millimeters from the root enamel junction (REJ) on the right of the graph to the maximum height of the tooth cusp (calculated from all available teeth) on the left of the graph.

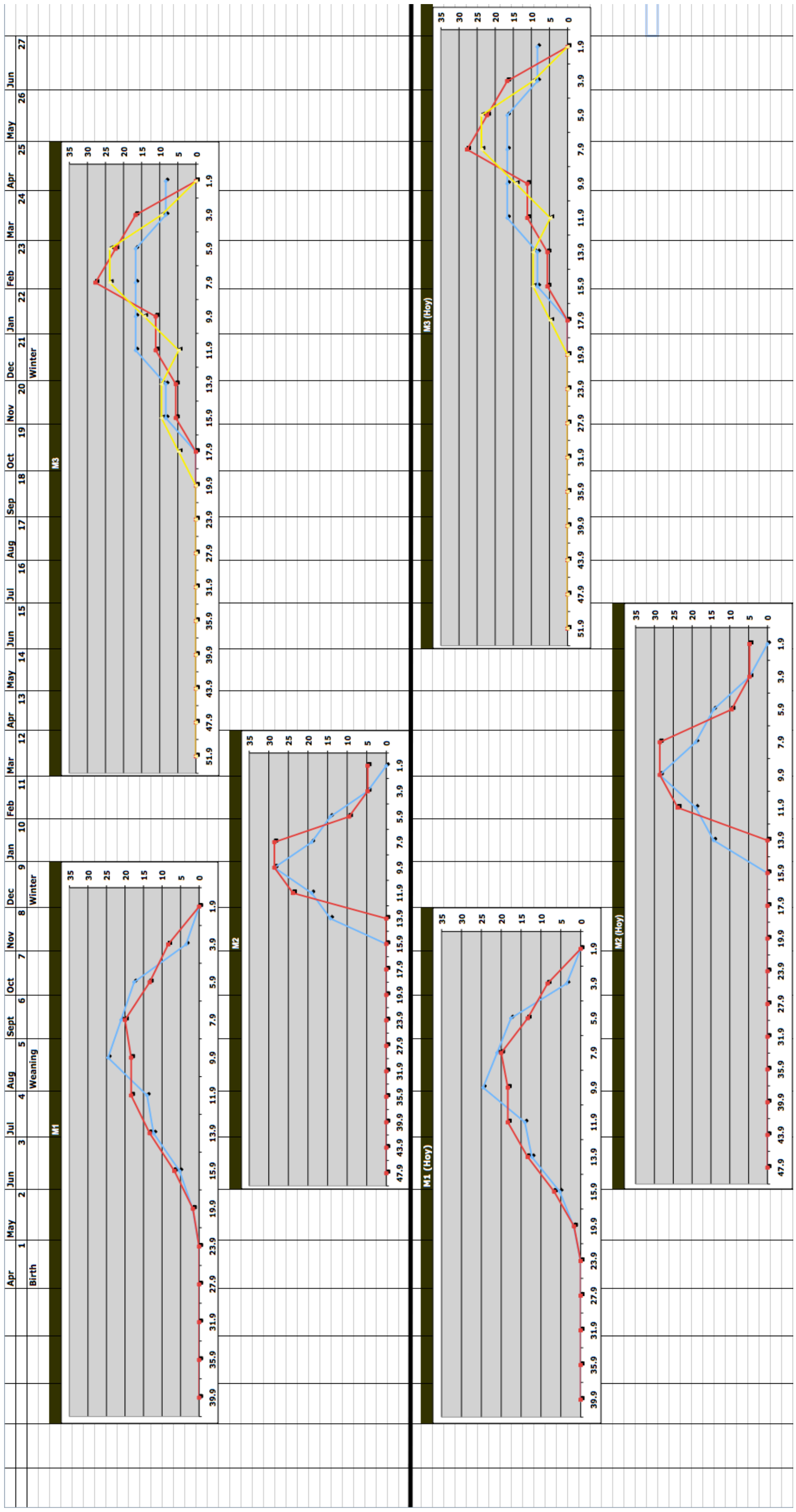

Figure 9.4: The modern Egyptian caprine material plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present. Hoy development data from Upex 2010: Figure 4.13.

9.2.3 Interpretation of defect type and severity

<u>Key Points</u>

The majority of Egyptian caprine samples have more low-level extended type defects such as depressions, although a few sites do have a higher percentage of more severe defect types (such as lines).

The linear type defects from all Egyptian modern and archaeological samples display low severity scores (levels 1 and 2).

The four key types of defects identified in modern and archaeological Egyptian caprine samples are: depressions, lines, pits, and shifts.

Shifts are the least common defect type to occur.

<u>General Results</u>

Tables 9.5, 9.6 and Figure 9.5 show the results of the analysis of defect types and severity scores. Overall, depression type defects are the most common. There are four sites (Abydos Middle Cemetery, Amarna, Saïs, and Tell el-Borg) where linear type defects are more common. Samples from sites that have linear type defects display very low severity scores (1 or 2), with only four samples (Abydos Middle Cemetery, South Abydos, Saïs, and the modern samples) having any evidence of higher severity scores (only level 3).

Within the Saïs caprine sample, there was a possible fourth type of defect identified. This ‘shift’ type of defect was identified in three (12%) of the twelve Saïs first molars. Shift type defects will be discussed in further detail in section 9.3.4 and are excluded from analysis for the reasons given there.

Site	% of linear type defects	% of depression type defects	% of pit type defects	% of shift type defects
Elephantine (Old Kingdom)	40%	57%	3%	-
Abydos Middle Cemetery (Old Kingdom)	51%	49%	-	-
Giza (Old Kingdom)	43%	57%	-	-
Kom El-Hisn (Old Kingdom)	33%	67%	-	-
Mendes (Old Kingdom)	50%	50%	-	-
Abydos Settlement Site (FIP)	20%	80%	-	-
South Abydos (Middle Kingdom)	50%	50%	-	-
Aswan (Middle Kingdom)	25%	63%	13%	-
Amarna (New Kingdom)	61%	37%	2%	-
Kom Firin (New Kingdom)	43%	57%	-	-
Saïs (TIP)	65%	19%	4%	12%
ZUR (New Kingdom)	40%	50%	10%	-
Tell el-Borg (New Kingdom)	75%	25%	-	-
Aswan (Late Period)	11%	89%	-	-
Aswan (Ptolemaic-Roman)	45%	55%	-	-
Modern Egyptain Caprines	29%	71%	-	-

Table 9.5: Comparison of enamel hypoplasia from all Egyptian sites.

Site/ Severity Score	1	2	3	4
Elephantine (Old Kingdom)	21%	79%	-	-
Abydos Middle Cemetery (Old Kingdom)	30%	60%	10%	-
Giza (Old Kingdom)	47%	53%	-	-
Kom El-Hisn (Old Kingdom)	22%	78%	-	-
Mendes (Old Kingdom)	-	100%	-	-
Abydos Settlement Site (FIP)	22%	78%	-	-
South Abydos (Middle Kingdom)	37%	61%	2%	-
Aswan (Middle Kingdom)	100%	-	-	-
Amarna (New Kingdom)	52%	48%	-	-
Kom Firin (New Kingdom)	67%	33%	-	-
Saïs (TIP)	33%	60%	7%	-
ZUR (New Kingdom)	25%	75%	-	-
Tell el-Borg (New Kingdom)	35%	65%	-	-
Aswan (Late Period)	100%	-	-	-
Aswan (Ptolemaic-Roman)	53%	47%	-	-
Modern Egyptian Caprines	33%	56%	11%	-

Table 9.6: Comparison of enamel hypoplasia severities of linear defects only for all Egyptian sites.

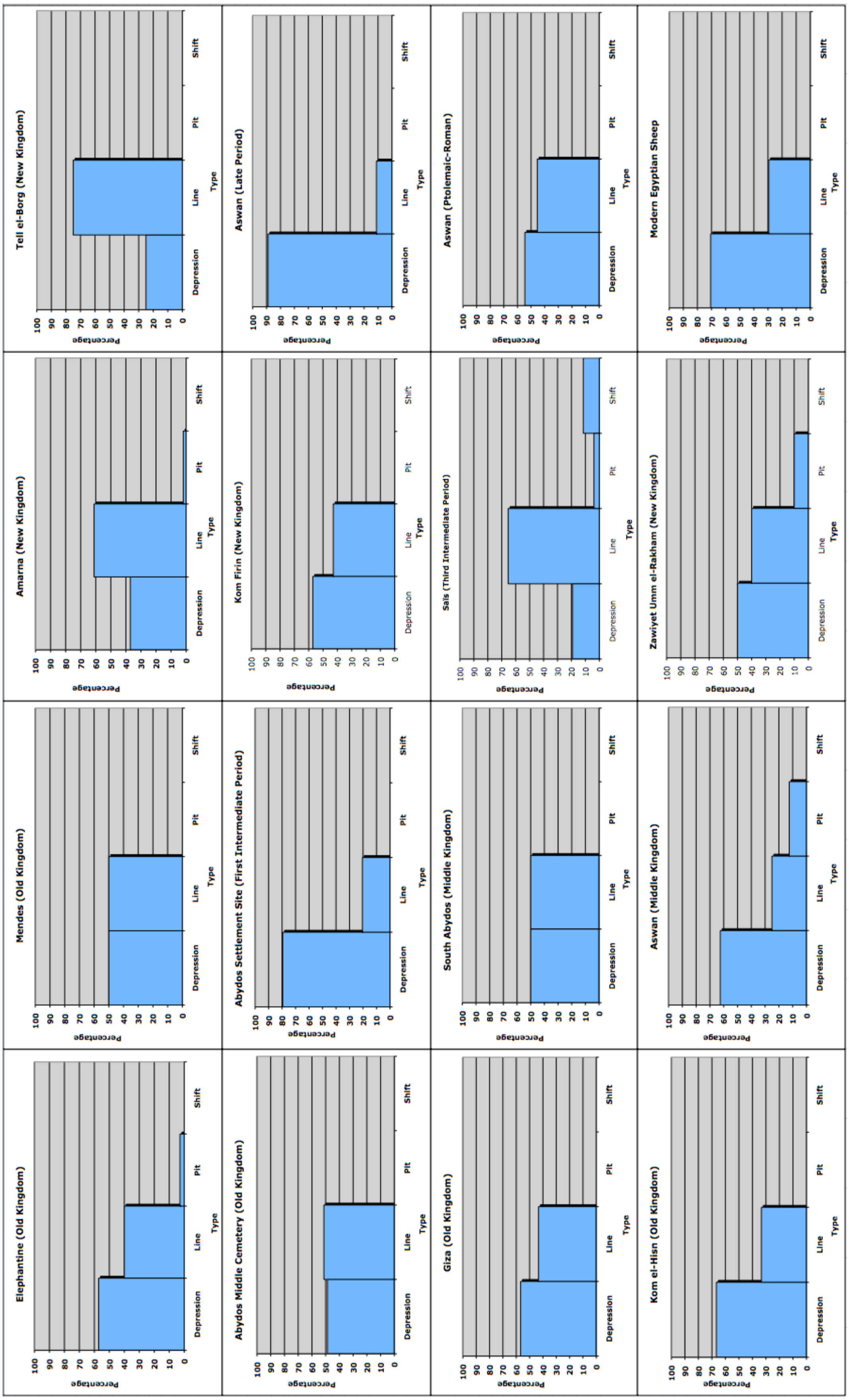

Figure 9.5: Comparing the percentage of different defect severity scored between the modern and archaeological populations.

9.3 Discussion

9.3.1 Interpreting caprine husbandry practices

In both Chapter 2 and the introduction to Chapter 7, it was stated that sheep and goat teeth would not be differentiated due to the difficulties in separating the species in the absence of complete mandibles. However, it should be noted that there might be variations in response to the environment between sheep and goat. As goats are better suited to more arid conditions and are more resilient than sheep, a low hypoplasia profile might be indicated by the species.

Another avenue where the frequency of hypoplasia might provide some variation is in their management strategies, as caprine herding can vary depending on both the environment and the potential goals of herd structure (e.g. meat/milk/wool) that might influence a preference for a particular species, breed, age range or sex (Redding 1981: 3, 30). Although there is little environmental variation within Egypt (two main areas are the Nile valley/floodplain and the desert), as Chapter 6 demonstrated, pig hypoplasia is the result of the environment and seasonal variations, except for sites with more intensive pig rearing, which seems to decrease the frequency of enamel hypoplasia through reducing environmental stress.

Although caprines are usually left to graze/browse, herding in the Middle East region (and is also the likely case in Egypt) has two different regimes, which are characterized as either intensive or extensive (Redding 1981: 12), and thus will be referred to throughout this chapter when analyzing the enamel hypoplasia frequency patterns for each site. Redding (1981: 12) states that extensive husbandry of sheep and goats is characterized by the maintenance of the animals on natural pasture with little or no supplementary feeding, and poor control of the breeding process. Intensive husbandry involves the maintenance of the animals in fenced pastures, supplementary feeding with fodder, and housing of the animals during unfavourable weather conditions. Thus, this section will attempt to address whether the presence of enamel hypoplasia can provide another avenue in addition to the age/sex data, which might be another parameter by which to investigate herding in Egyptian caprine populations.

At first glance, the site of Mendes stands out in the caprine assemblage as having the lowest frequency (17%) of enamel hypoplasia (as seen in Table 9.2), compared to all the other sites studied. However, the Mendes caprine teeth assemblage is the second smallest sample overall (eighteen teeth and only three with evidence of enamel hypoplasia), with Zawiyet Umm el-Rakham being the smallest (thirteen teeth), although a slightly higher percentage of teeth (62%) with LEH. Tell el-Borg, like Mendes also has eighteen teeth, but rather has a significantly higher percentage of teeth with LEH (89%). Comparing all three of these sites with small samples, two of the sites (Tell el-Borg and Zawiyet Umm el-Rakham) show similar LEH frequencies, but Mendes still stands out as an outlier. Thus, this likely is an artifact supporting that the Mendes LEH frequency is a real pattern possibly indicating a better treatment of caprines. This might be related to the importance of the *B3-nb-ddt* ram cult at Mendes as discussed in section 7.2.2, indicating that all caprines were highly valued and well looked after.

Aside from the Mendes sample, the site with the lowest frequency of enamel hypoplasia in caprine teeth, like the pig teeth is that of Amarna (44%). Again, this result is a bit surprising considering the harsh, desert environment; one might expect a higher frequency of enamel hypoplasia. Thus, two questions can be posed to explain this low frequency: is it due to either a specific species present (i.e. sheep versus goat) or, as with the pig remains, due to a specific rearing regime?

To begin with, the sheep/goat ratio discussed in Chapter 7 is based on Hecker's (1984) analysis, which concludes that only goats are present in the Workmen's Village (as of yet, no sheep/goat ratio has been calculated for the entire site). However, Hecker does not record how he differentiated between the two, so it is possible that there are sheep among the goats. For this dissertation, Hecker's identification will be followed under the assumption that there are only goats at the site based on the fact that they are more adept in the harsher environmental conditions as browsers than sheep.

The other issue to address is the caprine-rearing regime. The excavators posit that goats were probably kept in the open space at the south-west corner of the site (Hecker 1984: 159; Peet and Woolley 1923: 54, 60), most likely near the same rubbish heaps that the pigs were using (Shaw 1984: 49). Some goats may have also been penned in the individual workmen's houses (Peet and Woolley 1923: 60). Most likely, a combination of both existed in the Workmen's Village (Hecker 1984: 159). This would indicate that the negligible amount of hypoplasia in the Amarna goat population is likely the result of an intensive rearing regime, with the animals having better access to food and possible housing. Also, goats are slightly better adapted to a more arid environment in general, and more hardy than pigs (and sheep), making life in the Workmen's Village less stressful for them than it would be for the other species. This is also further supported by the fact that, as seen in Table 9.4, the percentage of teeth with hypoplasia decreases in the second (38%) and third molar (41%) as compared to the first molar (48%). This suggests that although caprines did experience some early life stress (possibly from birth or weaning, which will be discussed in section 9.3.2), they encountered less stress during the later stages of dental development, indicating that they were not affected by pressures such as winter nutritional stresses or parasitic infections etc, again which will be discussed further in section 9.3.2 in relation to time of birth and seasonality that were likely counteracted by their rearing regime.

Other Egyptian caprine assemblages that display a low frequency of teeth with enamel hypoplasia (as seen in Table 9.2 which all have percentages under 60%) include Elephantine (at 59%), Giza (at 59%), Kom el-Hisn (at 53%), Saïs (at 50%), Aswan- both Late Period (47%) and Ptolemaic-Roman (at 53%) assemblages, and the modern caprine (at 48%) population. As it is impossible at this point to know if any of these sites had possible penning like Amarna, it can be assumed that they at least had a likely more intensive husbandry regime.

On the other hand, the fortress site of Tell el-Borg has the highest frequency of caprine teeth with enamel hypoplasia (89%), followed closely by Kom Firin with 88% of teeth showing a presence of enamel hypoplasia. The Tell el-Borg assemblage having 89% of teeth with hypoplasia is a bit surprising, considering the fact that this is a fortress settlement. Given the military nature of the settlement, it is expected that there would be an intensive rearing regime (such as penning) to best supply the soldiers stationed at the site, which might decrease the presence of LEH. On the other hand this high percentage of hypoplasia could be due to the site being located on the desert/marsh edge, which might have also contributed to the defect formation as well. However, given the relatively small size of the Tell el-Borg sample (Total N=18 teeth), it is difficult for this sample to provide any statistically valid results. Kom Firin on the other hand is also a possible fortress settlement (Spencer 2008: 23), but it does not have a much larger sample size, totaling twenty-five teeth. Despite the small sample sizes it is interesting to note that both fortress settlements display high frequencies of teeth with enamel hypoplasia. Zawiyet Umm el-Rakham is also a fortress settlement, although is the smallest sample of caprine teeth (N=13) with only 62% of teeth displaying evidence of enamel hypoplasia. Despite this exception, this high frequency of caprine teeth displaying evidence of LEH is clearly something to investigate in the future with respects to fortress settlements. Thus, there are two explanations for this high frequency: either there was more extensive rearing at theses sites with the caprines freely browsing/grazing with no control of their food or it is something relating more to seasonality, which seems to be the more likely possibility considering that, as seen in Table 9.4, both Tell el-Borg and Kom Firin show higher frequencies of hypoplasia in the second and third molar as compared to the first molar. This will be discussed further in section 9.3.3.

9.3.2 Understanding Seasonality and physiological impacts: Physiology and animal husbandry

In both the modern and archaeological material discussed in this chapter, enamel hypoplasia defects are distributed over the cervical halves of the crowns in all three molars, with the exception of the second molar distribution from Saïs. Looking at Table 9.3, 64% of the first molars from the modern caprine population evidence compared to 50% of teeth representing all the archaeological caprine assemblages display evidence of enamel hypoplasia. What this suggests is that modern Egyptian sheep encounter more stress during the first nine months of life (based on the Weinreb and Sharav 1964 Awassi sheep eruption data) as compared to all the archaeological assemblages. It is possible that there could have been more evidence for early life stress displayed on the first molar, as described in Chapter 8, most of the archaeological assemblages are aged to between attrition stages E and H (based on the methodology as established by Payne 1973), which would mean that because of dental attrition, enamel hypoplasia evidence is most likely destroyed.

As has been established with both pig and caprine assemblages (Dobney and Ervynck 2000: 603; Dobney *et al.* 2004: 197; Arbuckle 2004; Upex 2010) and in the case of both the archaeological and modern Egyptian pig assemblages as discussed in Chapter 6, birth and weaning are physiological events that are documented and are known to cause visible dental defects on the first molar. The question of whether these events can be identified in the Egyptian caprine material is what will be discussed in this section.

<u>Birth</u>

Following the modern Egyptian caprine assemblage chronology (Figure 9.4), by the time of birth, crown formation of the first molar is half formed (Weinreb and Sharav 1964), thus any instances of enamel hypoplasia should occur at between 23.9-27.9 millimeters on the tooth crown above the root enamel junction (REJ). Looking at Figure 9.1-9.3, none of the archaeological or modern Egyptian seem to have any peaks of hypoplasia relating to birth. The only exception is that of Saïs, which seems to have a very small peak between 21.9- 23.9 millimeters above the REJ, which is likely the result of birth.

The overall lack of hypoplasia peaks relating to birth is rather similar to both the modern and archaeological caprine assemblages from Kenya as described by Upex (2010: 213). She further states that this is not surprising given that ungulate birth is usually a quick process (Upex 2010: 213). Furthermore, additional factors such as climate can influence the presence of hypoplasia at birth; as despite the harshness of the desert, Egypt is a much warmer climate, compared to Europe where caprine samples do display a hypoplasia peak likely due to birth (Upex 2010: 150, 271).

<u>Weaning</u>

In all the modern and archaeological Egyptian caprine populations, a large peak of enamel hypoplasia is visible in the cervical half of the first molar between 7.9- 9.9 millimeters above the REJ. Based on the rates of dental development (as seen with the modern population in Figure 9.4) this peak of enamel hypoplasia is seen as relating to a stress event that occurs after birth, but before the animal has reached nine months of age (when the development of the first molar is completed based on Weinreb and Sharav 1964). The most probable explanation for this peak is weaning and the associated nutritional and physiological stresses that accompany this period. The only exception is the site of Saïs, which peaks slightly earlier at around 13.9 millimeters above the REJ. These variations will now be further discussed.

Although most of the samples peak between 7.9-9.9 millimeters above the REJ, putting this peak at about five to six months after birth, the Saïs first molar data set has a peak more centrally located, at about three to four months after birth (height of 13.9 millimeters above the REJ). This seems to suggest that weaning was occurring earlier than all the other archaeological and modern populations possibly indicating forced weaning.

What makes the data slightly harder to interpret is that some of the samples (Elephantine, Abydos Middle Cemetery, Amarna, and the Ptolemaic/Roman assemblage from Aswan) have a double peak of enamel hypoplasia with the first peak at a height between 5.9-9.9 millimeters above the REJ and a second at about 13.9 millimeters above the REJ, placing both these peaks at about three to four months and five to six months after birth. The earlier peak of about three to four months after birth is obviously not the result of birth. If indeed the Saïs sample does have caprine weaning at an earlier age, then early weaning becomes a possibility. However, having a second peak at the exact age of weaning makes it more likely that there are two populations within this enamel hypoplasia distribution. This seems to be supported by the age distributions as discussed in the previous chapter, section 8.4.1, which also indicated two populations within all of these sites. This issue will be discussed further with respects to seasonality in the next section.

9.3.3 Understanding seasonality and physiological impacts: Seasonal Environmental Factors

As discussed in Chapter 6, it is possible that some occurrences of enamel hypoplasia are linked to seasonal decline in environmental conditions and or the main environmental factor in Egypt: the annual flooding of the Nile. If this is the case, then the distribution of hypoplastic defects, which reflect the seasonal cycle, could be expected. However, as Upex (2010: 216) states, in order for seasonal patterning to be identified in the distribution of enamel hypoplasia on the tooth crown, there needs to be a clearly defined season of birth, to ensure that seasonal events affect all animals when they are at a similar age. In Egypt, like Kenya (as in Upex 2010: 216) animals are known to give birth at any point throughout the year. However, in interviews conducted by the author with various sheep butchers and herders throughout the Cairo area, it was found that sheep are born once a year in the summer (March/April). Thus, it will be argued here that there is in fact one birthing season in the summer.

The modern seasons in Egypt and its impact on birthing seasons

As discussed in Chapter 3, section 3.3 and Chapter 6 in section 6.3.3, the annual flooding of the Nile is the most important climactic factor in Egypt. Furthermore, section 7.1.4 discussed that although some modern sheep breeds in Egypt are known to breed throughout the year (Aboul-Ela 1987), it is most likely that the breeds of caprines in ancient Egypt reproduced only once a year during the summer (Angela von den Driesch, personal communication and interviews with Cairo sheep butchers) when food would have been most plentiful and the animals would have not been affected by either decreased temperature due to winter or the annual flood, a time when food would have been scarce.

Modern Seasonality

The modern caprine material (seen in Figure 9.4), as discussed in section 9.2.2, shows the height distributions of enamel hypoplasia as plotted on a dental development graph based on the development rates as described by both Weinreb and Sharav (1964) on Awassi sheep and by Upex (2010) on modern Shetland sheep form Hoy, Orkney Islands, Scotland. The first molar shows a peak of enamel hypoplasia right between four to five months in both development rates, which may be explained by weaning.

Although the second molar also displays only one peak at about 9.9 millimeters above the REJ, there is a slight discrepancy between the two development methods. Following Weinreb and Sharav (1964), the second molar peak occurs at about nine months after birth, coinciding with the time of winter, whereas Upex's (2010) method would put this peak at about twelve months after birth, right at the beginning of summer. As the beginning of summer is not likely to cause much physical stress on the animal, winter is the more likely explanation of this peak.

The third molar also shows a similar pattern. As one clear peak is visible at 7.9 millimeters above the REJ, according to Weinreb and Sharav (1964) this would put the defect at twenty-two months after birth, again at the time of winter. Upex's (2010) method would put this peak at twenty-seven months after birth, almost in the middle of summer. Again, winter when the temperature would drop and food resources would be more limited is the more likely explanation for this stress.

Although both dental developmental rates (Weinrab and Sharav 1964 & Upex 2010) may confirm with respects to the first molar, there are obvious discrepancies between the second and third molars. Upex (2010: 152) contends that modern North Ronaldsay sheep are more affected by seasonal dietary variation caused by the onset of the summer months, and a reduction in the amount of seaweed available, their main dietary component. As it is doubtful that Egyptian caprines experienced a similar reduction in the amount of food available during the summer months, Egyptian caprine teeth more likely develop in a pattern similar to that discussed in Weinreb and Sharav (1964), and thus have peaks on the second molar at nine months old and on the third molar at twenty-three months old at the time when nutritional stresses associated with winter would be experienced. Furthermore, the second and third molar peaks going by the Hoy development data would occur at eleven and twenty-six months after birth, which are not consistent with any particular seasonal stress such as winter, like what is seem when using the Weinreb and Sharav (1964) development rate. Therefore, for the rest of this dissertation, the Weinreb and Sharav (1964) development rates will be used in reference to the caprine material. Thus, defects on the second and third molars are most likely the result of nutritional stresses associated with winter. As this is a modern population, the annual flooding of the Nile would have no impact since the construction of the Aswan Dam in the 1960's completely stopped the annual flooding north of the dam.

Archaeological Seasonality

As it is not known if there was a particular season of birth for ancient Egyptian caprines, in order to construct a possible model for ancient seasonality, one must use the modern material, with a known time of birth and death in order to construct a few possibilities. Thus, like the pig material, two possible birthing seasons of April (summer) and November (winter) will be investigated to see if there are any patterns that might reflect diachronic changes throughout dynastic Egypt or the varying Nile flood levels.

As there are fifteen archaeological caprine populations in this dissertation, a dental development graph will not be constructed for each site to avoid redundancy. As a result the site of Giza was chosen to compare the two possible seasons of birth (*i.e.* summer verses winter), as at this point it represents both the largest caprine sample, and is a site that was provisioned, with food resources being brought to the site from other areas of Egypt, and not locally obtained (Redding, In Press). Thus, the caprines were likely to have been specially selected, something supported both by the age range (mostly between three to four years at time of death) and by the restricted, normal distribution is size, all discussed in Chapter 8. Although this sample may not necessarily represent a known husbandry regime, it does represent a controlled caprine population that was selected by whomever was importing the caprines for consumption by the workmen. Furthermore, Giza displays a pattern of enamel hypoplasia that is seen in the majority of the archaeological caprine assemblages discussed in this dissertation. Furthermore the Old Kingdom shows decreased annual floods towards the end of the period so there may have been an accumulative stress on food supplies (Butzer 1973: 33; Said 1993: 134). Such a factor is important in the diachronic study of LEH presence.

The Giza LEH distribution (Figure 9.6) do show some similarities to the modern material (Figure 9.4), except that the peak on the second molar in the Giza distribution shows a slightly wider range (peaking between 9.9-13.9 millimeters above the REJ) as compared to the modern material that peaks at 9.9 millimeters above the REJ. Putting aside the issue of seasonality, both scenarios show one large peak at about five months after birth, and as discussed in the previous section, is likely result of weaning.

The second molar also displays one peak, and has a somewhat broad range between 9.9-13.9 millimeters above the REJ, putting this peak at about eight to nine months after birth. Comparing the two seasonality scenarios, the summer season of birth would put this peak at winter. However, the winter season of birth scenario would put this peak at the flood season. This same pattern is also seen on the third molar, where the peak is at about twenty-one months after birth.

In order to investigate if one birth season scenario is more likely than the other, looking at the first molar in the summer season of birth, weaning would fall in August/September when the flood would just be receding. This is a time of year when there would be less food available especially after a low flood the previous year, likely adding to the nutritional stress already associated with weaning which could make, which would fit the tight distribution pattern seen. Furthermore, the likely decrease in food availability during the winter months would make a summer season of birth strong possibility. Additionally, on the third molar, there is a small second peak seen at about 17.9 millimeters above the REJ (about 18 months after birth). If a summer season of birth, this small peak would fall right after the flood recession. If a winter season of births this peak would fall right about the *khamsin* season/beginning of summer. As both scenarios are possibilities for this peak, the fact that all data from each individual site has been pooled and thus, single or double peaks (as is the case for the third molar) do not necessarily represent the same individual. When referring to Appendix 3 for the Giza raw data, the vast majority of the third molars have only one occurrence of LEH. This likely suggests two different birthing seasons, which when considering the large caprine population that was needed in order to support the vast population of the workmen's village, is not surprising.

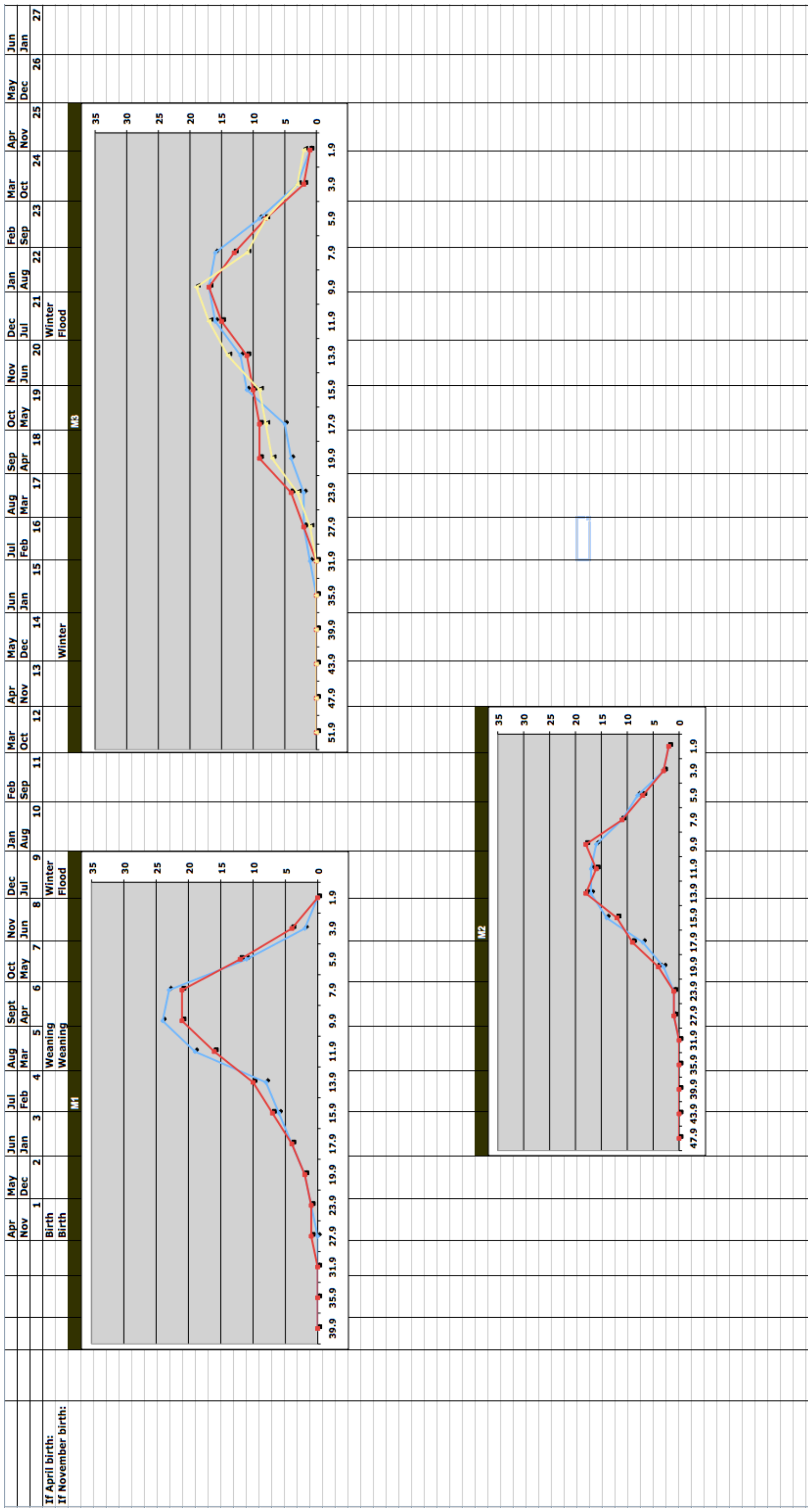

Figure 9.6: Showing the caprine material from Giza plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

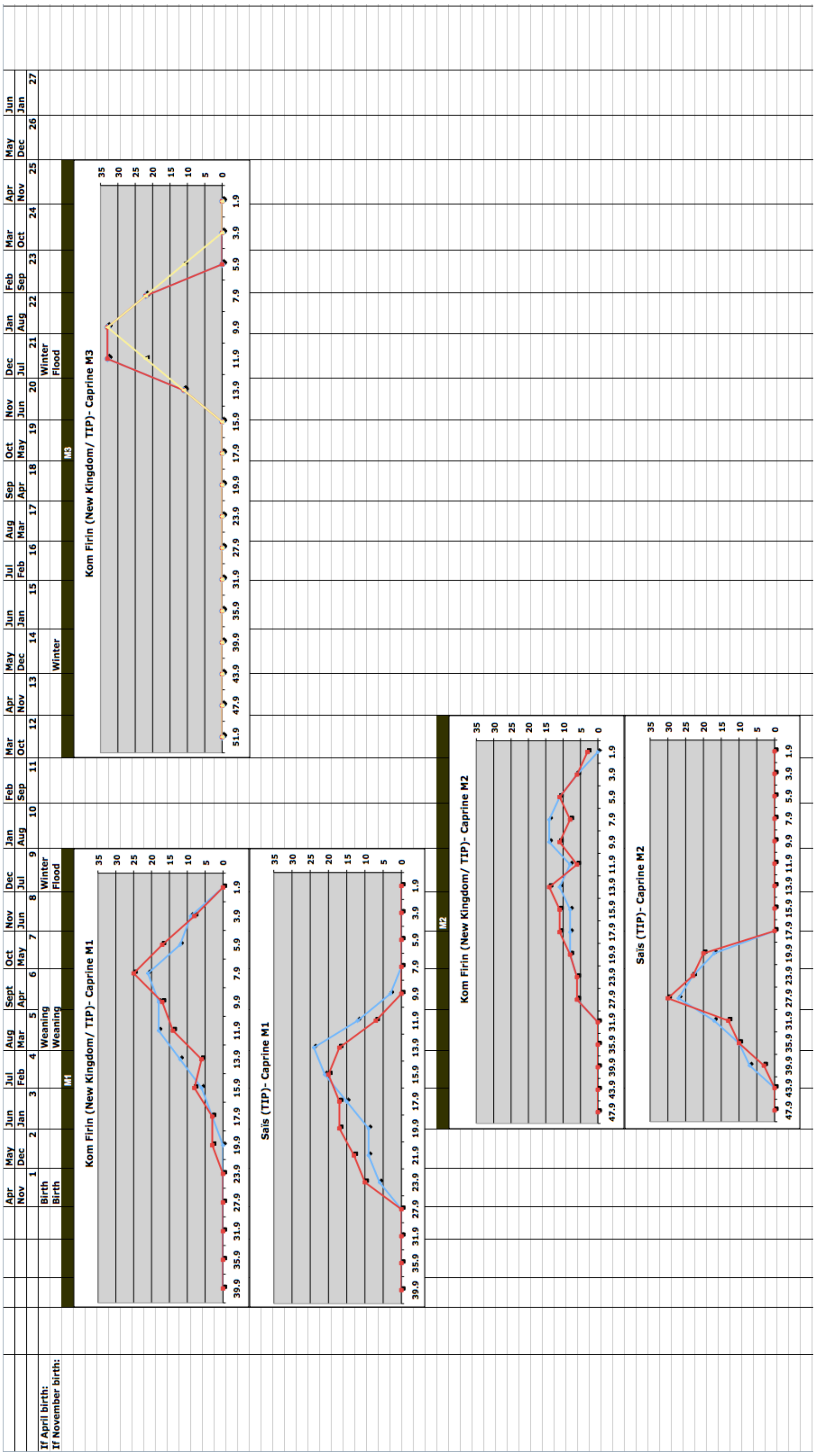

Figure 9.7: Showing the caprine material from Kom Firin and Saïs plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

Looking at a slightly later time period- the New Kingdom/Third Intermediate Period (TIP), the sites of Kom Firin and Saïs provide two interesting pattern comparisons.

Looking at Figure 9.7, the Kom Firin sample has one large peak on the first molar that occurs about six months after birth, coinciding with weaning. As stated in section 9.3.2, the Saïs sample also has a large peak on the first molar, which occurs slightly earlier (about three to four months after birth), possibly suggesting early (possibly forced) weaning. In the summer season of birth scenario, this first molar peak at Saïs occurs in the flood season, making an already stressful weaning time even more so. This would possibly explain the slightly larger LEH height distribution range as seen in the Saïs sample. Furthermore, Kom Firin also displays a small peak on the first molar that occurs about three months after birth, which could also be due to either the flood and/or a combination of some caprines that might have been weaned early. The second molar, however, displays two different patterns.

The Kom Firin second molar LEH height distribution does not display any clear peak, but mostly occurs between eight to nine months after birth, coinciding with winter in the summer birth scenario and with the flood in the winter birth scenario. In either case, there would be stress based on climatic variability and differential access to food, which in most instances seems to be the case at all of the archaeological sites. The Saïs distribution, however, provides the only anomaly in the entire caprine sample. Where as most of the second molar LEH height distributions peak at about eight to nine months after birth, the Saïs sample has a peak on the second molars at about six months after birth. One possibility is that this is not a seasonally related stress, but another physiological stress (such as a parasitic or infectious disease). However, Upex (2010: 215) contends that some samples are known to have some weaning overlap, which can be seen on the second molar in addition to the first molar. If there was indeed early weaning at Saïs, then the peak on the second molar would occur about a month or so after the peak on the first molar. However, if the caprines at Saïs were born in the summer, then this peak could be explained again, as combination of weaning/stress from flood that went on for a period of about two months, four to six months after birth. This longer, more stressful period during the early life of caprines at Saïs can also be explained by the geographical location of Saïs as compared to Kom Firin. Although both sites are from about the same time period and are both settlements on 'turtle backs' in the western delta (Wilson 2006: 8; Spencer 2008: 4), the relationship of both these sites to nearby water channels is slightly different. As seen in Figure 3.7, Kom Firin lies about 25 kilometers west of the current Rosetta branch and about 10 kilometers of the Canopic branch (Spencer 2008; 3), whereas Saïs is located on the eastern back of the Rosetta branch (Wilson 2006: 7). Although Kom Firin is located in the floodplain region, the site of Saïs would have been affected to a greater degree by the annual flood, considering its closer position (as compared to Kom Firin) to a major waterway, the Rosetta Branch of the Nile. This might create a greater degree of stress on the animals as a result of the flood as Saïs would effectively have been an island during the flood, so it is likely that all the animals would have been penned in the towns and villages. Browsing was most likely not possible, although they were most probably fed regularly. Although no third molar data is available for the Saïs populations (only two third molars have any evidence of LEH, as seen in Appendix 3), the patterns on the first and second molar do seem to support a spring season of birth, as again the decrease both in temperature and food resources is likely to create a greater degree of stress on the animals. However, more work is needed to compare sites like Kom Firin and Saïs to see of the annual flood might have had a greater effect at one site or another. To do this, future excavation is needed to increase the tooth sample size.

There are other causes of enamel hypoplasia (such as infections, parasitic diseases, and multiple seasons of birth) that have not yet been discussed. These are possible explanations for a few sites that display bimodal distributions on the second and third molar. Some of these outliers will now be discussed:

Looking at the second molar LEH height distributions in Figure 9.8, the sites of Abydos Middle Cemetery (AMC), Tell el-Borg, and Aswan (Ptolemaic/Roman assemblage) two clear peaks are observed. The AMC and Tell el-Borg assemblages both display a peak at about eight months after birth and at about ten months after birth. With respect to the Tell el-Borg assemblage, although the peaks of enamel hypoplasia do not exactly match up, the peak at eight months on the second molar is very close to a peak on the first molar that also occurs at eight months. Thus, it is possible that the peak on the second molar may in fact coincide with the peak on the first molar, perhaps relating to a late weaning. The peak at ten months rather seems to be related to nutritional stresses associated with winter, again, if one assumes that this caprine population was born in the summer. Although the Tell el-Borg sample is too small to provide statistically valid results, this seems to display the same pattern at

AMC and thus remains a strong possibility. The pattern on second molar representing the Aswan population (Ptolemaic-Roman), however, is slightly different.

Two peaks are also seen in the LEH height distribution of the Aswan (Ptolemaic-Roman) caprine population. One of the peaks occurs at about ten months, and like the other caprine populations is likely to have been the result of nutritional deficiencies associated with winter, again assuming a summer birth season. However, the first peak occurs slightly earlier, at about seven months as seen in Figure 9.8. This peak is not likely to have been the result of weaning, as the more likely 'weaning' peak on the first molar is seen occurring slightly earlier at about five to six months. Thus, unless this peak is the result of the flood recession that would occur in September/ October (which is highly unlikely), the only other explanation is a second population that is present in this sample, possibly born in the winter.

Although the presence of a second population seen in the height distribution of enamel hypoplasia is a suggestion that has only been noted in reference to wild boar and pigs (Dobney et al. 2004: 202; Mohr 1960), it is possible that a similar pattern could be seen in caprine populations, given the fact that it is possible that there could be more than one birthing season for caprines in Egypt. Thus, it is highly possible that the earlier peak could represent a second birth cohort, comprising of animals possibly born in the winter.

The sites of Tell el-Borg, Abydos Settlement Site, and South Abydos also display a bimodal distribution on the LEH height distribution of the third molars, which show peaks at nineteen to twenty months and twenty-two to twenty-three months (as seen in Figure 9.8). Thus, three possibilities come to mind — especially for the distributions representing the Abydos Settlement Site and South Abydos: the first is if we assume a summer season of birth, then this first peak (at nineteen- twenty months after birth) could be the result of some sort of parasitic infection as a result of the flood recession followed by winter stress as seen with the peak at about twenty-three months after birth. Another possibility is if one assumes a winter birth, then the first peak at about twenty months would correspond to about the time of the flood, and the second peak at twenty- three months could be the result of a parasitic infection as a result of the flood recession. A third possibility is, again, a second birth cohort, comprising animals possibly born in the winter, again assuming a summer season of birth, which is most likely to have been the case in the Tell el-Borg assemblage given the bi-modal distribution in the second molar as well. However, as this bimodal distribution from the Abydos Settlement Site and South Abydos is only seen in the third molars (the second molar LEH height distribution has only one peak), the most likely scenario is that this could be the result of a parasitic infection followed by the stress as a result of winter. This is especially the case for the South Abydos assemblage where the peak at twenty months is actually higher than the peak at twenty-three months, given the exceptionally high flood levels of the Middle Kingdom. This suggests that some sort of parasitic infection as a result of soil water logging following the annual flood recession may have affected the caprine population.

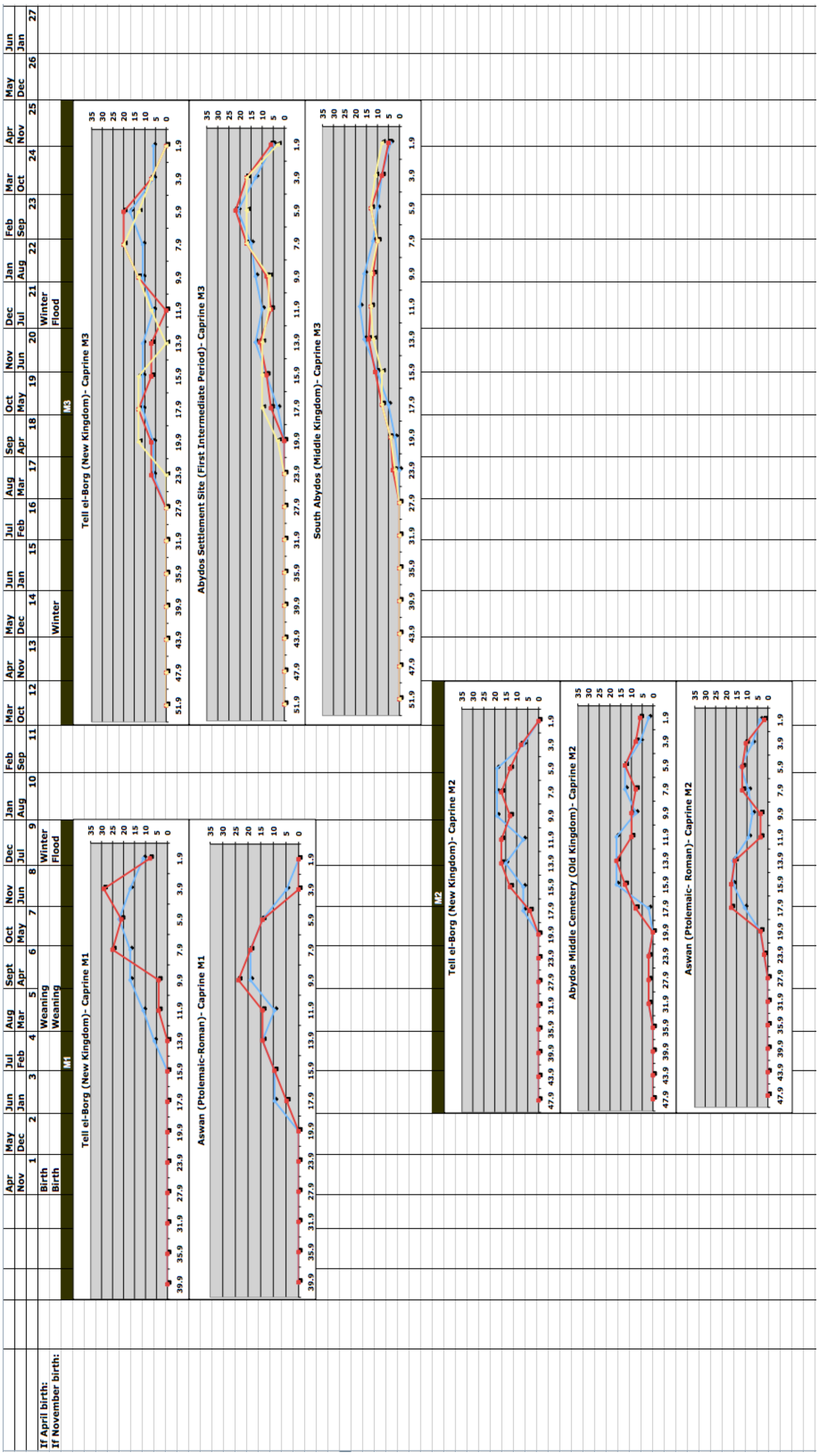

Figure 9.8: Showing the caprine material from Abydos Middle Cemetery, South Abydos, Abydos Settlement Site, Tell el-Borg, and Aswan (Ptolemaic-Roman) plotted as percentage running means onto a chart of tooth development rates. Months after birth are marked along the top of the graph along with the two seasons of birth scenarios of April (summer) and November (winter). The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present

9.3.4 *Interpretation of defect type and severity*

As discussed in Chapter 6, section 6.3.4, different forms of enamel hypoplasia can be related to different types of stress events that occur during the animal's life (Witzel *et al.* 2006). Linear type defects indicate more abrupt and severe periods of stress, whereas depressions represent milder, longer periods of stress (Witzel *et al.* 2006: 108).

As stated before, the overall frequency of caprine teeth with enamel hypoplasia is relatively low, which could be indicative of the fact that caprines are better suited for survival in the Egyptian environment due to their domestication in the similar ecological zone of the Near East. However, unlike the pig, which shows a higher percentage of teeth with linear type defects, caprines display a higher percentage of teeth with depression type defects.

<u>Defect Type</u>

In order to compare the different defect types, an analysis was carried out on the type of defect of all combined archaeological sites in comparison to the modern material. This was done as a number of archaeological sites did not have enough of a particular defect type to provide a large enough data set to be statistically valid. The distribution of lines, depressions, and shifts (pits were not common enough to be included in the analysis) are shown plotted against a seasonal calendar (Figure 9.9) in an attempt to investigate if there is any link between the different types of defects and seasonal events, based on a spring season of birth (as discussed in the previous section). For the purpose of this analysis (and to avoid redundancy), the distributions on the anterior cusp only are plotted, but this does not affect the data in any way because, as demonstrated in Figure 9, the distribution of defects on the anterior and posterior cusps is almost identical.

On the first molar, there seem to be no defects that are related to birth. Instead, they all seem to be related to weaning. Not surprisingly, all the shift-type defects occur much earlier than both the linear and depression defects, which are due to the fact that they are all from the Saïs sample, likely supporting a strategy of earlier weaning. Furthermore, a slightly different pattern is also seen between the linear and depression type defects.

As depression type defects are more common in the Egyptian caprine sample than linear type defects, it is no surprise that depression type defects occur slightly earlier and at a slightly wider range than the linear type defects. This also seems to support the fact that not only is this stress related to weaning, but the flood as well. The flood would cause a longer lasting period of stress for the animal, but at low intensity because of the changing environment from the end of July onwards. In addition, the likely re-location of animals to dry areas as a result of the flood, may be a reason why not only depression type defects are more common, but confirms a summer season of birth.

With regard to the modern material, only three teeth displayed evidence of linear type defects (hence, the wide distribution range) compared to sixteen teeth having evidence of depression type defects. Although it is difficult to compare the two, weaning does seem to cause a longer period of stress in the animals in the modern population as well.

On the second and third molar for both the modern and archaeological populations, the depression and linear type defects still seem to occur close together, but depression type defects seem to occur about a month earlier than linear-type defects and at a wider range. Linear type defects seem to have a clearer peak, which is especially the case in the second molar. Again, Witzel *et al.* (2006: 108) demonstrated that depression type defects in low crowned species can be related to long duration minor impact stress events such as malnutrition during the winter months, which is likely to have been the case, as these peaks occurred during winter. The modern material seems to follow a slightly different pattern, peaking about a month later than the archaeological material, although the peak still seems to be the result of nutritional stress from winter.

As previously mentioned, during the recording of the Saïs caprine population, a 'shift-type' defect was noted. This type of defect is discussed by Upex (2010: 162) as the cervical half of the crown 'doglegs' in a posterior direction (Figure 2.4). Upex (2010: 162) notes that this crown formation is not a pathological dental defect, but is rather caused by the development, eruption, and shedding of the surrounding teeth. Upex also further comments that when deciduous teeth grow, erupt and are shed, they exert various pressures on the developing tooth crown that they surround, causing the developing tooth to alter accordingly. These crown variations or 'shifts' are only noted on a total of three first molars in the Saïs population. Furthermore, as seen in

Figure 9.7, on the first molar these 'shift type' defects occur in a mid-crown location (about 13.9 millimeters above the REJ), much earlier than the depression and linear type defects. As Upex discusses with regard to North Ronaldsay (Orkney Islands, UK sheep) and Kenyan sheep populations (2010: 162), shifts are more related to tooth crown development and growth rather than a physiological or nutritional stress. As this type of defect is very rare in the Egyptian caprine data, this might further support that an early weaning of the caprines occurred at Saïs, resulting in both the slightly earlier formation of LEH and, in some cases, an alteration in the formation of the first molar, resulting in the presence of the shift-type defect.

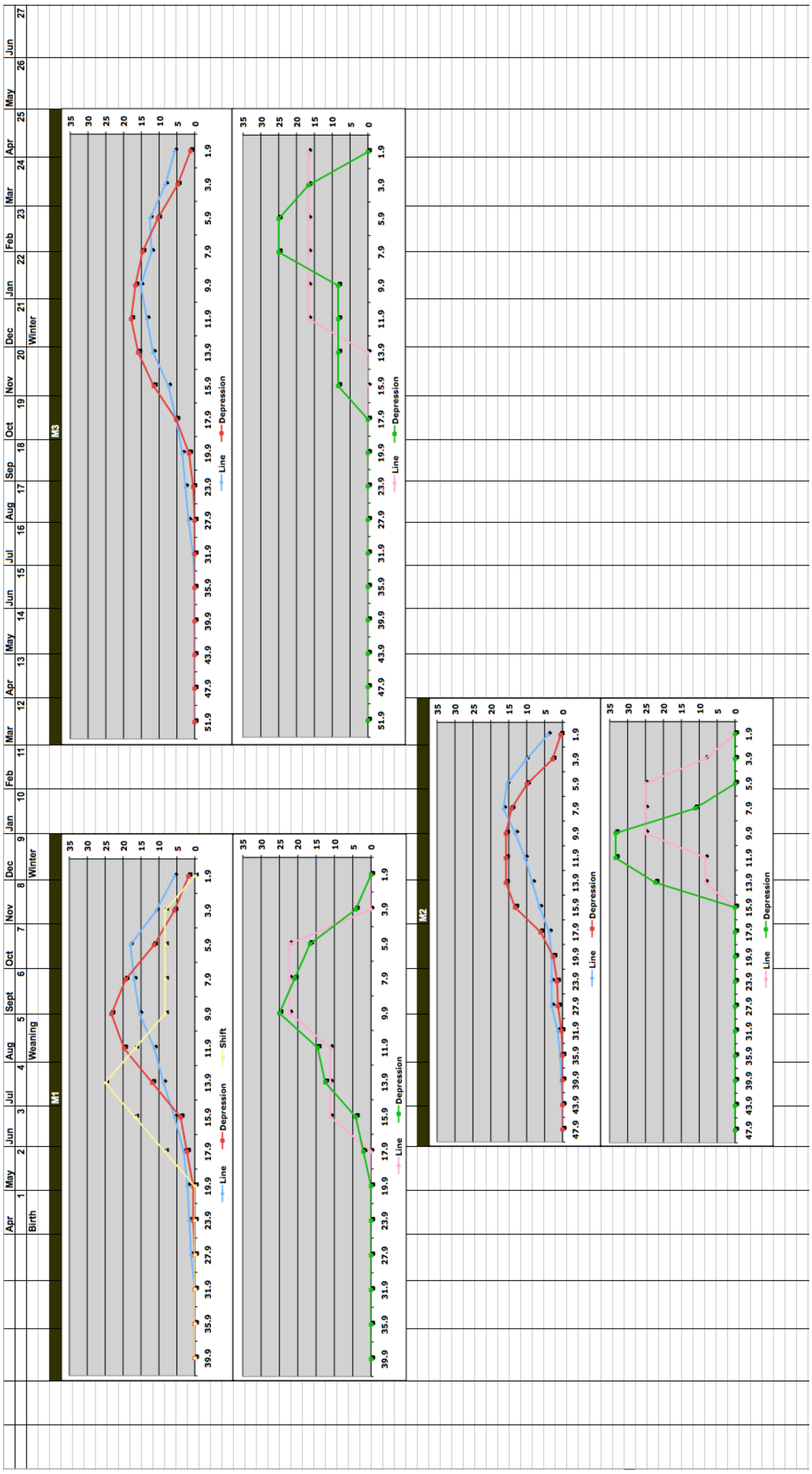

Figure 9.9: Showing the defect types from the all combined archaeological sites (top charts) as compared to the modern caprine population (bottom charts) plotted as percentage running means onto a chart of tooth development rates based on a summer season of birth. Months after birth and physiological stressors are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present

Defect Severity

Like the previous section on defect type, all archaeological sites were combined for analysis, as most sites simply did not have enough teeth displaying a specific severity level of linear type defects to provide a large enough sample size to be statistically valid. As discussed in Chapter 2, severity scores are only recorded for linear type defects.

Linear type defects were scored according to their severity level (as discussed in Chapter 2) and the frequency of the different severity scores plotted against crown development as seen in Figure 9.10 again, assuming a spring season of birth. The distribution of severity scores represents the anterior cusps only, as the distributions of defects on the anterior and posterior cusp are almost identical. With respects to the modern material, a chart was only created for the second molar as there are not enough teeth displaying different linear type defect severity scores on either the first or third molar (See Appendix 3).

The previous section showed that aside from the first molar where depression type defects seem to occur about two months earlier than linear type defects, the second and third molars seem to have no significant difference between when the specific types of hypoplastic defects occur. The defect severity scores seem to follow a similar pattern with no obvious differences between the different severity levels. The only exception is on the third molar that the level 3 defects occur about a month earlier than the level 1 and 2 defects. But, since there are only three third molars displaying evidence of a level 3 defect, this is too small of a sample to be of any significance. As the vast majority of teeth are only of a level 1 or 2 severity score, in addition to the very small modern sample, it is difficult at this time to ascertain if varying severity levels are related to different events in the animal's life.

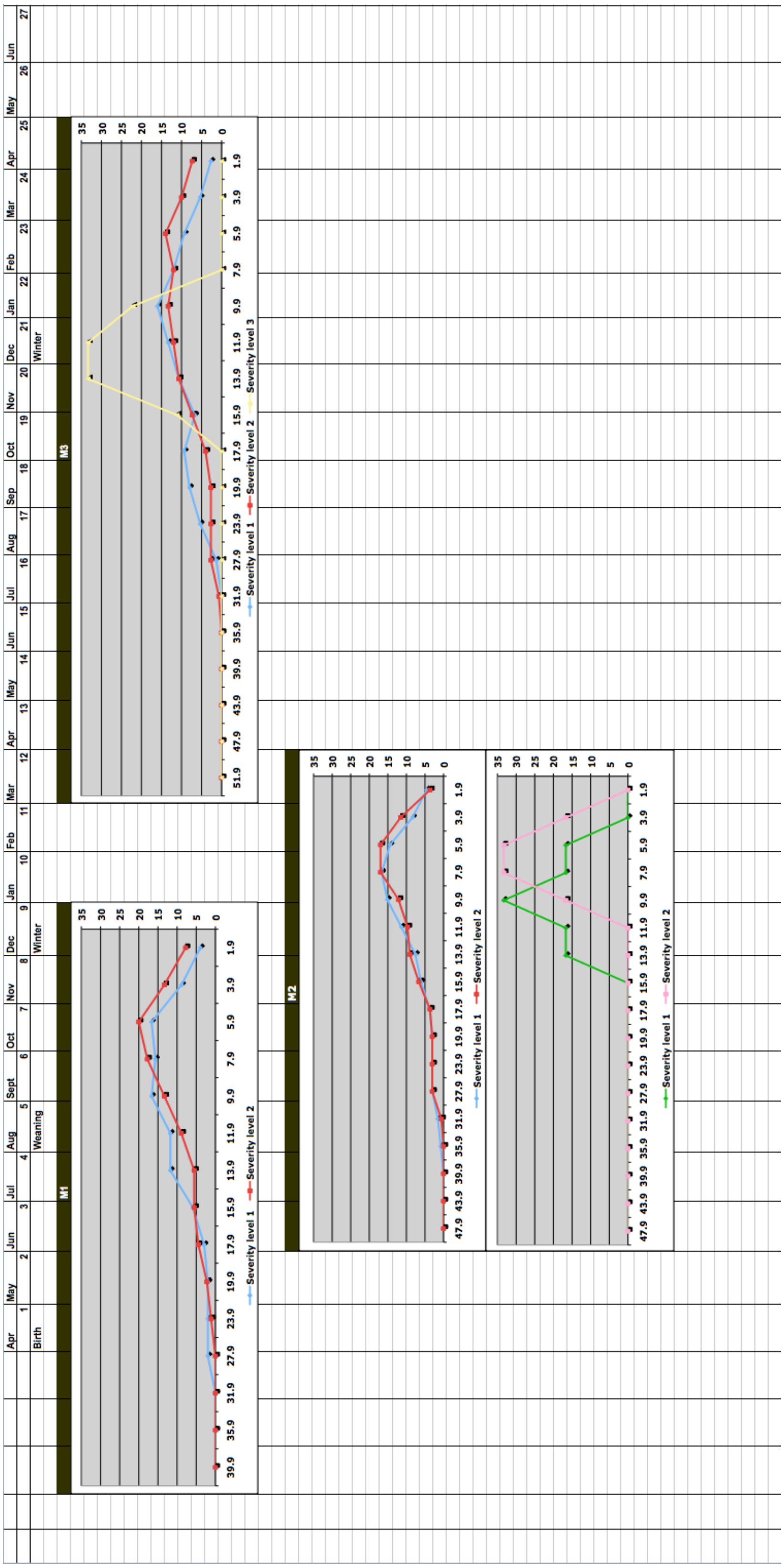

Figure 9.10: Showing the severity scores of enamel hypoplasia for the all combined archaeological sites (top charts) as compared to the modern pig population (bottom charts) plotted as percentage running means onto a chart of tooth development rates based on a summer season of birth. Months after birth and physiological stressors are marked along the top of the graph. The X-axis shows the distance of the hypoplasia from the REJ, plotted up to the maximum height in each molar (measured in millimeters). The Y-axis shows the relative frequency of hypoplasia present.

9.4 Conclusions

9.4.1 Interpreting caprine husbandry practices

Overall, the majority of the recorded sites display a very low frequency of teeth with enamel hypoplasia, which is not surprising given the fact that caprines are better adapted to survive in environments such as Egypt, given their Near Eastern origin and adaptability. Figure 9.11 shows the total frequency index for all Egyptian modern and archaeological caprine assemblages. As with the pig results, the site of Amarna stands out from the other archaeological sites in terms of caprine enamel hypoplasia patterns as it has considerably lower evidence of stress than other archaeological assemblages. This possibly indicates that the caprines at Amarna either had better access to food or a more intensive rearing regime (such as penning) at the site, or a combination of both. The only other sites with similar low frequency index values are that of the Aswan Late Period assemblage and Mendes, possibly indicating a similar situation to that at Amarna. However, although the Mendes assemblage is a very small sample, as caprines were sacred here, they represent a special flock, which was fed regularly and well looked after.

Analysis of the caprine frequency index (Figure 9.11) does not reveal any patterns that might reflect ecological setting or changing flood levels throughout dynastic history. Instead what the frequency index seems to suggest is that caprines at sites such as Amarna and Aswan (Late Period assemblage) may have been subjected to a slightly different rearing regime, possibly one that entailed more intense involvement (such as penning) on the part of humans. On the whole, the overall low frequency of LEH may be due to the fact that caprines are so well adapted to the environment and are in general very adaptable animals that they did not suffer stress in the same way as the more sensitive pig.

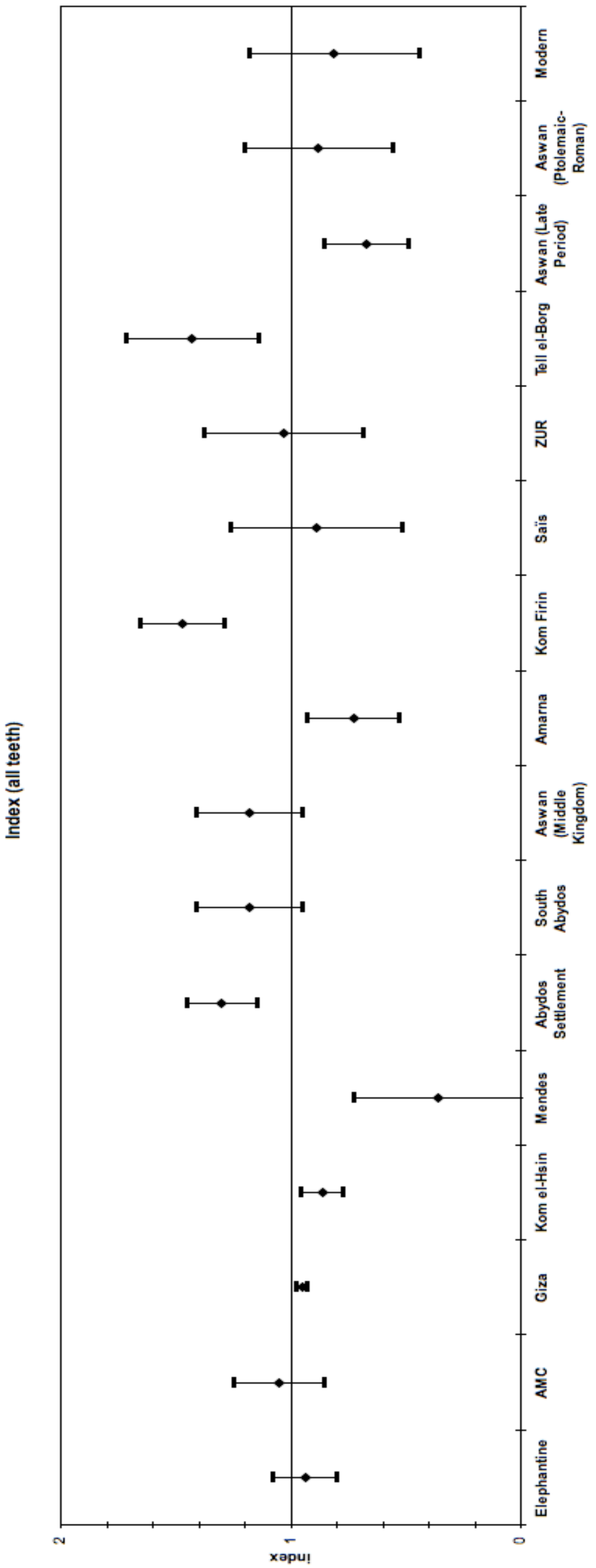

Figure 9.11: Index comparing the average frequency of LEH for all the archaeological and modern Egyptian caprine assemblages, calculated for all molars combined. The error bars represent the mean plus or minus the standard deviation.

9.4.2 Understanding seasonality and physiological impacts

The distribution of hypoplasia on the tooth crown seems to exhibit little difference between all the modern and archaeological sites, with the majority of enamel hypoplasia being located in the cervical portions of the tooth crowns. The only outlier is the population from Saïs, which seems to be the result of early (possibly forced) weaning and/or stresses caused by the annual flood.

Confirming what has been suggested by previous studies on both pig and caprine enamel hypoplasia (Dobney and Ervynck 2000; Dobney *et al.* 2004, Arbuckle, In Press; Upex 2010), peaks of enamel hypoplasia on the first molar are related to both birth and weaning. In the later part of dental development, environmental occurrences such as winter and the associated temperature decreases and nutritional stresses seem to be the cause for peaks of enamel hypoplasia on the second and third molars.

Again, establishing the environmental conditions of ancient Egypt provides some interpretational difficulty, especially in establishing if there was a season of birth. Despite these difficulties, there are a few unique patterns in the caprine hypoplasia distributions represented by the sites with bimodal distributions, which seem to strongly support two different seasons of birth, in addition to the opposite LEH height distribution seen in the Saïs population. What these outlier patterns suggest is that there may be either regional (in the case of the Abydos populations) or site specific (as in the case of the Saïs population) patterns. However, based on the selected sites that were applied to the two different scenario of a winter verses summer birth, a summer birth season seems to be the more common.

9.4.3 Interpretation of defect type and severity

Depression type defects are by far more common in both the modern and archaeological caprine assemblages, which likely reflects either a more prolonged period of lower level stresses or possibly a different response to the ancient environmental conditions of Egypt. When plotted against the chronology of tooth crown development, the only major significant differences between the frequency distributions of lines and depressions occur on the first molar, likely to be a combined result in response to weaning/annual flood. No major differences are noted on the second and third molars. Furthermore, teeth displaying linear type defects mostly display very low severity scores, likely indicating that what stresses were experienced, did not have that major an impact on the caprine population.

10 Conclusions

Until this study, no systematic work had ever been carried out on the presence of linear enamel hypoplasia in animal teeth in Egypt. For the first time, eleven archaeological pig populations and thirteen archaeological caprine populations, which vary chronologically and geographically, have been studied to determine what information regarding animal husbandry and seasonal environmental factors can be elicited from them. It has concluded that biometry works on pigs-especially for identifying the presence of wild boar. This suggests that their hunting was still an important part of animal husbandry through out dynastic Egypt. The application of biometry to caprine populations encounters some problems due to the difficulty in separating sheep and goat. The application of Zeder and Pilaar's (2010) methodology for differentiation sheep from goat mandibles would in the future help to possibly solve some of the biometrical problems and test if it is really applicable to caprine teeth.

The presence of LEH in both pig and caprine populations is very frequent. Its formation is most likely due to the environment, namely the annual flood of the Nile. LEH formation, however, can be counteracted by more intense rearing regimes, namely penning. This research also tells us that penning was a far more common practice than previously though. However, this research has also pointed out bothe the need for larger faunal samples and the importance of saving them for future study and to confirm if in fact these conclusions are true.

This final chapter draws together all of the data and results presented previously. It will provide an analytical summary of linear enamel hypoplasia analysis along with age distribution and biometrical patterns in both modern and archaeological Egyptian suid and caprine populations.

Using the data gathered, this thesis has set out to explore three key research themes, as well as to discuss ancillary concerns resulting from them:

1) What is the frequency of LEH in pig and caprines and do coherent patterns exist in the archaeological material that might reflect husbandry regimes and/or ecological setting.

2) Was there any diachronic variability.

3) How similar is the LEH data in archaeological material to that of modern material?

Various aspects of each of these three main questions have been discussed in the previous chapters, including areas such as biometrical and age distributions, interpreting husbandry practices, understanding seasonal and physiological impacts, and interpretation of defect type and severity. All of these will be touched upon below.

10.1 What is the frequency of LEH in pig and caprines and do coherent patterns exist in the archaeological material that might reflect husbandry regimes and/or ecological setting?

The major goal of this thesis is to look at changes in suid and caprine husbandry practices. In order to look at patterns in husbandry practices through the presence of LEH, its frequency had to first be established. Thus, this section will establish its presence, investigate if coherent patterns do exist in both suids and caprines, and address if there are any problems in the interpretation of this data.

10.1.1 *What is the frequency of LEH in pigs and caprines?*

Site	Time Period	Pig LEH %	Caprine LEH %
Elephantine	Old Kingdom	88%	59%
Abydos Middle Cemetery	Old Kingdom	-	69%
Giza	Old Kingdom	79%	59%
Kom El-Hisn	Old Kingdom	69%	53%
Mendes	Old Kingdom	70%	17%
Abydos Settlement Site	First Intermediate Period	69%	83%
South Abydos	Middle Kingdom	75%	73%
Aswan	Middle Kingdom	-	64%
Elephantine	New Kingdom	72%	-
Amarna	New Kingdom	57%	44%
Kom Firin	New Kingdom	64%	88%
Saïs	Third Intermediate Period	69%	50%
ZUR	New Kingdom	-	62%
Tell el-Borg	New Kingdom	78%	89%
Aswan	Late Period	-	47%
Aswan	Ptolemaic-Roman	67%	53%
Cairo/Shobra	Modern	56%	48%
TOTAL	**ALL PERIODS**	**66%**	**59%**

Table 10.1: Comparing overall LEH frequency in both pigs and caprines for all ancient and modern Egyptian populations.

LEH is common in both ancient Egyptian pigs and caprines, although, as seen in Table 10.1 above, it is slightly more common in pigs than sheep. This is not surprising given that caprines are far more adapted to survive in the diverse environment of Egypt. This is possibly due to their Near Eastern origin and adaptability, and are thus less prone to stress than pigs that quite possibly were independently domesticated in Egypt. Pigs are more sensitive animals than caprines; if they are exposed to very high temperatures, do not having access to a wallow and/or shelter, they can die from overheating relatively quickly. Given the different physiology of the animals, the LEH difference is not surprising. In fact, at sites where the frequency of pig LEH is low, this might suggest that the Egyptians knew that the animals needed certain conditions in order to survive. Thus, they tried to provide areas such as pens and wallows to meet the biological needs of pigs. In this sense it is possible to say certain ancient Egyptian husbandry regimes were sensitive to animals' needs.

The site of Amarna stands out from all the other archaeological assemblages as its pig population has the lowest frequency of LEH and its caprine population the second lowest. This is likely due to its intense animal rearing regime of penning and/or enclosed pastures, which at this point is the only ancient Egyptian site known to have pig pens, as animals would not have survived in the dry, desert edge environment otherwise. Based on similar moderate LEH frequencies, one might posit that sites such as Kom Firin, Kom el-Hisn, Abydos Settlement Site, and Aswan (Ptolemaic-Roman) may also have similar intensive pig rearing regimes. In fact, excavations at Kom el-Hisn have revealed mudbrick pens, but the species that were kept there are not known at this point (Richard Redding, Personal Communication). It is suggested (Hecker 1984: 159) that there may have been buildings for caprines as well at Amarna (although Hecker does not propose where at the site), but this is a possibility that has not yet been confirmed. However, the low LEH frequency suggests that there may have been at least some form of more intense caprine management at Amarna as compared to the other sites.

Mendes also stands out as the site with the lowest frequency of caprine LEH. Although it is one of the smallest caprine samples, as discussed in section 9.3.1 it can be compared with the data from sites such as Tell el-Borg and Zawiyet Umm el-Rakham with similar, if not smaller, sample sizes. In this case the Tell el Borg and Zawiyet Umm el Rakham caprine populations have significantly higher percentages of teeth with LEH. This seems to suggest that the LEH frequency at Mendes is a real pattern indicating better treatment of caprines, possibly related to the importance of the *B3-nb-ddt* ram cult at the site.

Comparing the overall frequency indices as is seen in the Table 10.1 above, caprines have a considerably lower LEH frequency index, probably due to their better adaptability to the environment. Pigs, however, have a higher index, which is considerably higher compared to European data sets (European data courtesy of Keith

Dobney), likely indicative of the harsher desert margin environment of Egypt. Although successful attempts at managing pigs (such as penning) were made at Amarna, it is clear that other sites more likely practiced free-ranging as their management choice for pigs. Presumably this involved less money and energy, but took a slightly higher toll on the physiological stress experienced by pigs. On the whole, this study clearly demonstrates that LEH is a common occurrence in both the Egyptian pig and caprine populations that can be counteracted by human involvement and their management strategy.

10.1.2 Do coherent LEH patterns exist in the pig and caprine populations that might reflect husbandry regime and/or ecological setting?

Are there patterns that reflect husbandry regime?

From the data presented in Chapters 6 and 9, the vast majority of the pig and caprine populations seem to support a summer season of birth. There are, however, three pig populations (Amarna, Kom el-Hisn, and South Abydos) and five caprine populations (Abydos Middle Cemetery, Tell el-Borg, Aswan Ptolemaic-Roman, Giza, and Abydos Settlement Site) that have substantial evidence for two birthing seasons a year, as evidenced by double peaks in the LEH height distribution charts (see Figures 6.1-6.3 and 9.1-9.3). This is not surprising given the fact that Egypt is, generally, a very hot environment lacking facilities for keeping fresh meat. Having a large animal turnover rate, particularly at sites such as the Giza Workmen's Village, would help to support a large human population that may not be able to preserve large quantities of meat, making at least two birthing seasons a year necessary.

Aside from the sites that represent two birthing seasons, the only other site of note that represents a significantly different LEH pattern from the rest and that probably reflects a difference in husbandry regime is the caprine population from Saïs. Whereas all the pig and caprine assemblages seem to display a fairly similar pattern, the Saïs caprine assemblage stands out as having a completely opposite pattern. The first and second molars display LEH peaks significantly earlier (see Figures 9.1, 9.2, 9.7) than all the other caprine assemblages studied. Thus, the Sais assemblage seems to indicate earlier, possibly forced, weaning. As this Saïs caprine assemblage represents mostly Third Intermediate Period and some late New Kingdom levels, it is possible that this could be a site-specific pattern that developed later in the history of the site. As occupational evidence for the site dates to as early as the Neolithic period (Wilson 2006: 83), more excavation is needed to increase the sample size to see if this possible early/forced caprine weaning pattern was being practiced in the earlier occupational periods at the site.

Are there patterns that reflect ecological setting?

The most important seasonal event that has been discussed throughout this thesis is the annual flood of the Nile. As most of the site's LEH patterns seem to be more reflective of the chosen husbandry regime/season of birth, there are a few exceptions that seem to reflect the ecological setting. As all the LEH data discussed for every site has been pooled together in order to construct the LEH height distribution charts, the single and double peaks can, but do not necessarily represent the same individual animal. When double peaks occur, this can suggest either two birthing seasons as discussed above, or different physiological impacts on the same individual animal. This can easily be checked when referring back to the raw data to see if multiple occurrences of LEH occur on the same individual tooth. In the case of the Old Kingdom Elephantine and Ptolemaic-Roman Aswan pig assemblages, double peaks are seen on both the second and third molar (Figures 6.2 and 6.3). When referring back to the raw data (Appendix 2), the vast majority of second and third molars from both these sites display more than one occurrence of LEH on the individual molar. Combining the multiple occurrence of LEH with both sites' locations on the Nile (or Elephantine's island location in the Nile) in Upper Egypt, it can be expected that the annual flood was one of the physiological stresses affecting the animals. This is further confirmed when looking at the schematic dental developmental graph of the Old Kingdom Elephantine material (Figure 6.8). This shows that the earlier peak on the second molar falls around the time of the annual flood, with the second peak falling around the time of winter (if based on a summer season of birth), both stressful seasons for animals. Although more work is needed to see if this pattern only exists in Upper Egyptian sites located in close proximity to the Nile, it can be confirmed that sites such as Elephantine and Aswan have LEH patterns that clearly reflect ecological setting.

10.1.3 Are there problems with the interpretation of this data?

The main obstacle experienced during the research for this thesis and its analysis is the lack of available samples and the small size of the vast majority of those that were available. The main reason for these small sample sizes is a combination of availability of a sample, small areas of excavation at a particular site, and in some cases the excavation strategy– *i.e.* excavations haven't found an abattoir where lots of heads were dumped. Future excavation is needed at many of the sites that have been discussed in this thesis to confirm if the proposed LEH, biometrical, and age distribution patterns are in fact real patterns or the result of insufficient data. Another problem is the difficulty in differentiating sheep from goat teeth, resulting in the combining of the two species for reasons discussed in the introduction to Chapter 7. DNA and isotopic analysis would prove to be very useful in this species differentiation to see if in fact sheep and goat do display different LEH patterns or not.

The interpretation of LEH defect types and their severity also proves to be a problematic issue. This was mainly due to the very recently developed methodology for its recording. Upex (2010: 289) discusses how more work is needed, particularly with reference to depression-type and shift defects, and how these types of defects form, especially in high crowned species such as caprines.

It is interesting to note that the Egyptian pig population shows a significantly higher frequency of linear-type defects, whereas the caprine population shows a significantly higher percentage of depression-type defects. As more work is needed as to how these defects form, only two possibilities for this pattern can presented at this time. The first is the high possibility that different species react differently to the same environmental condition. Whereas pigs may need human involvement in order to survive in an environment such as the Workmen's Village at Amarna, other species such as goats might thrive independently. This might be the same reason as to why LEH defects form in a particular way in different species.

As discussed in sections 2.2.1 and 2.2.2, linear-type defects are more typically caused by a severe stress impact that lasts for a short duration, whereas depression-type defects indicate a slowing down in the rate of enamel secretion over an extended period of time. If caprines are showing more depression-type defects, this may mean that they are experiencing some sort of stress that lasts over a longer period of time but at a lower intensity, where as pigs are experiencing a more intense severe stress that lasts over a short duration. On the other hand, the difference in defect formation could be due to a different diet or, in fact, the rearing location, as it is known that caprines are often herded on to the outskirts of settlements (Redding 1992: 103). Pigs, on the other hand, would more likely have been kept closer to the settlement as they required more attention, and it would have put them closer to the organic refuse from human day-to-day waste that they often consumed as part of their diet. This would serve a secondary purpose of keeping the settlement clean, as was done until the recent purge of pigs in the *zebalin* (garbage collectors) settlement in Cairo. If caprines and pigs were being kept at different locations at or near a site, this might affect the formation and type of LEH.

Taking into consideration the way in which LEH defects form and comparing what we know about small cattle husbandry to the better-documented cattle husbandry, the difference in defects might support the idea that sheep (or at least the ones with more depression-type defects) have in fact been herded over long distances, possibly together with cattle as has been suggested by Brewer, Redford, and Redford (1994: 79). Again, as this is an area that needs further methodological work, these are only possibilities showing the potential for the use of LEH defect types.

10.2 Is there variability with diachronic change?

The second major question of this thesis is to look at diachronic changes of husbandry practices through the analysis of age distributions, biometry, and LEH throughout all of dynastic Egypt. For both suids and caprines, information was recorded on both the age at death and size (based on tooth width) as additional ways in which to look at changes in husbandry practices over time. These are also essential to record as both affect the presence of LEH as older, more worn teeth can have any evidence of hypoplasia destroyed. This section will be divided into two parts: age distribution/ biometrical variability over time, and LEH variability over time.

Variation of age distribution and biometry

Age distributions in pigs and sheep display two different patterns. Pigs are mostly slaughtered at a subadult age (eighteen to twenty one months), which is a pattern that is seen throughout all of dynastic Egypt from bone evidence and even on the modern sample, a pattern that is typical of meat utilization. The sole exception is Amarna, where the age of death of a significant part of the sample (about 40%) is at a much younger age (about six to twelve months). Again, this is likely due to the more intensive pig-rearing regime in place at the site, where there was a heavier demand for meat to support the citizens of the workmen's village.

At all of the sites caprines show a slightly older age distribution at death, with populations ranging from two to as much as six years. Most probably this is due to the need to maximize secondary resources such as milk, and possibly wool/hair. This is a pattern that is seen at most of the archaeological sites except for Amarna. There, meat production was more likely the goal of the herds, as the kill-off pattern corresponds exactly to that of the modern population that was derived from Cairene butchers. The indicative pattern for meat exploitation peaks between six to twelve months of age at death, with a second peak at around six to eight years, probably representing individuals kept for breeding purposes.

Caprine size distributions remained fairly consistent throughout all of dynastic Egypt. Despite the differences in geography and time period, no major variations in caprine size was detected throughout Egyptian history, or between sites, on the whole. There are a few minor exceptions, which raise the possibility of being able to detect higher percentages of sheep or goats within the caprine populations. For example, the slightly smaller average size overall of the caprine population at Amarna, may suggest that, statistically, there was a greater presence of goats. Such may also have been the case at the South Abydos town of *Wah-Sut*, and the Abydos Settlement Site. Although it is possible that goats could have had different husbandry regimes compared to sheep, which one might expect to manifest itself in different patterns, the caprine sizes still seem to fall within the same constant, resulting in a caprine population that is fairly similar in size.

Pigs, however, display a slightly different pattern that does show variation over time. Size distributions based on the tooth width of the pig assemblages seem to indicate that not only were wild boar present in some of the recorded populations, but there also seems to be a decrease in size throughout dynastic Egypt. This is possibly related to more intensive pig rearing regimes that developed overtime. However, it seems to be the case that wild boar continued to be present, as in some of the sites there was a small percentage of teeth falling within the wild boar size range. The presence of the wild boars might indicate that they were continually hunted (albeit in small numbers) throughout all of dynastic Egypt.

Variation in LEH

There is not much-change in the presence, frequency, and/or distributions of LEH in either the pig or caprine populations over time. Major changes are more site-specific such as the case at Amarna (New Kingdom) with more intensive pig and caprine rearing, and possibly at Saïs with early/forced weaning of caprines in the Third Intermediate Period. There is however, an important change to note at Abydos between the First Intermediate Period (FIP) and the Middle Kingdom.

At the Abydos Settlement Site in the First Intermediate Period, there is an increase in the frequency of LEH in Caprines, but a decrease in LEH frequency in pigs. Considering the suggested drought conditions of the time, this means that the pigs were looked after better than the caprines, as the drought seems to have affected the latter more adversely. As climate/environment and diet are intrinsically linked, that is, poor climate/environment almost always equals a poor diet, this high LEH percentage in the Abydos Settlement Site caprines seems to indicate an environmental stress that is quite possibly due to the low flood levels and thus lack of food resources experienced during the First Intermediate Period. However, by the Middle Kingdom at South Abydos there is a 10% drop in caprine LEH frequency, as only 73% of teeth show any evidence of LEH compared to 83% in the First Intermediate Period.

10.3 How similar is the archaeological material to the modern material?

Throughout the dissertation the archaeological material has been compared to a modern population of pigs and caprines that have acted as a control group of a known age and husbandry regime. This section will also be divided into two parts comparing the two different data sets (modern and archaeological) in terms of age distribution/biometry and LEH frequency and its patterns.

<u>Age Distribution and Biometry</u>

To begin with the age distribution of the pig population, the modern sample represents a known domestic breed that is a hybrid of European and Asian domestic pigs (Greger Larson and Keith Dobney, Personal Communication). This population was slaughtered between eighteen to twenty months. All of the archaeological sites have similar age distributions for their age at death, although the Amarna population is slightly younger. This could indicate either a greater preference for younger meat, or such an intensive pig regime, that a multitude of pigs were available so that younger ones could be consumed regularly.

The caprine age-at-death distributions are also similar, in that they are also older than their modern counterparts (six to twelve months) at death, again with the exception of Amarna where they are younger. Both the pig and caprine samples indicate that if there was a meat production focus, then age distributions will be younger, as is the case with the modern populations presented. If secondary resources are the goal, as seems to be the case of the archaeological caprine assemblages, then an older age distribution will be expected.

In terms of biometry based on tooth width size, all of the ancient pig populations are considerably larger than the modern Egyptian sample. This is not surprising given the DNA analysis proving that modern Egyptian pigs are a hybrid breed. Asian domestic pigs are known to be an advanced domestic breed whose reproductive maturity is reached much quicker than the average breed, but are subsequently smaller in size. The data highlights the fact that the ancient and modern pig populations are not the same genetically, likely due to the closer genetic link of the ancient pigs with the native wild boar. Further work on the genetic background of the ancient pigs is therefore needed.

Caprines, however, both modern and archaeological, are all relatively similar in size. However, Lower Egyptian (Delta) sites are slightly larger than Upper Egyptian sites. As DNA analysis has yet to be performed on both modern and ancient Egyptian caprines, it is difficult to see if there are different breeds (and species/sub-species for that matter) present in all the different assemblages.

LEH Frequency

Both the modern and archaeological pig and caprine populations follow consistent LEH patterns. This points to not much of a difference in environmental or husbandry regimes. The modern pig and caprine populations, however, are most similar in both LEH frequency and height distribution to the Amarna pig and caprine populations. This would suggest similar husbandry regimes such as penning, and possibly a similar diet, mainly consisting of kitchen refuse. This would indicate that the greater the human involvement in animal management, the lower the amount of physiological stresses experiences by the animals. The only lack of evidence is in first molar data in the modern pig population. This is due to an older age distribution, which means that any earlier LEH evidence has been destroyed by tooth wear.

10.4 Avenues for future work

When used in combination with adequate comparative, environmental, and archaeological data, LEH can be very useful in investigating archaeological questions regarding variation in animal management between sites, environmental variations, and periods of seasonal and physiological stress. It has been demonstrated that there is a clear link between seasonal/physiological stressors and peaks in the occurrence of LEH in both Egyptian pigs and caprines. However, although there are some relatively large samples, the main need is for even larger samples from a variety of sites and time periods to become available for analysis in order to confirm or reject of the LEH frequency patterns relating to animal husbandry and ecology proposed here.

A second avenue for future study with reference to the availability of more samples is that of samples dating to earlier periods- specifically the Neolithic period. This early data could be used to investigate if LEH was a common occurrence, possibly supporting an independent domestication (particularly of the pig) in Egypt. If these early samples become available, another extremely helpful and powerful tool that both Zooarchaeologists and Egyptologists hope will become more readily available is DNA testing on animal remains. Many of the issues such as domestication, breed differentiation, and thus differences in age distribution, biometry, and LEH between sheep and goats could be easily answered.

A final avenue for future study is the presence and frequency of LEH in cattle. As discussed in section 1.4, much is known about the highly valued cattle, but little about caprines. As it has been proposed that due to the frequency of depression-type defects, this could be the result of long distance herding, it would be interesting to compare both the frequency and defect types of cattle to caprines to see if they are affected in the same way, likely supporting the hypothesis that they were herded together.

10.5 General Conclusions

This research has clearly demonstrated that LEH is a common occurrence in both modern and archaeological pig and caprine populations. It potentially can be a very useful tool in investigating a wide range of questions regarding animal husbandry and diachronic changes in archaeological populations. Given the fact that this is the first study of its kind in Egypt, and covers a number of archaeological sites with varying sample sizes, these results are only a first step in using LEH to study changes in animal husbandry and environment diachronically and geographically, and future work is needed.

Overall there are no significant changes in caprine husbandry throughout dynastic Egypt. Instead, caprines age distributions, size, presence, and frequency remained fairly constant. The only exception is a the site of Amarna where there is an obvious effort to have a more intensive involvement in both caprine and especially pig rearing which is likely due to the dry, desert nature of the site in which otherwise pigs would have not survived. The pig was essential at Amarna- particularly in the workmen's village as it probably provided the most important and economical source of protein that was easy to maintain, along with having a very quick reproductive turnover rate. Pigs might also have played a role in the unofficial economy of the site.

It is possible that pig rearing regimes similar to that practiced at the Amarna Workmen's Village existed at sties such as Kom el-Hisn and Kom Firin. However, further analyses, both of a larger faunal sample, as well as more excavations at the site to see if pig pens in fact actually existed at these sites is necessary.

Caprines do not evidence any major changes in their husbandry regime, both geographically and chronologically. Most probably, they were left to be herded on the outskirts of most settlements, largely being kept for their secondary resources. However, there do seem to be some site-specific patterns such as what is seen at Saïs where there may have been early/forced weaning The reason for this is unknown, as this is the only site known at this time to have this pattern. It could be a later development in the history of the site, or something that may be specific to the site only ate this time possible due to some unknown environmental condition. As there are no modern parallels known at this time, it is difficult to speculate why this may have been occurring at this time. Future work is needed first to see if this is a real pattern of this time period at Saïs and if it occurred earlier and continued later in the site's history.

On the whole, the analysis of LEH in ancient Egyptian suids and caprines reveals a number of site-specific patterns and few diachronic changes. However, there is significant potential for future work on other ancient Egyptian assemblages to investigate wider patterns of animal husbandry and over a larger time period, hopefully including earlier periods such as the Neolithic and Predynastic period. It is hoped that this work has provided the foundation for future study of LEH in ancient Egyptian animal populations, and has demonstrated the potential for its use in a wide range of important archaeological questions and issues relevant to both Zooarchaeology and Egyptology. One hopes it will stimulate researchers in Egypt to save and curate archaeological faunal samples.

Appendix 1: Ancient Egyptian Chronology

Time Period	Date
Old Kingdom	c.2686-2125 BC
First Intermediate Period	c.2160-2055 BC
Middle Kingdom	c.2055-1650 BC
Second Intermediate Period	c.1650-1550 BC
New Kingdom	c.1550-1069 BC
Third Intermediate Period	c.1069-664 BC
Late Period	c.664-332 BC
Ptolemaic/Roman Period	c. 332 BC- AD 395

Appendix 2: Pig Raw Data

Elephantine (Old Kingdom):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
36902 D/r	m1	B	Y	L	8.06	11.2	2.51	--	1.52	line	1	16
36901 Q/m	m1	A	Y	R	9.37	10.1	4.12	--	--	line	1	15
34103 E/a	m1	C	Y	L	7.34	10.2	2.99	--	2.19	line	1	24
34103 E/a	m1	C	Y	R	8.25	10.9	5.32	--	5.24	line	1	20
34103 E/a	m1	E	Y	L	6.01	11.9	1.79	--	1.87	line	1	
34103 E/a	m2	U	Y	L	11	8.71	3.31	--	4.99	line	2	24
							1.19	--	1.33	line	1	
34103 E/a	m2	V	Y	R	--	--	--	--	--	--		20
34103 E/a	m2	C	Y	L	9.09	13.2	7.99	--	7.26	line	2	
							2.54	--	2.41	line	2	

Giza:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
BB.6U26	m1	K	Y	R	4.37	10.95	--	--	--	--		34
BB.GU-V24	m1	G	Y	R	5.03	11.47	--	--	--	--		
BB.GUTV24-25	m1	H	Y	L	6.18	11.1	4.6	--	--	line	2	
							2.24	--	2.32	depression		
BB.6U26t	m1	B	Y	R	6.95	9.92	1.42	--	2.2	line	2	16
MSE.4M28	m1	E	Y	R	5.94	11.22	--	--	--	--		
BB.6U23.4	m2	J	Y	L	2.75	12.6	1.63	--	--	depression		
BB.6U26	m2	F	Y	R	6.36	13.39	6.91	--	6.48	line	2	34
							5.95	--	5.94	line	2	
							2.97	--	2.54	depression		
BB.GT7.28	m2	E	Y	L	7.75	14.31	5.48	--	5.68	line	2	
							2.95	--	2.57	line	2	
BB.GUTV24-25	m2	E	Y	L	6.96	12.73	1.87	--	1.43	depression		
BB.6U25/6U26	m3	D	Y	R	5.72	16.3	1.84	0.69	--	line	1	
BB.6U26	m3	C	Y	R	12.4	15.3	4.66	5.39	5.93	line	2	34
							1.6	1.46	2.36	line	2	
BB.GT26-27	m3	C	Y	L	8.19	15.81	5.3	4.08	--	line	2	
							3.46	3.03	2.97	line	2	
BB.GU-V24	m3	C	Y	R	10.9	15.66	2.97	2.88	1.64	line	1	
MSE.4.M28	m3	A	Y	R	13.1	15.77	4.33	4.2	--	line	2	

Kom el-Hisn:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
Rm19; Su2	m1	A	Y	L	11.4	13.18	--	--	--	--		16
Rm10; Su2	m1	K	Y	L	4.56	11.11	1.26	--	--	line	2	
1256/1072; Su1	m1	K	Y	L	4.83	12.39	--	--	--	--		
Rm16; 1212/1050-52; Su1	m1	N	Y	L	2.94	11.08	--	--	--	--		
Rm19; Su1	m1	F	Y	R	7.99	12.11	--	--	3.75	line	2	27
Rm23; Su1	m1	G	Y	L	4.47	10.74	--	--	--	--		
Rm19; Su1	m1	G	Y	L	5.44	12.32	--	--	--	--		30
Rm2; Su3	m1	B	Y	L	7.22	10.16	2.55	--	2.18	depression		
1192S/1035E; Su12	m1	F	Y	L	5.26	11.03	2.47	--	1.9	depression		
Rm5; Su9	m1	B	Y	L	8.36	11.11	6.24	--	4.92	line	2	22
1209S/1070E; Su2	m1	N	Y	R	1	11.79	--	--	--	--		46
Rm10; Su2	m2	J	Y	L	4.02	13.88	1.78-0.6	--	1.97-1.	pits		
Rm12; Su1	m2	F	Y	L	6.31	11.41	3.94	--	3.86	line	2	
							--	--	4.01	pit		
							1.57	--	1.34			
Rm12; Su1	m2	B	Y	L	10.4	13.45	3.53	--	3.77	line	3	
Rm12; Su1	m2	B	Y	L	12.1	14.55	8.12	--	6.09	line	2	
Rm19; Su1	m2	D	Y	R	7.05	13.04	3.36	--	2.8	line	3	27
							2.38	--	1.73	line	2	
Rm19; Su1	m2	E	Y	L	6.66	14.02	3.93	--	2.65	line	3	30
1205S/1070E; Su3	m2	E	Y	L	7.34	12.92	5.21	--	5.68	line	2	
							2.39	--	1.9	line	1	
1205S/1070E; Su3	m2	E	Y	R	6.84	13.32	5.94	--	6.33	line	2	
							2.7	--	2.74	line	2	
1209S/1070E; Su2	m2	M	Y	R	4.12	14.1	--	--	--	--		46
1295S; 1095E; Su7	m3	C	Y	R	12.3	17.28	--	2.92	--	depression		
Rm10; Su3	m3	B	Y	R	15.6	15.47	7.88	6.84	--	line	3	
							4.37	2.93	--	line	3	
Rm18; Su9	m3	B	Y	L	12.3	18.3	3.05	3.46	--	line	3	
Rm19; Su1	m3	B	Y	R	10.4	17.45	2.95	2.7	--	line	2	
Rm19; Su1	m3	C	Y	R	9.14	14.65	8.92	8.12	--	line	2	27
Rm19; Su1	m3	C	Y	L	10.1	14.99	--	--	--	--		30
1261S/1074E; Su26	m3	C	Y	L	8.29	15.95	2.32	3.07	--	line	2	
Ahmed1; Room1; Su1	m3	D	Y	L	5.13	16.12	1.89	2.01	--	line	1	
1219S/1095E; Su5	m3	C	Y	R	12.5	17.88	--	3.27	--	depression		
1209S/1070E; Su2	m3	F	Y	R	4.68	15.1	2.71	1.96	1.39	line	1	46
Rm23; Su3	m3	C	Y	R	11	18.8	--	--	--	--		
Rm23; Su3	m3	C	Y	R	11.1	15.22	--	2.53	2.18	line	2	

Mendes:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
AJU.04.94B	m1	H	Y	R	3.8	10.67	--	--	--	--		30
AJU.05.134	m1	B	Y	R	7.29	10.98	--	--	--	--		20
AJB.04.66ext1	m1	H	N	R	6.37	13.22	--	--	--	--		23
AJB.04.burial4B	m1	F	Y	L	5.82	14.94	3.92	--	3.36	depression		26
AJF.04.110	m1	D	N	R	7.87	--	4.59	--	4.22	line	2	
AJA.99.98-4	m1	C	Y	L	7.07	13.93	3.25	--	--	line	1	14
AJE.99.224-8/9	m1	C	N	L	8.29	11.28	--	--	--	--		
AJE.99.104-3	m1	C	N	R	9.7	14.25	4.01	--	--	line	2	
AKI.99.110	m1	G	Y	L	6.45	14.72	--	--	--	--		21
AJF.05.217.bn12	m1	1/2 (4)	Y	R	8.47	9.13	--	--	--	--		13
AJF.05.214.bn20	m1	G	N	R	5.99	8.19	--	--	--	--		20
AJU.05.146bn117	m1	C	N	L	6.62	10.91	3.26	--	3.04	depression		
AJ-DI-22.00	m2	C	Y	R	10.7	16.99	5.54	--	6.99	line	2	
							4.04	--	4.85	line	2	
AJU.04.94B	m2	E	Y	R	5.73	13.18	3.68	--	3.43	line	2	30
							2.13	--	1.73	line	1	
AJU.05.134	m2	erupt	Y	R	12.2	12.3	5.2	--	6.81	line	1	20
AJA.00.211	m2	D	N	R	--	--	2.3	--	2.61	line	2	16
AJB.04.66ext1	m2	E	N	R	6.57	15.57	2.5	--	--	line	2	23
AJB.05.108	m2	D	N	R	7.85	17.63	--	--	3.78	line	1	
AJB.04.burial4B	m2	C	Y	L	9.23	15.72	--	--	--	--		26
AJF.04.109	m2	E	Y	L	7.04	15.94	--	--	--	--		18
AJE-ANX.99.5mast	m2	B	N	L	10.3	16.09	2.48	--	3.3	line	2	
AJA.99.98-4	m2	A	Y	L	10.8	16.11	4.61	--	6.12	line	2	14
							3.61	--	4.68	line	2	
AJE.99locus5	m2	D	N	L	6.36	13.95	3.81	--	1.73	line	2	
AJE.99.103-4buria	m2	D	N	R	6.94	11.73	--	--	2.38	line	1	
AJE.99.104-3	m2	A	N	R	11.9	15.21	1.76	--	1.07	line	2	
AJU-IU.99.107buri	m2	B	N	R	9.19	16.6	1.97	--	3.32	line	2	
AKI.99.110	m2	D	N	L	6.78	17.75	3.52	--	3.19	depression		21
AJF.99.2	m2	B	Y	R	11	17.22	7.23	--	8.55	line	1	
							4.09	--	3.32	line	2	
							1.77	--	1.47	line	2	
AJF.99.2.bn3	m2	E	Y	R	5.36	16.65	3.84	--	3.31	depression		
AKI.99.109	m2`	E	Y	R	5.78	14.08	4.87	--	4.86	line	3	17
AJF.05.233.bn17	m2	G	Y	R	8.21	13.84	--	--	--	--		20
AJF.05.214.bn20	m2	C	Y	R	7.37	10.02	5.41	--	5.17	line	2	20
AJU.05.146bn117	m2	E	N	R	8.68	14.22	--	--	6.36	line	1	
							--	--	3.83	line	2	
AJU.05.146bn117	m2	A	Y	L	10.4	12.86	--	--	--	--		
AJB.07.200extbn2	m2	E	N	R	5.62	15.86	4.21	--	3.2	line	2	29
AJB.96.14-3	m2	A	Y	L	11.8	16.31	4.2	--	5.58	line	2	
							1.7	--	1.62	line	2	

Mendes (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
AS-D2-II.03	m3	C	N	L	--	15.43	--	4.29	1.89	line	2	
AJU.04.45	m3	G	N	R	--	--	--	2.26	2.98	line	2	
AJU.04.94B	m3	B	Y	R	11.2	13.89	4.96	4.91	4.38	line	2	30
AJU.03.24	m3	D	N	L	9.95	14.6	--	3.75	--	line	1	
AJU.05.134	m3	B	Y	R	13.9	19.62	2.04	2.02	3.38	line	2	
AJA.04.322	m3	D	Y	R	11.6	15.68	1.69	--	--	line	2	
AJU.03.27	m3	C	Y	R	11.9	15.3	3.19	2.61	7.43-2.!	line		
AJA.01.282	m3	C	N	L	--	15.03	--	2.26	2.39	line	2	
AJA.00.211	m3	B	Y	R	12.3	17.61	2.95	2.66	2.03	line	2	16
AJB.04.64	m3	C	Y	R	10.7	16.58	2.18	2.67	2.77	line	1	
AJB.04.42	m3	F	Y	L	9.15	19.13	2.76	3.58	2.46	line	2	
AJB.04	m3	E	Y	L	8.81	17.18	2.3	2.63	2.03	line	2	
AJB.04.57ext1	m3	C	Y	L	10.1	14.52	2.01	1.3	--	line	2	
AJB.04.66ext1	m3	D	N	L	10.3	--	--	--	--	--		
AJB.05.122ext	m3	A	Y	R	15.7	19.59	4.56	4.93	--	line	1	
AJB.05.122ext	m3	B	Y	L	15	19.86	6.41	5.58	--	line	2	
AJB.05.123	m3	C	N	L	11.7	--	--	--	--	--		
AJB.05.100ext	m3	B	N	R	11.9	13.39	3.97	2.95	--	line	2	
AJB.04.burial4B	m3	B	Y	L	11.7	17.57	--	--	--	--		26
AJF.04.109	m3	C	Y	L	10.9	17.7	4.35	4.87	--	line	1	18
AKJ.00.16-1	m3	C	N	L	8.75	15.57	6.18	--	--	line	2	
AKJ.01.2-3	m3	C	N	L	11.6	--	--	2.46	2.96	line	2	
AJA.99.84-4ext5	m3	B	N	L	15.2	16.57	--	5.91	4.57	line	2	
AJA.99.177-4ext4/	m3	B	N	L	14.6	14.74	--	3.31	--	line	2	
AJA.99.102-4ext4	m3	B	N	L	11.9	18.2	0.95	--	--	line	2	
AJE.202-8	m3	B	N	L	12.9	15.95	2.7	3.93	4.03	line	1	
AJF.99.2.bn6	m3	B	Y	R	10.1	13.13	2.61	3.73	--	line	2	
AKI.99.109	m3	B	N	R	12.7	15.18	--	4.76	--	line	2	17
AJR.05.10-1	m3	A	Y	R	14.8	18.83	2.97	--	--	line	2	
AJF.05.233.bn17	m3	C	Y	R	11.7	16.54	3.66	3.18	1.81	line	1	20
AJU.05.143bn115	m3	A	N	L	13.6	--	--	--	--	--		
AJU.05.146bn117	m3	B	Y	R	9.87	15.89	4.45	4.82	4.95	line	2	
AJB.07.200extbn2	m3	B	N	R	10.6	15.6	1.72	2.73	2.78	line	2	29

Abydos Settlement Site:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
ASS 91/2/40/56	m1	E	Y	R	6.29	11.37	--	--	--	--		
ASS 91/2/18/20	m1	H	N	L	2.62	8.33	--	--	--	--		
ASS 91/3/21/60	m1	H	Y	R	3.99	14.11	--	--	--	--		30
ASS 91/10/3/8	m1	G	N	L	4.3	9.25	--	--	3.54	line	1	
ASS 91/7/24/39	m1	H	Y	L	5.47	10.21	--	--	--	--		29
ASS 91/6/8/15	m1	F	N	R	5.3	11.14	--	--	--	--		24
ASS 91/8/16/12	m1	E	Y	R	5.08	12.57	--	--	--	--		24
ASS 91/4/28/29	m1	E	Y	R	5.54	13.31	--	--	--	--		
ASS 91/4/40/78	m1	G	Y	R	6.08	14.58	--	--	--	--		29
ASS 91/2/40/56	m2	C	Y	R	8.61	14.7	2.18	--	3.18	depression		
ASS 91/2/14/9	m2	E	N	L	8.01	10.82	3.17	--	--	line	1	
ASS 91/3/21/60	m2	E	Y	R	7.27	15.53	5.24	--	4.4	line	1	30
							1.93	--	1.73	depression		
ASS 91/7/24/39	m2	D	Y	R	6.22	13.83	4.31	--	6.38	line	2	
ASS 91/7/24/39	m2	E	Y	L	6.68	14.55	6.24	--	5.88	line	2	29
ASS 91/6/8/15	m2	C	Y	R	9.4	13.92	3.26	--	3.1	line	2	
ASS 91/9/20/72	m2	U	Y	L	10.6	10.43	4.58	--	4.83	line	2	24
							2.53	--	2.05	line	2	
ASS 91/9/20/72	m2	F	Y	L	7.06	15.08	--	--	--	--		
ASS 91/8/16/12	m2	C	Y	R	7.92	13.08	1.63	--	2.6	line	4	24
ASS 91/8/8/6	m2	A	Y	L	10.4	12.28	3.99	--	3.27	line	1	
ASS 91/4/28/29	m2	G	Y	R	8.87	15.6	3.53	--	3.15	line	2	
ASS 91/4/40/78	m2	E	Y	R	7.18	16.9	3.87	--	3.77	depression		29
ASS 91/4/28/91	m2	G	Y	R	5.03	14.4	--	--	--	--		
ASS 91/2/14/9	m3	C	Y	R	10.5	15.69	2.84	2.06	--	line	1	
ASS 91/2/18/20	m3	A	Y	R	12.9	13.17	3.89	3.06	2.4	depression		
ASS 91/2/18/20	m3	C	Y	L	9.5	14.25	2.58	3.46	--	line	2	
							1.53	2.68	--	depression		
ASS 91/2/18/20	m3	D	Y	L	7.58	15.21	--	--	--	--		
ASS 91/3/21/60	m3	B	Y	R	9.38	15.81	3.64	2.39	2.68	line	1	30
ASS 91/7/24/39	m3	B	Y	R	10.7	15.52	4.36	3.99	--	line	2	
ASS 91/7/24/39	m3	B	Y	L	13.6	15.5	5.09	4.15	--	line	2	29
ASS 91/6/8/15	m3	U	Y	R	13.1	14.58	6.36	8.13	--	line	2	
							2.67	2.72	--	line	1	24
ASS 91/9/13/7	m3	B	Y	R	9.82	15.51	4.39	4.15	--	line	2	
ASS 91/9/20/72	m3	D	Y	L	9.05	15.26	1.43	1.79	--	line	3	
ASS 91/8/16/12	m3	A	Y	R	13.4	14.22	4.86	2.38	--	line	2	24
ASS 91/4/40/78	m3	B	Y	R	11	17.79	3.66	2.95	--	line	1	29
ASS 91/4/28/91	m3	D	Y	R	9.23	16.97	3.92	3.18	--	line	1	

South Abydos:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
SASEE04/157/2/1	m1	A	N	R	8.23	--	2.49	--	1.88	line	1	
SASEE04/150/3/1	m1	E	Y	R	5.32	13.4	--	--	--	--		22
SASEE04/123/22/1	m1	D	Y	L	6.17	9.92	2.35	--	2.23	depression		19
SASEE04/150/14/4	m1	G	N	L	3.6	10.59	2.13	--	--	line	1	27
SA99/81/14/2	m1	E(3)	Y	R	9.14	10.54	3.51	--	2.7	line	1	12
SA99/81/10/2	m1	G	Y	R	5.65	10.46	--	--	1.38	line	1	
SA99/81/10/2	m1	G	Y	L	4.12	11.09	--	--	--	--		28
SA99/101/14/1	m1	G	Y	R	3.69	10.64	1.07	--	1.76	line	2	27
SA97/46/17/5	m1	E	Y	L	5.91	10.38	1.81	--	2.29	depression		
SA97/46/14/3	m1	D	Y	L	5.95	12.43	2.74	--	3.38	line	1	
SA94/106/8/4	m1	E	Y	R	5.24	9.48	--	--	--	--		
SA99/106/10/10	m1	C	Y	L	6.36	10.24	2.11	--	1.87	depression		
SA99/65/12/1	m1	E	N	R	6.75	10.73	--	--	--	--		
SASEE04/123/22/1	m2	C	N	L	10.3	--	3.1	--	--	depression		
SASEE04/139/8/2	m2	D	Y	R	8.73	14.97	4.24	--	3.47	line	4	
SASEE04/150/8/1	m2	B	N	R	8.84	12.54	--	--	--	--		
SASEE04/150/3/1	m2	G	Y	R	3.27	12.61	--	--	--	--		
SASEE04/150/3/1	m2	A	Y	R	9.28	13.58	2.81	--	3.76	depression		22
SASEE04/139/12/4	m2	A	Y	L	9.26	15.05	3.52	--	3.4	line	2	
SASEE04/123/22/1	m2	B	N	L	12.2	12.53	9.41	--	--	line	2	19
							5.87	--	--	line	2	
SASEE04/150/14/4	m2	D	N	L	6.74	11.85	--	--	--	--		27
SASEE04/150/24/1	m2	C	N	R	10.7	13.98	2.4	--	2.03	depression		
SA99/81/10/2	m2	D	Y	L	6.68	11.83	2.53	--	2.22	depression		
SA99/81/10/2	m2	D	N	R	6.99	--	1.16	--	1.87	line	1	
SA99/81/10/2	m2	E	Y	L	5.63	13.63	2.57	--	2.62	line	2	28
SA01/106/4/14	m2	A	Y	R	10.9	12.71	2.15	--	2.97	line	1	
SA01/106/10/11	m2	B	N	R	8.84	12.42	2.92	--	4.2	line	3	
SA99/101/14/1	m2	D	Y	R	6.09	12.96	2.21	--	1.72	line	1	27
SA97/46/17/5	m2	A	N	L	9.38	12.35	3.08	--	--	line	2	
							1.49	--	--	line	2	
SA99/98/13/2	m2	E	Y	R	8.05	12.51	4.01	--	4.31	line	2	
SA94/106/8/4	m2	B	Y	R	9.42	11.55	2.52	--	--	line	2	
SA99/106/10/10	m2	V	Y	L	9.87	12.99	2.73	--	1.69	line	2	
SA99/92/4/6	m2	D	N	R	8.1	--	3.37	--	3.02	line	1	
SASEE04/150/3/1	m3	D	Y	R	7.26	14.18	4.53	3.94	--	line	1	
SASEE04/150/3/1	m3	A	Y	R	12.3	13.71	--	--	--	--		22
SASEE04/147/3/1	m3	A	N	R	13.2	14.27	--	3.4	--	line	2	
SASEE04/123/1/6	m3	U	Y	R	12	14.47	1.6	--	--	line	2	
SASEE04/123/22/1	m3	E(3)	Y	L	11.6	13.28	7.97	6.31	--	line	2	19
SASEE04/122/2/2	m3	A	Y	L	13.3	15.68	--	--	--	--		
SASEE04/150/14/4	m3	A	Y	R	11.8	14.98	5.69	4.8	--	line	2	27
SASEE04/150/24/1	m3	A	N	R	12.9	15.47	--	6.48	--	line	2	
SASEE04/150/2/1	m3	A	Y	R	13.6	17.33	8.24	9.15	--	depression		
							4.31	5.76	--	line	3	
SA99/81/10/2	m3	A	Y	L	10.4	13.32	6.91	--	--	line	1	28
SA99/83/9/1	m3	A	Y	L	13	15.31	2.03	2.3	--	line	1	
SA99/92/4/5	m3	A	Y	R	12	15.56	3.45	2.9	2.84	line	1	
SA99/92/4/5	m3	A	Y	L	11.3	14.75	2.28	2.98	--	line	1	
SA99/101/14/1	m3	A	Y	R	11.4	14.39	4.39	3.73	--	line	2	27
							2.38	1.87	--	line	2	
SA01/100/3/14	m3	E(3)	Y	L	11.7	13.43	6.62	--	--	depression		
SA01/97/8/6	m3	A	N	L	14.3	12.69	--	7.02	--	line	2	
SA99/65/12/1	m3	A	Y	R	10.4	14.29	6.07	8.04	8.31	line	3	
							2.75	3.99	4.21	line	3	
SA99/92/4/3	m3	A	Y	L	13.7	16.65	4.49	4.55	--	line	3	
SA99/79/1/3	m3	A	N	R	11.6	15.26	--	4.27	--	line	1	

Elephantine (New Kingdom):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
18760 a	m1	J	Y	L	4.92	10.86	--	--	--	--		31
18760 a	m1	J	Y	R	4.17	10.54	--	--	--	--		31
37601 K/a	m1	D	Y	L	5.16	10.75	2.42	--	1.58	line	1	30
37604 B/b	m1	E	Y	L	5.46	11.14	1.17	--	1.31	line	2	
36606 V/a	m1	H	Y	R	2.76	10.53	--	--	--	--		31
36606 V/a	m1	A	Y	L	7.96	10.39	--	--	2.18	line	1	
36606 V/a	m1	A	Y	L	9.61	10.78	2.71	--	4.19	line	1	
36606 R/e	m1	D	Y	L	7.01	10.86	--	--	--	--		
36607 E/f	m1	E	Y	L	6.53	11.01	6.19	--	--	line	1	
36607 Q/b	m1	B	Y	R	7.53	9.76	--	--	--	--		
36602 S/b	m1	F	Y	R	4.81	10.23	--	--	--	--		26
36602 S/b	m1	F	Y	L	4.67	9.9	--	--	--	--		26
36602 A/b	m1	E	Y	R	6.6	11.69	1.34	--	--	line	1	
36604 D/k	m1	J	Y	L	2.1	10.99	--	--	--	--		33
36604 V	m1	E	Y	R	4.96	10.83	2.99	--	3.18	line	2	25
36604 V	m1	E	Y	R	5.13	10.45	--	--	--	--		24
18760 a	m2	E	Y	L	5.02	12.64	4.36	--	5.22	line	2	31
18760 a	m2	E	Y	R	5.71	12.46	3.28	--	3.99	line	2	31
37601 K/a	m2	U	Y	L	10.2	13.45	2.71	--	2.5	line	1	30
37604 B/b	m2	C	Y	L	8.84	13.65	2.53	--	3.49	line	2	
37602 Y/c	m2	A	Y	R	7.34	10.47	3.88	--	4.81	line	2	
							2.64	--	3.72	line	2	
36606 V/a	m2	E	Y	R	5.91	13.04	3.13	--	2.31	line	2	31
36606 V/a	m2	U	Y	R	10.2	12.72	4.44	--	5.43	line	1	
							2.11	--	2.3	line	1	
36606 R/e	m2	A	Y	L	10	12.9	--	--	--	--		
36602 S/b	m2	D	Y	R	7.98	12.01	2.31	--	1.75	depression		26
36602 S/b	m2	D	Y	L	8.53	11.42	2.18	--	1.53	depression		26
36604 D/k	m2	F	Y	L	4.06	12.7	1.01	--	1.35	line	1	33
36604 V	m2	D	Y	R	9.67	12.59	4.88	--	5.86	line	2	25
							2.97	--	2.81	line	2	
36604 V	m2	C	N	R	8.72	13.16	2.73	--	2.96	line	1	24
18760 a	m3	B	Y	L	9.86	14.91	8.83	9.05	--	line	3	31
18760 a	m3	B	Y	R	10.1	14.53	6.51	7.89	--	line	3	31
37603 M/a	m3	C	Y	R	8.15	14.44	4.98	5.38	--	line	2	
							1.26	1.79	--	line	2	
36606 V/a	m3	C	Y	R	10.7	14.88	3.34	2.46	--	depression		31
36602 U/b	m3	A	Y	R	11.6	15.59	4.66	4.89	--	line	3	
36602 S/b	m3	A	Y	R	12.2	13.68	4.99	7.4	--	depression		36
							2.9	2.69	--	line	2	
36602 S/b	m3	A	Y	L	12.1	14.33	5.45	5.62	--	depression		26
36604 D/k	m3	C	Y	L	6.23	13.43	4.86	4.91	6.25	line	1	33
36604 V	m3	A	Y	R	12.7	15.59	6.99	6.57	--	line	2	25
36604 V	m3	A	Y	R	11.7	15.4	3.15	3.27	--	line	1	24

Amarna:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
TA.SV07#13 TR3(11767)	m1	C	N	R	5.82	10.73	--	--	--	--		
TA.SV06#13 TR1(11460)	m1	B	Y	L	7.42	11.11	3.72	--	3.47	depression		14
TA.SV05#13 TR1(11239)	m1	F	Y	R	5.69	11.07	2.42	--	2.01	line	1	19
TA.MC05#12 TR8(11065)	m1	A	Y	R	9.2	9.46	--	--	--	--		8
TA.MC05#12 TR6(11028)	m1	L	Y	L	3.81	9.91	1.67	--	--	line	2	42
TA.MC04#12 (10665)	m1	H	Y	R	5.91	10.42	--	--	2.84	line	2	28
TA.MC04#12 (10665)	m1	H	Y	L	5.5	10.45	--	--	--	--		28
TA.MC05#12 (10965)	m1	B	Y	R	9.07	11.45	1.76	--	1.22	line	2	
TA.MC04#12 (10366)	m1	A	Y	R	7.86	9.94	--	--	--	--		
TA.WV96 (1425)	m1	K	Y	R	3.93	11.03	--	--	--	--		34
TA.WV96 (1646)	m1	J	N	L	4.19	11.85	--	--	--	--		31
TA.WV96 (no context #)	m1	K	Y	L	4.4	10.51	--	--	--	--		40
TA.WV (5037)	m1	U	Y	L	8.29	10.08	6.36	--	--	line	2	
							--	--	2.58	depression		
TA.WV (6920)	m1	B	Y	L	7.78	11.22	4.33	--	2.64	depression		21
TA.WV (1838)	m1	C	Y	R	6.38	10.56	--	--	--	--		22
TA.WV (1839)	m1	D	Y	L	6.92	11.13	--	--	--	--		24
TA.WV (100)	m1	U	Y	R	8.95	9.66	--	--	--	--		
TA.WV (1287)	m1	U	Y	R	8.67	11.03	2.09	--	1.18	--		
TA.WV (769)	m1	E (3)	Y	L	--	--	--	--	--	--		
TA.WV (4504)	m1	B	Y	R	7.88	10.44	5.72	--	--	--		
TA.WV (3)	m1	A	Y	R	7.83	10.59	--	--	--	--		
TA.WV (5267)	m1	F	Y	R	5.67	10.47	1.73	--	1.43	line	2	
TA.WV (6299)	m1	F	Y	L	3.96	10.11	--	--	--	--		
TA.WV (6896)	m1	K	Y	R	3.56	11.09	--	--	--	--		
TA.WV (6033)	m1	G	Y	R	4.37	10.37	--	--	--	--		27
TA.WV (6929)	m1	G	N	L	5.79	10.92	--	--	--	--		28
TA.WV (1198)	m1	G	N	L	6.36	12.14	--	--	--	--		
TA.WV (2198)	m1	N	Y	R	2.07	8.48	--	--	--	--		42
TA.WV (1873) A	m1	J	Y	L	5.21	11.33	--	--	--	--		
TA.WV (1037)	m1	M	Y	L	4.06	11.23	--	--	--	--		38
TA.WV (965)	m1	G	Y	R	4.64	10.64	2.11	--	2.33	line	2	
TA.WV (6844)	m1	E	Y	L	6.33	10.55	1.43	--	1.39	line	2	
TA.WV (1535)	m1	D	Y	L	6.61	10.51	--	--	--	--		
TA.WV (1405)	m1	F	Y	L	5.65	11.36	--	--	--	--		25
TA.WV (1405)	m1	F	Y	R	5.68	11.8	--	--	--	--		25
TA.MC (3336.8,9)	m1	D	Y	L	6.13	11.53	1.09	--	1.49	line	2	
TA.MC (3336.8,9)	m1	E	Y	R	6.02	11.56	2.26	--	1.41	line	2	
TA.MC87#1,2 (3060.1)	m1	N	Y	L	2.47	10.71	--	--	--	--		41
TA.MC87#1,2 (2990.4)	m1	J	Y	L	6.18	10.84	--	--	--	--		
TA.MC87#1,2 (2995.1)	m1	B	Y	L	7.8	10.44	5.67	--	6.62	line	2	
TA.MC87#1,2 (2995.1)	m1	B	Y	R	8.33	10.22	6.07	--	6.43	line	2	
TA.MC87#1,2 (3058.31)	m1	L	Y	L	4.69	10.62	--	--	--	--		
TA.MC87#1,2 (2881.9)	m1	A	Y	R	7.8	10.53	--	--	5.15	line	2	
TA.MC (7235)	m1	N	Y	R	2.6	9.58	--	--	--	--		
TA.MC87 F6 (3327)	m1	K	Y	L	3.89	10.78	--	--	--	--		
TA.SV06#13 TR1(11460)	m2	U	Y	L	13.1	12.55	--	--	--	--		14
TA.SV05#13 TR1(11239)	m2	C	Y	R	8.56	13.2	2.5	--	3.06	depression		19
							0.91	--	1.35	line	2	

Amarna (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
TA.MC05#12 TR8(11065)	m2	V	Y	R	--	--	--	--	--	--		8
TA.MC05#12 TR6(11002)	m2	B	Y	R	6.3	14.7	2.6	--	1.82	line	2	
TA.MC05#12 TR6(11028)	m2	K	Y	L	4.02	12.08	1.76	--	1.2	line	2	42
TA.MC04#12 (10640)	m2	C	Y	R	8.7	13.36	4.37	--	2.62	line	1	
TA.MC04#12 (10665)	m2	E	Y	R	6.76	12.78	6.68	--	8.33	line	2	28
							4.46	--	4.27	line	2	
TA.MC04#12 (10665)	m2	E	Y	L	8.47	13.09	6.83	--	--	line	2	28
							4.23	--	--	line	1	
TA.MC04#12 (10419)	m2	D	Y	L	4.9	12.96	1.89	--	2.27	depression		
TA.WV96 (1425)	m2	F	Y	R	4.07	12.66	1.92	--	1.86	line	3	34
							1.32	--	--	line	1	
TA.WV96 (1843)	m2	C	Y	L	9.14	12.8	6.19	--	6.24	line	2	
							2.48	--	2.07	line	1	
TA.WV96 (1646)	m2	E	Y	L	6.82	14.38	4.37	--	6.31	line	2	31
							2.32	--	2.04	line	2	
TA.WV96 (no context #)	m2	J	Y	L	4.14	13.31	4.9	--	--	line	2	40
TA.WV (6920)	m2	E (3)	Y	L	9.05	11.23	2.86	--	2.38	line	2	21
TA.WV (1838)	m2	V	Y	R	13.5	13.13	9.08	--	8.99	line	2	22
TA.WV (1839)	m2	V	Y	L	10.7	13.15	--	--	2.87	--	2	24
TA.WV (5267)	m2	B	Y	R	9.24	12.63	--	--	--	--		
TA.WV (6299)	m2	E	Y	L	5.93	13.26	2.5	--	2.21	line	2	
TA.WV (6896)	m2	F	Y	R	4.23	14.01	--	--	--	--		
TA.WV (6033)	m2	D	Y	R	6.05	12.63	--	--	--	--		27
TA.WV (6034)	m2	D	Y	L	6.5	12.6	--	--	--	--		
TA.WV (6929)	m2	E	N	L	6.77	13.08	3.84	--	2.63	line	2	28
TA.WV (1198)	m2	D	Y	L	7.99	14.03	3.06	--	2.5	line	2	
							1.79	--	--	line	2	
TA.WV (2198)	m2	K	Y	R	4.79	11.14	--	--	--	--		42
TA.WV (1235)	m2	U	Y	R	12	16.74	3.86	--	3.55	line	2	
TA.WV (1873) A	m2	F	Y	L	5.72	13.63	1.79	--	1.98	line	3	
TA.WV (1037)	m2	H	Y	L	5.14	13.73	2.41	--	2.48	line	1	38
TA.WV (1523)	m2	H	Y	R	3.59	12.38	--	--	--	--		
TA.WV (965)	m2	C	Y	R	8.99	13.52	6.65	--	7.98	line	3	
TA.WV (7201)	m2	V	Y	L	11.1	13.6	5.1	--	7.07	line	2	
TA.WV (1535)	m2	E (3)	Y	L	12.8	11.52	4.67	--	4.66	line	4	
TA.WV (1405)	m2	C	Y	L	11.8	14.23	8.57	--	8.47	line	2	25
							1.76	--	1.77	line	1	
TA.WV (1405)	m2	C	Y	R	9.34	15.1	7.85	--	--	line	2	25
							1.78	--	3.33	line	2	
TA.MC (3336.8,9)	m2	A	Y	R	10.6	13.15	3.79	--	3.26	line	2	
TA.MC87#1,2 (3060.1)	m2	J	Y	L	3.1	13.1	--	--	--	--		41
TA.MC87#1,2 (3147.11)	m2	A	Y	L	13.6	11.57	8.63	--	--	line	2	
TA.MC (7235)	m2	U	Y	R	11.5	13.1	--	--	--	--		
TA.MC87 F6 (3327)	m2	F	Y	L	5.31	13.44	1.13	--	1.36	line		
TA.SV06#13 TR1(11460)	m3	V	Y	L	--	--	--	--	--	--		14
TA.MC05#12 TR6(11046)	m3	U	Y	R	12	15.82	2.92	2.75	--	line	1	
TA.MC05#12 TR6(11028)	m3	F	Y	L	5.48	14.28	2.4	4.33	--	line	1	42
TA.MC04#12 (10665)	m3	U	Y	R	11.5	15.91	3.59	--	3.25	line	2	28
							0.94	--	--	line	1	

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
TA.MC04#12 (10665)	m3	U	Y	L	11.1	15.77	3.93	3.1	--	line	2	28
							1.35	--	--	line	1	
TA.MC05#12 (10780)	m3	U	Y	L	12.6	15.78	2.34	2.85	3.36	line	2	
TA.MC04#12 (10348)	m3	D	Y	R	5.68	14.87	1.92	1.68	2.54	line	2	
TA.MC04#12 (10348)	m3	B	N	L	8.21	12.13	--	2.78	2.21	line	2	
TA.MC04#12 (10348)	m3	D	N	R	6.95	15.17	--	1.25	--	line	1	
TA.MC04#12 (10419)	m3	C	Y	L	9.04	13.74	4.2	3.99	--	line	2	
							1.63	0.73	--	line	1	
TA.MC04#12 (10336)	m3	C	Y	R	7.81	13.42	2.41	3.25	--	line	2	
TA.MC04#12 (10235)	m3	C	Y	L	7.67	14.6	1.43	1.96	--	line	1	
TA.WV96 (1425)	m3	C	Y	R	9.33	14.18	--	--	4.96	line	2	34
TA.WV96 (1843)	m3	V	Y	L	12	--	--	--	--	--		
TA.WV96 (1646)	m3	C	Y	L	10.9	16.93	5.81	6.82	--	line	2	31
							1.85	1.66	--	line	2	
TA.WV96 (no context #)	m3	F	Y	L	4.47	16.92	1.76	1.3	--	line	1	40
TA.WV (1645)	m3	D	Y	L	5.54	14.25	1.12	1.4	1.11	line	2	
TA.WV (1036)	m3	D	Y	R	4.53	14.85	6.08	--	--	line	1	
							1.58	--	1.4	depression		
TA.WV (232)	m3	D	Y	R	6.1	15.45	2.25	1.81	1.52	line	2	
TA.WV (6033)	m3	A	Y	R	10.2	14.4	4.99	--	--	line	2	27
TA.WV (6034)	m3	A	Y	L	9.79	14.87	4.43	4.23	--	line	2	
TA.WV (6929)	m3	A	N	L	10.4	14.26	--	2.64	--	line	1	28
TA.WV (2198)	m3	D	Y	R	5.15	15.69	1.98	1.68	3.1	line	2	42
TA.WV (7198)	m3	C	Y	R	10.9	16.91	3.04	3.29	--	line	2	
TA.WV (7196)	m3	C	Y	R	10.2	16.62	3.24	2.19	--	depression		
TA.WV (1037)	m3	C	Y	L	9.84	17.21	3.47	1.88	--	line	2	38
TA.WV (964)	m3	B	Y	R	13.5	15.33	5.61	5.95	--	line	3	
TA.WV (7200)	m3	D	N	L	8.42	14.94	--	5.46	--	line	2	
TA.WV (1405)	m3	A	Y	L	14.9	17.27	--	--	--	--		25
TA.WV (1405)	m3	A	Y	R	13.6	17.34	--	--	--	--		25
TA.MC (3336.8,9)	m3	C (1)	Y	R	--	--	--	--	--	--		
TA.MC87#1,2 (3060.1)	m3	D	Y	L	8.89	15.42	3.71	3.17	--	line	2	41
TA.MC87#1,2 (3230.2)	m3	C	Y	R	8.9	15.01	3	2.1	--	line	2	

Kom Firin:

Context	Square/Year	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
69	TAF2003	m1	B	Y	L	9.27	12.87	2.17	--	1.99	line	1	
35	TAE2003	m1	E(3)	Y	L	9.72	8.34	4.53	--	3.27	line	1	13
35	TAE2003	m1	B	Y	L	10.29	14.88	5.24	--	7.82	line	3	
3	A2002	m1	E	Y	L	6.44	14.02	3.97	--	3.48	line	1	19
22	TAC2003	m1	G	Y	R	5.69	11.06	2.73	--	3.24	depression		28
167	TG2004	m1	D	Y	R	6.38	10.75	2.02	--	2.34	line	2	20
								1.27	--	1.37	line	1	
1100	CA2007	m1	D	Y	R	7.06	10.99	--	--	--	--		31
711	EE2007	m1	A	Y	L	8.62	10.81	--	--	--	--		
20	TAA2003	m1	E	Y	L	4.97	12.06	--	--	--	--		
61	TAF2003	m1	B	Y	R	8.51	11.24	1.97	--	1.84	depression	1	
61	TAF2003	m1	F	Y	L	5.58	11.17	--	--	--	--		26
61	TAF2003	m1	E	Y	R	4.83	14.06	--	--	--	--		
161	TJ2004	m1	G	Y	R	4.31	11.56	--	--	--	--		
161	TJ2004	m1	G	Y	L	4.99	11.53	--	--	--	--		
228	TK2004	m1	N	Y	L	2.86	12.71	--	--	--	--		51
161	TJ2004	m1	C	Y	R	8.02	11.57	--	--	--	--		23
228	TK2004	m1	K	Y	R	4.12	13.82	--	--	--	--		30
407	NA2006	m1	J	Y	R	5.79	12.04	--	--	2.31	line	2	29
429	NA2006	m1	D	Y	R	7.48	--	--	--	--	--		
671	EE2007	m1	A	Y	R	9.45	13.19	4.16	--	3.96	line	2	26
1067	CB2007	m1	G	Y	L	4.2	10.88	--	--	--	--		27
457	EC2007	m1	E	Y	L	5.99	15.49	--	--	--	--		
462	EC2007	m1	C	Y	R	7.56	11.19	--	--	--	--		15
1092	CB2007	m1	F	Y	L	6.3	11.27	--	--	--	--		28
1104	CB2007	m1	D	Y	L	6.85	11.23	--	--	5.55	pit		
780	EC2008	m1	A	N	R	11.48	15.01	2.31	--	2.23	line	2	
1146	CB2008	m1	A	Y	L	9.8	12.15	--	--	--	--		
2200	ED2008	m1	K	Y	R	3.99	12.06	--	--	--	--		
1146	CB2008	m1	H	Y	L	3.63	13.47	--	--	--	--		
578	EC2008	m1	C	Y	L	7.99	12.99	--	--	--	--		15
840	EC2008	m1	C	Y	R	7.51	11.53	--	--	--	--		20
1122	CB2008	m1	N	Y	R	3.77	10.92	--	--	--	--		39
834	EC2008	m1	D	Y	L	5.28	11.38	--	--	--	--		
901	EC2008	m1	F	Y	R	6.21	11.38	--	--	--	--		26
901	EC2008	m1	F	Y	L	6.38	11.19	--	--	--	--		26
1658	CD2008	m1	N	N	L	2.34	14.98	--	--	--	--		
880	EC2008	m1	D	Y	L	7.35	11.31	--	--	--	--		16
900	EC2008	m1	E	Y	L	6.86	11.33	1.8	--	2.26	line		
853	ED2008	m1	C	Y	R	6.39	11.23	2	--	2.43	line	1	25
868	EC2008	m1	E	Y	R	6.16	11.46	--	--	--	--		29
868	EC2008	m1	E	Y	L	6.18	11.17	--	--	--	--		29
1623	CD2008	m1	D	Y	L	7.88	11.52	--	--	--	--		
845	EC2008	m1	A	Y	L	8.81	13.43	--	--	--	--		
2220	ED2008	m1	F	Y	R	5.39	10.97	--	--	--	--		25
2214	ED2008	m1	C	Y	L	9.26	13.05	2.59	--	1.67	depression		
2214	ED2008	m1	C	Y	L	7.42	10.23	2.28	--	2.05	depression		27
2214	ED2008	m1	B	Y	R	7.55	11.08	2.21	--	1.6	line	1	23
2214	ED2008	m1	D	Y	L	8.16	--	--	--	--	--		

Kom Firin (Continued):

Context	Square/Year	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
3	A2002	m2	D	N	L	8.16	17.9	3.71	--	--	line	2	19
								2.65	--	--	line	2	
22	TAC2003	m2	E	Y	R	8.14	13.32	4.79	--	4.93	line	2	28
								1.41	--	1.94	depression		
156	TG2004	m2	U	Y	R	10.67	13.06	3.63	--	2.99	line	1	
1092	CB2007	m2	A	Y	L	12.88	16.42	2.44	--	3.34	line	2	
								1.55	--	2.54	line	2	
1100	CA2007	m2	U	Y	R	10.59	13.12	6.12	--	7.75	line	3	31
161	TJ2004	m2	E	Y	R	6.95	13.66	6.72	--	5.69	line	2	
								1.85	--	2.05	depression		
161	TJ2004	m2	D	N	L	10.94	--	2.61	--	2.21	line	2	
228	TK2004	m2	N	Y	L	2.72	14.15	--	--	--	--		51
161	TJ2004	m2	A	Y	R	11.1	13.27	6.92	--	7.84	line	3	23
								2.58	--	1.47	depression		
228	TK2004	m2	D	Y	R	9.61	16.64	2.88	--	3.49	depression		30
407	NA2006	m2	D	Y	R	6.36	13.99	--	--	4.44	pit		29
								1.66	--	2.29	line	1	
671	EE2007	m2	A	Y	R	10.24	13.99	5.77	--	5.43	line	2	26
								2.23	--	1.46	line	1	
837	EC2008	m2	C	Y	L	9.73	12.92	--	--	--	--		
1067	CB2007	m2	E	Y	L	7.35	14.04	3.65	--	4.91	line	2	27
462	EC2007	m2	A	Y	R	11.91	13.88	1.82	--	2.24	line	2	15
462	EC2007	m2	A	Y	L	11.43	13.89	1.84	--	1.95	line	2	
1092	CB2007	m2	E	Y	L	7.42	13.99	1.85	--	1.05	line	1	28
838	EC2008	m2	A	Y	R	9.89	12.3	1.96	--	1.75	line	2	
838	EC2008	m2	A	Y	R	11.28	11.99	2.37	--	2.43	line	2	
2202	ED2008	m2	A	N	L	14.66	--	4.99	--	5.81	line	2	
								3.74	--	4.54	line	2	
578	EC2008	m2	A	Y	L	10.44	14.57	1.89	--	2.28	line	1	15
578	EC2008	m2	A	Y	R	11.53	14.17	2.09	--	1.95	line	1	
1122	CB2008	m2	H	Y	R	3.53	14.1	--	--	--	--		39
901	EC2008	m2	D	Y	R	8.65	13.42	2.09	--	2.07	line	3	26
901	EC2008	m2	D	Y	L	7.2	13.52	2.03	--	0.92	line	2	26
1658	CD2008	m2	G	N	L	2.8	15.17	--	--	--	--		
880	EC2008	m2	A	Y	L	10.4	13.56	5.44	--	5.88	line	3	16
880	EC2008	m2	A	Y	R	10.92	13.42	4.19	--	13.64	line	3	
853	ED2008	m2	A	Y	R	12.37	12.86	4.79	--	5.81	line	3	25
1181	CB2007	m2	A	Y	R	9.61	14.44	4.36	--	3.04	line	2	
868	EC2008	m2	A	Y	R	11.06	13.37	3.55	--	2.83	line	1	29
868	EC2008	m2	A	Y	L	10.67	13.08	2.57	--	2.25	line	1	29
2220	ED2008	m2	C	Y	R	8.45	12.49	2.19	--	1.67	depression		25
2214	ED2008	m2	G	Y	R	6.02	12.25	4.73	--	3.96	line	2	27
2214	ED2008	m2	A	Y	L	9.4	13.9	--	--	--	--		23
1636	CD2008	m2	C	Y	L	7.18	14.82	3.7	--	4.13	line	2	
2220	ED2008	m2	A	Y	L	9.25	13.59	3.56	--	3.49	line	2	
2220	ED2008	m2	J	Y	R	3.25	13.49	--	--	--	--		
77	TH2003	m3	C	Y	R	8.32	16.38	3.81	4.06	3.66	line	1	
								3.75	2.78	1.94	line	2	
								1.98	1.65	--	line	1	

Context	Square/Year	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
22	TAC2003	m3	A	Y	R	15.41	15.99	--	--	7.72	line	3	28
								3.18	2.86	4.01	line	3	
								2.68	1.65	2.96	line	3	
52	TAF2003	m3	C	Y	R	12.48	15.37	--	2.87	3.24	line	1	
156	TG2004	m3	C	Y	L	9.93	14.68	5.94	4.93	6.87	line	2	
228	TK2004	m3	K	Y	L	2.74	15.5	2.44	2.33	--	line	2	51
159	TG2004	m3	A	N	R	12.6	17.35	3.3	2.73	--	line	2	
								1.67	1.66	--	line	1	
228	TK2004	m3	A	Y	R	13.08	17.28	3.01	3.82	--	depression		
136	TG2004	m3	A	Y	L	13.1	16.17	3.45	3.66	--	line	2	
407	NA2006	m3	A	Y	R	11.86	16.98	2.66	2.41	--	line	2	29
671	EE2007	m3	A	Y	R	15.3	15.99	6.14	5.05	5.69	line	1	26
								3.13	1.26	--	line	1	
1143	CB2008	m3	E	N	R	5.56	16.2	--	--	--	--		
1067	CB2007	m3	U	Y	L	13.82	18.01	4.08	2.84	--	line	2	27
465	EC2007	m3	C	Y	R	9.3	17.89	2.42	1.18	--	line	1	
1092	CB2007	m3	B	Y	L	11.48	15.2	2.08	1.23	--	line	2	28
577	EC2007	m3	A	Y	R	11.58	15.77	3.96	3.29	2.87	line	2	
1146	CB2008	m3	E	Y	L	4.18	16.66	--	2.29	--	line	1	
1122	CB2008	m3	C	N	R	8.43	13.72	7.97	--	--	line	3	39
								5.14	--	--	line	3	
								2.47	--	--	line	3	
901	EC2008	m3	A	Y	R	13.26	16.46	9.5	9.23	--	line	2	26
								3.39	1.29	--	line	2	
901	EC2008	m3	A	Y	L	14.14	15.76	9.21	8.92	--	line	2	26
								2.78	1.97	--	line	2	
1661	CD2008	m3	D	Y	R	6.66	15.77	2.47	3.06	2.79	line	2	
								1.92	1.61	--	depression		
2225	ED2008	m3	C	Y	R	11.3	17.58	--	--	--	--		
869	EC/ED2008	m3	C	Y	R	7.09	17.42	--	3.99	--	line	2	
2220	ED2008	m3	A	Y	R	12.13	15.34	--	--	--	--		25
2214	ED2008	m3	C	Y	R	7.32	15.03	5.21	5.46	5.34	line	2	27
2214	ED2008	m3	C	Y	L	7.03	14.09	5.01	5.32	--	line	2	23
2220	ED2008	m3	E	Y	R	4.29	15.2	2.31	1.38	--	depression		
850	EC2008	m3	A	Y	L	14.42	18.21	3.8	5.14	4.72	line	4	

Saïs:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
1000.1-4	m1	Y	D	R	6.41	11.13	--	--	--	--		19
1000.1-4	m1	Y	D	L	8.17	14.01	4.34	--	--	depression		
1000	m1	N	E	R	7.02	14.68	--	--	3.89	line	2	
1000	m1	N	E	L	7.65	--	--	--	3.79	line	2	
5018	m1	Y	H	R	4.02	12.01	--	--	--	--		23
5017	m1	Y	G	R	4.72	10.9	--	--	--	--		
6004	m1	N	D	R	6.83	11.05	3.55	--	--	line	1	
5001	m1	Y	C	L	7.03	11.49	3.36	--	6.11	line	2	14
							2.62	--	3.53	line	2	
5001	m1	Y	C	R	6.96	11.59	3.57	--	3.99	line	3	
							2.92	--	3.67	line	2	
5001	m1	Y	C	L	7.65	11.83	--	--	2.2	depression		
1000.1-4	m2	Y	C	L	10.6	12.94	2.62	--	2.52	line	2	
1000.1-4	m2	Y	B	R	10.2	12.81	2.63	--	2.68	line	2	19
1000	m2	Y	B	L	9.2	13.38	3.13	--	2.41	line	1	12
							2.45	--	1.6	line	2	
1000	m2	N	B	R	11.1	14.42	4.69	--	--	line	2	
							1.68	--	--	line	1	
5018	m2	Y	E	R	6.43	14.44	1.53	--	2.81	line	1	23
6006	m2	Y	C	L	8.59	13.33	7.19	--	--	line	2	
							2.03	--	1.63	line	2	
5017	m2	Y	E	R	6.82	13.31	1.95	--	1.4	line	1	
5017	m2	Y	C	L	8.16	13.76	--	--	2.66	line	2	
6004	m2	Y	B	R	11.8	14.65	1.98	--	2.31	line	2	
5001	m2	Y	A	L	10.2	13.39	2.31	--	2.17	line	2	14
5001	m2	Y	A	R	10.4	13.59	10.49	--	--	line	1	
5001	m2	Y	A	R	11	14.47	4.98	--	4.68	line	2	
5001	m2	Y	A	L	11.3	14.31	6.1	--	6.75	line	2	
							3.84	--	5.29	line	1	
1000.2-2	m2	Y	V	L	7.67	10.49	--	--	3.13	line	1	9
1000.1-4	m3	Y	E	R	13.3	16.07	4.63	--	--	depression		19
1001	m3	N	B	L	12	14.72	--	5.16	--	line	2	
1000.1.5+7	m3	N	H	R	3.62	19.79	--	--	--	--		
1000	m3	Y	U	L	14.4	18.76	2.97	3.37	--	depression		12
1000	m3	Y	U	R	13.5	15.5	2.26	0.9	--	depression		

Tell el-Borg:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
TBIX.6.3	m1	N	Y	L	3.4	11.27	--	--	--	--	3	41
TBO-II.1-3	m2	E	Y	L	6.85	13.58	2.33	--	2.82	line	2	
TBIV.D18.3	m2	D	Y	L	5.85	12.79	1.42	--	0.93	line	2	
TBIX.6.3	m2	J	Y	L	8.16	13.95	--	--	--	--		41
TBO-II.1-3	m3	C	Y	L	13.94	15.29	4.27	3.87	3.12	line	1	
TBO-II.1-3	m3	C	Y	R	13.06	16.85	4.18	4.27	2.9	line	2	
TB6.B3	m3	B	Y	L	12.3	19.32	2.66	3.32	--	line	2	
							2.03	2.03	--	line	1	
							--	5.81	--	line	2	
							--	--	1.97	pits		
TBVI.R	m3	A	N	L	11.33	16.74	3.45	--	--	depression		
							1.68	--	--	line	1	
TBIX.6.3	m3	D	Y	L	11.72	15.22	4.89	3.96	--	line-heavy	3	41

Aswan (Ptolemaic-Roman):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS
8-43-7-3/2	m1	N	N	R	4.64	10.96	--	--	--	--		39
8-32-44-3/1	m1	G	N	L	6.84	12.31	--	--	--	--		
8-42-4-6/1	m1	C	Y	L	6.26	10.41	1.74	--	2.14	depression	2	11
7-32-36-5/2	m1	V	Y	R	7.97	9.91	2.57	--	3.99	line	2	
7-32-26-7/1	m1	E	Y	L	6.57	11.25	1.66	--	1.52	line	2	25
7-32-37-8/1	m1	E	Y	R	5.88	11.13	3.71	--	3.73	line	2	
7-32-26-9/2	m1	G	Y	L	5.38	10.35	--	--	--	--		30
7-32-26-9/2	m1	G	Y	R	4.25	11.49	--	--	--	--		30
6-13-104-3	m1	N	Y	R	3.64	10.8	--	--	--	--		41
6-13-56-6	m1	K	Y	R	3.16	11.04	--	--	--	--		34
5-13-153-4	m1	G	Y	L	5.64	11.09	--	--	4	line	2	
6-13-81-6	m1	E	Y	R	6.43	10.34	--	--	--	--		25
6-15-75-2/1	m1	G	Y	R	5.42	11.15	--	--	--	--		
6-13-117-1	m1	A	Y	L	8.79	10.33	4.01	--	2.93	line	2	21
8-32-25-5/1	m1	D	N	L	5.76	12.81	2.86	--	--	line	2	
8-32-22-3/2	m1	F	Y	L	4.62	8.12	--	--	1	line	2	20
8-43-7-8/1	m2	B	Y	R	13.81	14.71	5.06	--	3.93	line	1	
8-43-7-3/2	m2	G	Y	R	5.39	13.91	--	--	--	--		39
8-32-44-3/1	m2	E	Y	L	8.46	13.96	3.47	--	3.2	depression	2	
8-42-4-6/1	m2	E (3)	Y	L	11.27	10.22	2.58	--	2.25	line	2	11
7-32-26-7/1	m2	D	Y	L	7.35	14.16	2.7	--	3.4	line	2	25
7-32-37-8/1	m2	D	N	R	7.31	12.89	5.51	--	--	line	3	
7-32-26-9/2	m2	E	Y	L	7.73	14.44	2.31	--	2.16	line	2	30
7-32-26-9/2	m2	E	N	R	7.81	14.94	--	--	2.38	line	1	30
6-13-104-3	m2	J	Y	R	5.55	13.76	--	--	--	--		41
6-13-56-6	m2	E	N	R	6.28	13.31	--	--	--	--		34
6-13-117-1	m2	D	Y	L	7.88	12.92	2.92	--	2.4	depression	1	21
5-13-153-4	m2	D	Y	L	8.19	13.3	4	--	3.44	line	2	
6-13-81-6	m2	D	Y	R	9.29	12.8	5.11	--	3.16	line	1	25
6-13-81-6	m2	D	Y	L	8.93	12.26	3.76	--	2.45	depression	1	25
6-15-75-2/1	m2	C	Y	R	8.61	13.72	3.58	--	2.87	line	2	
8-32-13-3/1	m2	B	Y	L	8.65	12.76	3.92	--	3.54	line	1	
8-32-22-3/2	m2	C	Y	L	7.74	10.57	1.39	--	1.83	line	2	20
8-43-7-3/2	m3	D	Y	R	8.76	15.06	--	--	--	--		39
7-32-26-7/1	m3	A	Y	L	13.95	15.84	4.1	2.86	--	depression	1	25
7-32-26-9/2	m3	C	Y	L	10.46	14.73	6.27	7.04	--	line	2	30
							2.49	2.79	2.11	line	2	
7-32-26-9/2	m3	C	Y	R	9.46	14.85	5.16	6.19	--	line	2	30
							2.04	2.19	3.13	line	2	
6-13-104-3	m3	D	Y	R	8.7	14.83	1.56	1.29	1.84	depression	2	41
6-13-56-6	m3	D	N	R	7.63	12.44	2.15	1.63	1.89	line	1	34
6-13-117-1	m3	A	Y	L	11.25	14.91	1.81	1.87	--	line	2	21
6-13-81-6	m3	A	Y	R	12.63	14.67	6.53	6.7	--	line	2	25
							2.96	1.73	2.33	line	2	
6-13-81-6	m3	A	Y	L	12.46	14.83	7.07	7.13	--	line	2	25
							2.91	2.84	3.39	line	2	
5-13-494-2	m3	C	Y	R	10.29	16.68	4.17	3.97	--	line	2	
							2.06	1.91	2.29	line	2	
8-32-25-5/1	m3	A	N	R	14.33	13.67	2.81	--	--	line	2	
8-32-22-3/2	m3	C(1)	Y	L	11.43	12.59	6.88	--	--	line	2	20

Shobra (Modern):

No	Element	Age group	Crown Complete?	L / R	Hight	width	A Cusp	M Cusp	P Cusp	Type	Severity	MWS	Sex
1	m1	E	Y	L	6.22	10.33	--	--	--	--		21	male
2	m1	G	Y	L	4.44	10.69	--	--	--	--		29	female
3	m1	E	Y	L	6.68	9.49	5.34	--	--	depression		19	male
4	m1	D	Y	L	6.29	9.07	--	--	--	--		17	female
5	m1	D	Y	L	6.36	10.19	--	--	--	--		17	female
6	m1	E	Y	L	6.45	10.44	--	--	--	--		25	male
7	m1	G	Y	L	5.44	10.13	--	--	--	--		27	male
8	m1	C	Y	L	6.51	9.96	--	--	4.44	line	1	16	female
9	m1	N	Y	L	3.45	10.11	--	--	--	--		50	female
10	m1	C	Y	L	6.84	9.67	4.36	--	--	line	1	14	male
11	m1	D	Y	L	6.33	10.26	--	--	--	--		18	male
12	m1	F	Y	L	4.99	9.58	--	--	--	--		27	female
13	m1	E	Y	L	6.86	10.49	--	--	--	--		19	male
14	m1	B	Y	L	6.5	10.25	--	--	--	--		12	male
15	m1	E	Y	L	6.08	11.12	--	--	--	--		20	male
16	m1	C	Y	L	6.25	10.39	--	--	--	--		17	male
17	m1	H	Y	L	3.44	8.88	--	--	--	--		30	female
18	m1	K	Y	L	5.28	11.74	--	--	--	--		33	female
19	m1	K	Y	L	3.14	10.18	--	--	--	--		35	female
1	m2	C	Y	L	7.52	13.04	5.18	--	5.27	line	1		
2	m2	E	Y	L	6.37	12.93	3.52	--	3.1	line	1		
3	m2	B	Y	L	9.77	12.25	6.32	--	5.43	line	1		
							2.31	--	1.84	line	1		
4	m2	A	Y	L	11.43	11.63	2.33	--	2.11	depression			
5	m2	A	Y	L	10.38	13.27	4.42	--	5.09	line	1		
6	m2	D	Y	L	7.96	13.55	8.26	--	5.74	line	1		
7	m2	D	Y	L	7.31	13.27	4.51	--	3.81	line	1		
8	m2	A	Y	L	9.16	12.62	7.4	--	5.96	line			
							5.35	--	--	line	2		
9	m2	J	Y	L	6.3	12.73	--	--	--	--			
10	m2	U	Y	L	13.63	11.14	--	--	--	--			
11	m2	B	Y	L	10.66	13.51	--	--	--	--			
12	m2	D	Y	L	7.91	12.31	3.32	--	2.72	depression			
13	m2	B	Y	L	8.48	12.74	2.52	--	2.06	line	1		
14	m2	A	Y	L	9.01	12.53	2.13	--	1.65	depression			
15	m2	B	Y	L	9.79	13.42	5.8	--	5.75	line	1		
							4.05	--	4.25	line	1		
16	m2	B	Y	L	8.31	12.85	3.59	--	3.01	depression			
17	m2	E	Y	L	6.21	11.89	--	--	--	--			
18	m2	E	Y	L	7.51	14.67	4.13	--	3.93	line	2		
							3.18	--	2.36	line	2		
19	m2	F	Y	L	5.14	13.1	3.51	--	2.11	line	1		

No	Element	Age group	Crown Complete?	L / R	Hight	width	A Cusp	M Cusp	P Cusp	Type	Severity
1	m3	E (3)	Y	L	15.4	12.85	3.28	3.06	--	depression	
2	m3	B	Y	L	9.63	13.89	6.85	6.36	--	line	1
							3.81	3.63	--	line	2
3	m3	V	Y	L	13.54	14.17	4.97	3.48	--	depression	
4	m3	V	Y	L	12.36	11.31	--	--	--	--	
5	m3	V	Y	L	14.43	14.91	4.59	4.49	--	depression	
6	m3	U	Y	L	13.92	14.05	3.06	4.86	--	line	2
7	m3	A	Y	L	16.12	14.81	9.94	12.54	--	line	1
							5.75	5.53	--	line	2
8	m3	V	developing	L	12.61	12.44	--	--	--	--	
9	m3	D	Y	L	4.85	14.66	4.43	4.38	--	line	2
							3.68	2.5	--	line	2
10	m3	C (1)	developing	L	--	--	--	--	--	--	
11	m3	V	Y	L	16.76	14.78	5.53	4.54	--	depression	
12	m3	B	Y	L	10.23	12.87	4.54	5.07	--	line	2
							3.13	2.11	--	depression	
13	m3	C (1)	Y	L	14.64	14.54	9.12	9.34	--	line	2
14	m3	C (1)	developing	L	--	--	--	--	--	--	
15	m3	E (3)	Y	L	16.03	15.33	5.94	6.56	--	line	2
							4.42	5.15	--	line	2
16	m3	V	Y	L	14.78	14.54	5.13	6.43	--	line	1
17	m3	B	Y	L	12.7	12.43	3.88	3.04		line	1
18	m3	C	Y	L	9.71	15.19	5.99	7.04	--	line	1
							4.22	3.18	--	line	1
19	m3	D	Y	L	7.75	13.94	3.14	2.32	--	line	1

Appendix 3: Caprine Raw Data

Elephantine (Old Kingdom):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
37901 G/d	m1	D	Y	L	7.48	6.5	8	--	--	--		
37901 M/a	m1	E	Y	L	14.51	7.59	8	4.5	--	5.75	line	2
37901 M/u	m1	D	Y	L	23.38	7.12	6	--	--	--		
37901 M/q	m1	G	Y	R	4.87	8.11	14	--	--	--		
36901 U/g	m1	I	Y	R	1.22	6.69	14	--	--	--		
36702 D/m	m1	G	Y	L	8.4	8.18	15	2.67	--	4.7	depression	
36902 G/p	m1	B	Y	R	26.57	7.6	1	--	--	--		
35702 B/c	m1	E	Y	R	11.96	8.55	8	--	--	--		
37901 N/w	m1	E	Y	R	24.08	7.61	8	10.91	--	13.01	depression	
37901 K/l	m1	D	Y	L	23.69	7.77	7	9.43	--	10.76	depression	
								3.54	--	4.07	line	2
379	m1	F	Y	R	13.25	7.58	9	9.47	--	8.45	depression	
379	m1	E	Y	L	21.22	7.88	8	--	--	--		
37901 S/l	m1	H	Y	R	6.99	7.22	14	--	--	--		
37901 M/s	m1	E	Y	L	21.68	7.73	8	10.83	--	11.86	depression	
37901 M/s	m1	8	N	R	21.59	7.12	8	5.21	--	--	depression	
37901 M/a	m1	E	Y	L	14.8	7.88	8	5.31	--	5.71	depression	
37901 M/b	m1	E	Y	R	17.99	8.36	8	3.63	--	4.13	line	2
37901 G/d	m2	D	Y	L	25.45	7.17	6	11.36	--	8.85	line	1
37901 A/g	m2	D	Y	L	26.81	8.9	6	7.51	--	8.82	line	1
37901 M/a	m2	E	Y	L	26.92	8.2	7	9.38	--	9.15	depression	
								7.42	--	7.33	line	2
37901 M/u	m2	D	Y	L	33.51	8.63	1	--	--	--		
37901 M/q	m2	G	Y	R	11.53	8.86	8	4.44	--	5.66	line	2
36901 E/2	m2	E	Y	L	29.01	9.15	7	--	--	--		
36901 U/g	m2	I	Y	R	3.71	8.24	14	--	--	--		
36702 D/m	m2	G	Y	L	--	--	8	--	--	--		
35702 B/c	m2	E	Y	R	25.7	8.99	8	6.58	--	7.04	depression	
37901 N/w	m2	E	Y	R	31.82	7.77	5	--	--	--		
37901 N/w	m2	2	Y	R	30.33	8.05	2	8.36	--	8.64	depression	
379	m2	F	Y	R	24.76	8.28	8	8.25	--	8.53	line	2
								6.79	--	7.12	line	2
								5.61	--	5.43	line	2
379	m2	E	Y	L	34.38	8.76	7	8.23	--	7.71	depression	
37901 M/s	m2	E	Y	L	34.02	8.49	6	15.47	--	15.39	depression	
								8.57	--	8.28	depression	
37901 M/a	m2	E	Y	L	27.2	9.12	7	8.17	--	11.04	line	2
								6.39	--	8.46	depression	
								5.79	--	5.88	line	2
37901 M/b	m2	E	Y	R	29.8	8.75	7	11.52	--	13.5	depression	
37901 M/a	m3	E	Y	L	31.59	7.7	3	9.43	9.45	9.04	pit	
								3.83	3.98	--	pit	
36901 E/2	m3	E	Y	L	39.23	8.83	4	--	--	--		
36901 U/g	m3	I	Y	R	10.94	8.43	11	--	--	--		
35702 B/c	m3	E	Y	R	35.86	8.64	8	9.02	10.33	--	depression	
37901 N/w	m3	E	Y	R	30.64	7.51	2	--	--	--		
379	m3	F	Y	R	29.92	8.52	9	14.04	13.36	13.42	depression	
								10.27	9.53	8.86	depression	
								7.22	6.91	6.38	line	2
37901 M/a	m3	E	Y	L	29.58	8.74	4	9.4	8.95	9.25	line	1
								5.28	3.99	--	depression	
37901 M/b	m3	E	Y	R	33.4	8.22	2	--	--	--		

Abydos Middle Cemetery:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
37901 G/d	m1	D	Y	L	7.48	6.5	8	--	--	--		
37901 M/a	m1	E	Y	L	14.51	7.59	8	4.5	--	5.75	line	2
37901 M/u	m1	D	Y	L	23.38	7.12	6	--	--	--		
37901 M/q	m1	G	Y	R	4.87	8.11	14	--	--	--		
36901 U/g	m1	I	Y	R	1.22	6.69	14	--	--	--		
36702 D/m	m1	G	Y	L	8.4	8.18	15	2.67	--	4.7	depression	
36902 G/p	m1	B	Y	R	26.57	7.6	1	--	--	--		
35702 B/c	m1	E	Y	R	11.96	8.55	8	--	--	--		
37901 N/w	m1	E	Y	R	24.08	7.61	8	10.91	--	13.01	depression	
37901 K/l	m1	D	Y	L	23.69	7.77	7	9.43	--	10.76	depression	
								3.54	--	4.07	line	2
379	m1	F	Y	R	13.25	7.58	9	9.47	--	8.45	depression	
379	m1	E	Y	L	21.22	7.88	8	--	--	--		
37901 S/l	m1	H	Y	R	6.99	7.22	14	--	--	--		
37901 M/s	m1	E	Y	L	21.68	7.73	8	10.83	--	11.86	depression	
37901 M/s	m1	8	N	R	21.59	7.12	8	5.21	--	--	depression	
37901 M/a	m1	E	Y	L	14.8	7.88	8	5.31	--	5.71	depression	
37901 M/b	m1	E	Y	R	17.99	8.36	8	3.63	--	4.13	line	2
37901 G/d	m2	D	Y	L	25.45	7.17	6	11.36	--	8.85	line	1
37901 A/g	m2	D	Y	L	26.81	8.9	6	7.51	--	8.82	line	1
37901 M/a	m2	E	Y	L	26.92	8.2	7	9.38	--	9.15	depression	
								7.42	--	7.33	line	2
37901 M/u	m2	D	Y	L	33.51	8.63	1	--	--	--		
37901 M/q	m2	G	Y	R	11.53	8.86	8	4.44	--	5.66	line	2
36901 E/2	m2	E	Y	L	29.01	9.15	7	--	--	--		
36901 U/g	m2	I	Y	R	3.71	8.24	14	--	--	--		
36702 D/m	m2	G	Y	L	--	--	8	--	--	--		
35702 B/c	m2	E	Y	R	25.7	8.99	8	6.58	--	7.04	depression	
37901 N/w	m2	E	Y	R	31.82	7.77	5	--	--	--		
37901 N/w	m2	2	Y	R	30.33	8.05	2	8.36	--	8.64	depression	
379	m2	F	Y	R	24.76	8.28	8	8.25	--	8.53	line	2
								6.79	--	7.12	line	2
								5.61	--	5.43	line	2
379	m2	E	Y	L	34.38	8.76	7	8.23	--	7.71	depression	
37901 M/s	m2	E	Y	L	34.02	8.49	6	15.47	--	15.39	depression	
								8.57	--	8.28	depression	
37901 M/a	m2	E	Y	L	27.2	9.12	7	8.17	--	11.04	line	2
								6.39	--	8.46	depression	
								5.79	--	5.88	line	2
37901 M/b	m2	E	Y	R	29.8	8.75	7	11.52	--	13.5	depression	
37901 M/a	m3	E	Y	L	31.59	7.7	3	9.43	9.45	9.04	pit	
								3.83	3.98	--	pit	
36901 E/2	m3	E	Y	L	39.23	8.83	4	--	--	--		
36901 U/g	m3	I	Y	R	10.94	8.43	11	--	--	--		
35702 B/c	m3	E	Y	R	35.86	8.64	8	9.02	10.33	--	depression	
37901 N/w	m3	E	Y	R	30.64	7.51	2	--	--	--		
379	m3	F	Y	R	29.92	8.52	9	14.04	13.36	13.42	depression	
								10.27	9.53	8.86	depression	
								7.22	6.91	6.38	line	2
37901 M/a	m3	E	Y	L	29.58	8.74	4	9.4	8.95	9.25	line	1
								5.28	3.99	--	depression	
37901 M/b	m3	E	Y	R	33.4	8.22	2	--	--	--		

Giza:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
BB.6U23.4	m1	F	Y	L	14.87	8.62	11	--	--	--		
BB.6U24-25	m1	E	Y	R	20.75	7.57	8	6.75	--	--	depression	
BB.6U26	m1	G	Y	R	12.53	7.89	10	--	--	--		
BB.6U24-25	m1	D	Y	L	26.04	7.41	7	--	--	--		
BB.6U24-26	m1	F	Y	R	15.46	8.51	8	9.81	--	9.66	line	1
BB.6U/U23	m1	H	Y	L	10.15	7.16	14	--	--	--		
BB.6U/U23	m1	C	N	L	28.4	8.51	2	--	--	--		
BB.GT25	m1	E	Y	L	15.78	8.37	8	--	--	6.33	depression	
BB.6U26+V26	m1	F	Y	R	16.23	7.47	10	12.23	--	12.12	depression	
BB.6U/V23	m1	E	Y	L	17.25	8.25	8	9.24	--	9.59	depression	
BB.GT23-24	m1	G	Y	L	11.32	8.19	11	--	--	--		
BB.GT24	m1	E	Y	R	16.82	7.55	8	12.98	--	14.76	line	2
								6.48	--	5.31	line	2
BB.GT28	m1	H	Y	L	4.82	7.03	14	--	--	--		
3025	m1	F	Y	R	21.07	6.78	8	8.93	--	7.04	line	2
BB.GT22	m1	D	Y	L	33.17	8.47	4	--	--	--		
BB22	m1	D	Y	R	25.94	8.28	7	18.11	--	20.75	depression	2
BB.GT21	m1	D	Y	L	24.48	7.16	8	9.54	--	12.82	line	1
BB.GU-V24-25	m1	D	Y	L	21.78	6.39	8	9.32	--	9.31	line	1
BBE.G529	m1	H	Y	L	9.02	7.45	14	--	--	--		
MSE.4.28	m1	E	Y	R	21.74	7.92	8	7.03	--	7.33	depression	2
MSE.4K28	m1	D	Y	L	24.89	7.02	7	7.63	--	--	line	1
MSE.4.28	m1	E	Y	R	24.89	7.99	8	7.47	--	7.73	line	1
								4.54	--	5.21	line	1
MSE.4I28	m1	F	Y	L	18.49	7.71	8	--	--	--		
MSE.4I28	m1	F	Y	R	23.51	7.97	8	10.99	--	12.87	depression	2
MSE.4I28	m1	D	Y	L	32.2	7.84	5	16.05	--	14.9	line	2
MSE.4I28	m1	D	Y	L	21.1	8.75	8	8.04	--	7.01	depression	1
MSE.4I28	m1	F	Y	L	27.28	8.03	8	12.28	--	--	depression	1
MSE.4L28	m1	E	Y	R	15.24	8.83	8	8.48	--	7.96	depression	1
MSE.4H28	m1	F	Y	R	25.57	7.33	8	--	--	--		
MSE.4H28	m1	F	Y	R	21.72	9.04	8	9.02	--	8.68	depression	2
MSE.4H28	m1	G	Y	L	12.45	7.84	11	--	--	--		
MSE.4H28	m1	E	Y	L	25.98	6.69	7	5.09	--	6.12	depression	1
MSE.4H28	m1	G	Y	L	14.47	8.33	9	--	--	--		
MSE.4H28	m1	F	Y	L	19.17	7.42	8	6.16	--	5.42	depression	1
MSE.4H28	m1	E	Y	R	21.31	8.48	7	--	--	--		
MSE.4H28	m1	E	Y	R	24.43	8.26	7	--	--	--		
MSE.4H28	m1	D	Y	L	19.61	8.07	8	--	--	--		
MSE.4H28	m1	G	Y	L	10.47	7.76	11	--	--	--		
MSE.4H28	m1	D	Y	R	17.21	8.82	8	--	--	--		
MSE.4L28	m1	F	Y	R	21.41	8.39	8	--	--	--		
MSE.4H28	m1	E	Y	R	20.2	7.59	8	10.77	--	11.85	depression	1
MSE.4H28	m1	D	Y	R	16.42	8.13	8	--	--	--		
MSE.4H28	m1	F	Y	L	20.3	8.84	8	9.03	--	10.67	depression	1
MSE.4H28	m1	D	Y	R	17.8	7.52	8	--	--	6.86	depression	1
MSE.4H28	m1	F	Y	R	24.11	8.62	8	--	--	--		
MSE.4H28	m1	E	Y	L	23.11	8.18	8	7.61	--	8.28	line	1
MSE.4H28	m1	F	Y	L	23.08	7.93	8	11.45	--	9.96	depression	1

Giza (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
MSE.4H28	m1	E	Y	R	27.12	8.29	8	14.5	--	16.01	depression	1
MSE.4H28	m1	E	Y	R	21.01	8.49	8	9.44	--	8.92	depression	1
MSE.4H28	m1	F	Y	L	26.11	8.7	8	--	--	--		
MSE.4H28	m1	E	Y	L	22.87	8.46	8	--	--	--		
MSE.4H28	m1	D	Y	L	19.94	8.97	8	--	--	--		
MSE.4H28	m1	F	Y	L	25.3	9.63	8	--	--	--		
MSE.4H28	m1	F	Y	L	19.13	9.05	8	--	--	--		
BB.6U23.4	m2	F	Y	L	28.25	9.53	8	13.23	--	14.14	depression	
BB.6U26	m2	G	Y	R	24.18	9.16	8	15.2	--	19.1	line	2
BB.6U26	m2	F	Y	L	29.67	8.61	8	11.59	--	13.25	line	2
								6.2	--	6.46	depression	
BB.6U24.6V24	m2	F	Y	L	28.03	7.33	8	9.45	--	8.25	line	1
BB.6U24.6V24	m2	D	N	L	--	--	2	--	--	--		
BB.6U24-26	m2	F	Y	R	25.14	9.01	8	15.09	--	15.08	line	1
BB.6U/U23	m2	H	Y	L	16.69	8.24	8	--	--	10.75	pit	
BB.GT25	m2	E	Y	L	33.55	8.7	8	22.29	--	22.78	depression	
								15.11	--	16.09	line	2
BB.6U/V23	m2	E	Y	L	35.15	8.76	4	--	--	--		
BB.6U/V23	m2	E	Y	R	36.64	8.09	4	--	--	--		
BB.6U/V23	m2	I	Y	R	12.68	8.23	13	7.64	--	9.45	depression	
BB.6S22	m2	E	Y	L	33.93	7.75	4	19.97	--	--	depression	
BB.GT23-24	m2	G	Y	L	24.61	8.61	8	10.8	--	10.44	depression	
BB.GT28	m2	H	Y	L	10.08	9.66	14	2.37	--	1.78	line	2
BB.GT24	m2	F	Y	R	17.83	7.69	8	15.62	--	--	depression	
								12.72	--	13.84	line	2
3025	m2	F	Y	R	33.33	9.11	8	6.8	--	7.45	line	2
BB.GT21	m2	D	Y	L	31.71	9.5	4	12.15	--	12.35	line	1
BB.GU.V23	m2	F	Y	L	32.79	9.56	8	--	--	11.14	depression	1
BBE.G529	m2	H	Y	L	14.48	8.17	11	2.82	--	3.23	line	1
MSE.AJ28	m2	D	Y	R	36.48	7.7	5	16.84	--	15.35	depression	1
								10.6	--	9.46	depression	1
MSE.4.28	m2	F	Y	L	31.05	8.48	8	13.92	--	14.05	line	2
								6.26	--	6.74	line	2
MSE.4M28	m2	D	Y	L	36.05	8.45	2	--	--	--		
MSE.4M28	m2	G	Y	L	35.51	8.68	8	11.72	--	--	line	2
MSE.4.28	m2	F	Y	R	32.9	8.61	7	10.16	--	10.52	line	1
MSE.4.28	m2	E	Y	R	34.54	8.6	6	7.16	--	7.02	line	1
MSE.4R28	m2	G	Y	L	16.69	7.61	8	4.8	--	5.31	line	1
MSE.4K28	m2	E	Y	L	35.01	8.11	5	--	--	--		
MSE.4I28	m2	F	Y	L	29.16	9.1	6	15.29	--	16.21	depression	1
								3.77	--	3.72	line	2
MSE.4I28	m2	F	Y	R	34.53	8.68	6	17.81	--	15.8	line	1
								12.65	--	9.96	depression	2
MSE.4I28	m2	E	N	L	29.3	7.23	6	9.3	--	8.91	depression	1
MSE.4I28	m2	D	Y	L	32.17	8.06	2	11.92	--	10.78	depression	1
MSE.4I28	m2	F	Y	R	33.2	8.67	7	--	--	--		
MSE.4I28	m2	F	Y	L	29.9	9.15	7	--	--	--		
MSE.4I28	m2	G	Y	L	30.03	8.77	8	13.72	--	15.79	depression	1

Giza (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
MSE.4I28	m2	E	Y	R	35.25	9.18	5	--	--	--		
MSE.4I28	m2	E	Y	L	31.32	8.13	6	13.55	--	14.72	depression	1
MSE.4I28	m2	E	Y	R	34.15	9.03	5	--	--	--		
MSE.4H28	m2	F	Y	R	34.84	8.93	7	14.41	--	17.36	depression	2
								6.86	--	6.59	depression	2
MSE.4H28	m2	G	Y	R	28.15	8.06	8	--	--	--		
MSE.4H28	m2	G	Y	R	30.71	8.14	8	--	--	--		
MSE.4H28	m2	E	Y	R	20.66	8.08	9	--	--	--		
MSE.4H28	m2	F	Y	R	26.97	8.75	7	8.88	--	9.41	depression	2
MSE.4H28	m2	E	Y	R	28.92	8.56	2	--	--	--		
MSE.4H28	m2	G	Y	L	23.31	9.24	8	--	--	--		
MSE.4H28	m2	D	Y	R	31.96	8.83	2	--	--	--		
MSE.4H28	m2	D	Y	R	32.42	9.98	2	17.28	--	16.47	depression	1
MSE.4H28	m2	G	Y	L	26.04	8.49	8	10.15	--	8.54	depression	1
MSE.4H28	m2	E	Y	L	29.4	8.29	6	10.34	--	10.96	depression	1
MSE.4L28	m2	F	Y	L	27.89	8.18	7	14.63	--	13.03	depression	2
								7.35	--	6.3	depression	2
MSE.4L28	m2	G	Y	L	27.22	8.68	8	10.13	--	7.09	depression	2
MSE.4H28	m2	G	Y	L	31.52	7.94	8	6.87	--	9.24	line	1
								4.24	--	7.06	line	2
MSE.4H28	m2	G	Y	L	25.26	8.69	8	9.39	--	10.68	depression	1
MSE.4H28	m2	E	Y	L	38.56	9.09	4	--	--	--		
MSE.4H28	m2	E	Y	L	35.82	8.56	6	10.44	--	10.03	depression	1
MSE.4H28	m2	D	Y	L	32.12	7.95	2	--	--	--		
MSE.4H28	m2	F	Y	L	27.41	7.69	7	8.61	--	10.05	depression	2
MSE.4H28	m2	D	Y	R	32.71	8.1	2	--	--	--		
MSE.4H28	m2	F	Y	L	32.39	8.82	7	9.6	--	10.58	depression	1
MSE.4H28	m2	E	Y	L	35.13	9.55	6	--	--	--		
MSE.4H28	m2	G	Y	R	27.3	9.11	8	12.06	--	10.48	depression	1
MSE.4H28	m2	E	Y	R	30.62	8.16	6	9.13	--	11.27	line	1
MSE.4H28	m2	F	Y	R	30.49	8.51	7	--	--	--		
MSE.4H28	m2	F	Y	R	31.06	8.39	7	13.42	--	14.42	depression	2
MSE.4H28	m2	E	Y	L	35.57	9.24	6	--	--	--		
MSE.4H28	m2	F	Y	R	31.05	8.43	7	9.1	--	10.53	line	1
MSE.4H28	m2	E	Y	L	33.91	9.25	6	9.18	--	9.55	line	1
MSE.4H28	m2	C	Y	R	25.9	8.37	1	--	--	--		
MSE.4H28	m2	E	Y	L	34.22	9.01	6	12.16	--	13.92	depression	1
MSE.4H28	m2	F	Y	R	32.99	8.77	7	--	--	--		
MSE.4H28	m2	G	Y	L	28.51	8.41	8	13.26	--	13.31	depression	2
								6.08	--	5.52	depression	1
MSE.4H28	m2	F	Y	R	29.63	8.68	7	--	--	--		
MSE.4H28	m2	E	Y	L	35.16	10.3	6	13.36	--	13.63	depression	2
MSE.4H28	m2	D	Y	L	33.78	8.91	2	--	--	--		
MSE.4H28	m2	F	Y	L	31.58	9.81	7	--	--	--		
MSE.4H28	m2	F	Y	R	32.01	8.86	7	14.67	--	15.05	depression	1
MSE.4H28	m2	G	Y	L	25.99	8.84	8	--	--	--		
BB.6U23.4	m3	F	Y	L	38.07	9.66	8	15.72	15.98	17.79	line	2
								7.18	7.51	7.97	depression	
BB.6U26	m3	G	Y	R	31.22	8.85	10	19.96	23.24	--	line	2
								11.13	14.85	--	line	2

Giza (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
BB.6U24-26	m3	F	Y	R	34.7	8.61	7	16.92	18.77	18.16	line	1
								15.2	15.66	16.34	line	1
BB.GT25	m3	E	Y	L	37.67	8.55	4	12.34	16.92	14.22	line	2
BB.GU25	m3	E	Y	L	35.63	8.88	4	--	--	--		
BB.6U/V23	m3	I	Y	R	18.03	8.38	11	--	--	--		
BB.GT23-24	m3	G	Y	L	33.74	8.44	10	--	--	--		
BB.GT28	m3	H	Y	L	23.75	9.5	10	12.93	16.26	17.02	line	2
BB.GT24	m3	F	Y	R	39.24	9.08	9	24.12	23.49	21.03	line	2
3025	m3	F	Y	R	38.96	9.74	8	7.91	7.08	6.76	line	2
BB.GU.V23	m3	F	N	L	48.59	9.22	5	10.04	--	--	line	1
BBE.G529	m3	H	Y	L	21.73	8.3	10	7.13	8.43	8.77	line	1
MSE.4.28	m3	E	N	L	28.62	9.15	2	--	--	--		
MSE.4.28	m3	E	N	L	38.18	9.91	3	--	13.83	12.38	line	2
MSE.4.28	m3	E	Y	L	38.22	9.16	2	20.29	20.44	--	line	1
MSE.4.28	m3	E	Y	R	33.44	9.01	2	--	--	--		
MSE.4.28	m3	E	Y	L	34.79	9.19	2	--	--	--		
MSE.4M28	m3	F	Y	L	42.81	9.27	8	17.7	16.85	13.97	line	2
								12.62	11.65	7.71	line	2
MSE.4R28	m3	G	Y	L	26.24	8.05	10	--	--	5.91	depression	3
MSE.4I28	m3	F	Y	L	36.55	8.73	7	12.03	13.23	--	depression	2
MSE.4I28	m3	E	Y	L	33.54	8.79	2	--	--	--		
MSE.4I28	m3	E	Y	R	34.77	9.56	2	--	--	--		
MSE.4H28	m3	E	Y	L	35.39	8.58	4	4.84	4.77	3.36	depression	2
MSE.4H28	m3	G	Y	R	29.79	8.81	10	12.52	15.55	15.94	depression	2
								7.85	9.53	11.25	depression	2
MSE.4H28	m3	G	Y	R	26.07	8.42	10	--	--	--		
MSE.4H28	m3	G	Y	R	24.21	8.93	10	12.08	12.86	11.88	depression	2
MSE.4H28	m3	I	Y	R	17.45	6.61	11	--	--	--		
MSE.4L28	m3	H	Y	R	26.67	7.92	10	6.8	9.06	10.4	depression	2
MSE.4L28	m3	E	Y	L	39.57	8.61	3	6.3	6.43	5.61	line	2
								5.06	4.91	--	line	2
MSE.4L28	m3	H	Y	R	27.81	8.65	10	8.76	11.81	11.76	depression	2
MSE.4L28	m3	I	Y	L	17.75	10.3	11	9.39	7.67	7.14	depression	1
MSE.4L28	m3	H	Y	L	20.85	8.74	10	--	--	--		
MSE.4L28	m3	F	Y	R	42.66	8.08	6	14.12	16.03	15.99	line	1
MSE.4L28	m3	F	Y	L	42.08	7.97	6	9.09	11.41	11.1	line	1
MSE.4H28	m3	H	Y	R	35.14	9.3	10	15.33	19.41	--	depression	4
MSE.4H28	m3	E	Y	R	33.22	8.77	2	--	--	--		
MSE.4H28	m3	H	Y	L	30.01	8.65	10	6.58	8.36	6.74	depression	1
MSE.4H28	m3	G	Y	L	23.49	8.23	10	7.88	9.36	9.98	depression	1
MSE.4H28	m3	G	Y	R	31.67	8.84	10	2.95	2.69	3.65	line	1
MSE.4H28	m3	E	Y	R	32.53	8.56	2	10.31	10.94	9.03	line	1
MSE.4H28	m3	E	Y	R	29.03	8.7	2	--	--	--		
MSE.4H28	m3	E	Y	R	36.11	8.84	4	8.87	7.74	6.52	line	1
MSE.4H28	m3	G	Y	R	24.23	8.57	10	--	--	--		
MSE.4H28	m3	G	Y	L	26.59	8.45	10	10.69	11.63	11.75	depression	1
MSE.4H28	m3	E	Y	L	32.73	9.76	2	--	--	--		
MSE.4H28	m3	E	Y	R	32.43	8.7	2	--	--	--		
Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
MSE.4H28	m3	E	Y	R	31.2	9.17	2	--	--	--		
MSE.4H28	m3	F	Y	L	28.98	8.78	9	5.15	6.93	8.62	depression	1
MSE.4H28	m3	F	Y	L	33.57	9.65	8	7.78	7.94	10.87	depression	1
MSE.4H28	m3	E	Y	L	31.07	8.68	2	--	--	--		
MSE.4H28	m3	H	Y	R	30.27	9.6	10	8.64	10.52	10.36	depression	1
MSE.4H28	m3	G	Y	L	32.24	10.1	10	9.11	8.9	10.26	depression	1
MSE.4H28	m3	F	Y	R	40.27	9.24	8	17.44	17.4	19.63	line	1
MSE.4H28	m3	E	Y	R	33.75	8.23	2	--	--	--		
MSE.4H28	m3	F	Y	L	34.99	8.78	8	8.52	7.88	9.22	depression	1
MSE.4H28	m3	G	Y	R	27.96	8.58	10	11.81	12.33	12.04	line	1
MSE.4H28	m3	G	Y	L	27.53	8.82	10	8.89	8.23	9.91	depression	1
MSE.4H28	m3	H	Y	L	28.77	8.11	10	13.37	10.76	12.21	depression	1

Kom el-Hisn:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
Rm19;Su2	m1	D	Y	L	--	--	10	--	--	--		
no label	m1	F	Y	R	--	--	8	--	--	--		
Rm17; Su2	m1	F	Y	R	24.56	7.36	7	8.17	--	7.8	depression	
Rm18; Su4	m1	G	Y	R	9.12	8.18	11	2.93	--	3.73	depression	
Rm19; Su2	m1	G	Y	R	15.2	7.77	10	--	--	--		
1220/1072; Su4	m1	G	Y	R	12.72	8.25	11	5.72	--	5.79	depression	
Rm19; Su2	m1	D	Y	L	20.65	7.63	8	7.61	--	9.25	depression	
1200S/1088E	m1	C	Y	L	32.96	8.52	2	--	--	--		
1192S/1035E; Su12	m1	G	Y	L	19.26	8.07	8	3.98	--	5.47	depression	
1159S/1040E; Su6	m1	C	Y	R	27.15	8.36	2	--	--	--		
1159S/1040E; Su6	m1	G	Y	R	13.49	7.85	11	5.63	--	8.05	line	2
1192S/1035E; Su7	m1	H	Y	R	6.44	8.69	14	--	--	--		
Rm23; Su3	m1	F	Y	R	15.44	7.26	8	--	--	--		
Rm19;Su2	m2	D	Y	L	--	--	8	--	--	--		
no label	m2	F	Y	R	--	--	8	--	--	--		
Rm18; Su4	m2	G	Y	R	19.03	8.19	8	9.71	--	10.04	line	2
								4.03	--	3.43	line	2
								1.69	--	2.13	line	1
Rm19; Su2	m2	G	Y	R	23.61	7.67	8	--	--	--		
Rm17; Su4	m2	F	Y	R	30.03	7.81	7	9.78	--	6.95	depression	
Rm19; Su2	m2	D	Y	L	32.34	8.4	5	--	--	--		
1192S/1035E; Su10	m2	H	Y	L	6.45	8.03	14	--	--	--		
1192S/1035E; Su12	m2	G	Y	L	36.48	9.42	8	13.82	--	15.28	depression	
								9.75	--	10.13	depression	
								4.75	--	4.71	line	2
1159S/1040E; Su6	m2	G	Y	R	25.72	8.27	8	10.22	--	11.36	line	2
								3.91	--	3.26	line	1
1192S/1035E; Su7	m2	H	Y	R	13.36	9.93	11	--	--	--		
Rm23; Su3	m2	F	Y	R	27.28	8.19	8	14.59	--	15.94	depression	
								6.63	--	7.77	depression	
								1.7	--	1.31	depression	
1984	m2	C	Y	L	36.74	9.03	4	13.55	--	14.2	depression	
Rm19;Su2	m3	D	Y	L	--	--	1	--	--	--		
no label	m3	F	Y	R	34.3	10.9	6	--	--	--		
Rm17; Su2	m3	G	Y	R	28.27	8.61	10	10.42	10.87	--	depression	
Rm19; Su2	m3	G	Y	R	--	--	10	--	--	--		
Rm19; Su1	m3	F	Y	R	31.1	8.9	8	15.19	--	--	depression	
Rm19; Su2	m3	D	Y	L	--	--	1	--	--	--		
1192S/1035E; Su10	m3	H	Y	L	16.66	8.29	10	3.15	2.73	3.53	line	2
ST2A; SU1	m3	G	Y	L	18.01	8.97	10	9.14	12.01	9.66	depression	
1204S/1060E; S12	m3	G	Y	R	25.01	8.94	10	11.85	12.02	11.98	depression	
								3.08	2.55	3.88	line	2
1192S/1035E; Su7	m3	H	Y	R	17.49	9.53	10	12.06	10.01	--	depression	
Rm23; Su3	m3	F	Y	R	35.48	9.45	5	4.76	5.23	4.15	depression	

Mendes:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
AJU.05.143bn115	m1	E	N	R	21.5	7.03	8	--	--	--		
AKA.96.8-5lot9	m1	I	Y	L	5.32	8.31	14	--	--	--		
AJU.05.143bn115	m1	E	Y	R	19.03	8.62	8	--	--	--		
AJU.05.143bn115	m1	E	Y	L	--	--	8	--	--	--		
AKN.03.Temple9	m1	E	Y	R	--	--	--	--	--	--		
AJU-126.05	m1	G	N	R	--	--	--	--	--	--		
ALG.93.41-1/2wallb	m2	E	N	L	--	8.87	7	--	--	--		
AJU.05.143bn115	m2	G	N	R	35.46	8.35	8	15.43	--	15.33	depression	
AJU.05.143bn115	m2	E	Y	R	31.57	9.52	7	11.86	--	11.71	depression	
AJU.05.143bn115	m2	E	N	L	32.37	9.44	7	--	--	--		
AKN.03.Temple9	m2	E	N	R	--	8.84	6	20.7	--	17	line	2
AJU-126.05	m2	G	N	R	27.86	8.8	8	--	--	--		
AKA.00	m3	G	Y	L	17.33	9.4	10	2.7	5.05	6.9	line	2
AKA.00	m3	G	N	L	22.82	10	10	--	--	--		
AJU.05.143bn115	m3	E	N	R	34.3	9.22	4	--	--	--		
AJU.05.143bn115	m3	E	N	L	34.96	9.17	4	--	--	--		
AKN.03.Temple9	m3	E	N	R	--	9.58	4	--	--	--		
AJU-126.05	m3	G	N	R	37.59	8.93	10	--	--	--		

Abydos Settlement Site:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
ASS 91/2/40/56	m1	H	Y	L	12.51	8.36	11	--	--	--		
ASS 91/2/40/56	m1	G	Y	R	22.22	7.98	8	6.7	--	10.42	depression	
ASS 91/9/9/3	m1	H	Y	R	9.8	9.73	10	8.83	--	5.15	depression	
ASS 91/2/40/37	m1	H	Y	R	9.14	8.04	13	--	--	--		
ASS 91/2/18/20	m1	G	Y	L	20.37	7.16	8	10.79	--	9.99	depression	
ASS 91/3/21/75	m1	H	Y	L	1.86	7.25	14	--	--	--		
ASS 91/10/3/8	m1	E	N	L	27.39	8.46	7	9.63	--	9.67	depression	
ASS 91/10/3/8	m1	E	N	R	23.52	7.26	7	11.06	--	--	depression	
ASS 91/6/11/27	m1	D	Y	L	23.18	7.28	8	11.06	--	10.26	depression	
ASS 91/14/6/7	m1	E	N	L	22.62	7.79	7	6.48	--	7.75	depression	
								3.27	--	3.67	line	2
ASS 91/14/6/7	m1	E	N	R	28.41	8.38	6	--	--	--		
ASS 91/9/20/41	m1	G	Y	R	16.1	7.58	8	--	--	5.7	depression	
ASS 91/8/15/15	m1	H	Y	R	4.35	8.12	14	--	--	3.27	depression	
ASS 91/11/2/3	m1	E	Y	L	15.6	7.91	8	9.17	--	9.99	depression	
ASS 91/2/18/20	m2	E	Y	L	28.4	7.62	6	4.77	--	7.04	depression	
ASS 91/3/21/75	m2	H	Y	L	13.34	7.62	9	4.03	--	6.7	depression	
ASS 91/6/11/27	m2	D	Y	L	34.09	7.63	5	13.85	--	15.29	depression	
								6.16	--	6.75	depression	
								3.27	--	3.56	line	2
ASS 91/14/6/7	m2	E	Y	L	34.08	7.76	7	8.56	--	8.26	depression	
ASS 91/9/13/7	m2	G	Y	R	25.33	8.61	8	11.45	--	12.46	depression	
ASS 91/9/28/50	m2	E	Y	R	28.16	8.71	7	15.62	--	17.74	depression	
								7.48	--	6.17	depression	
ASS 91/9/20/41	m2	G	Y	R	23.69	2.6	8	7.26	--	7.15	depression	
ASS 91/9/20/41	m2	D	Y	R	31.61	7.94	4	9.41	--	7.23	depression	
ASS 91/8/15/15	m2	H	Y	R	15.46	8.61	8	6.73	--	6.46	line	2
								4.15	--	3.73	line	2
ASS 91/8/15/15	m2	G	Y	R	26.11	8.48	8	--	--	2.91	depression	
ASS 91/11/2/3	m2	E	Y	L	25.36	8.33	9	12.37	--	11.76	line	1
								5.92	--	5.2	depression	
ASS 91/11/2/5	m2	E	Y	R	32.74	9.05	7	12.4	--	13.3	depression	
								6.19	--	4.95	depression	
ASS 91/4/2/38	m2	F	Y	L	20.85	7.84	8	10.81	--	11.12	depression	
ASS 91/4/28/51	m2	H	Y	L	15.03	8.54	10	6.99	--	8.64	depression	
ASS 91/9/9/3	m3	G	Y	R	27.17	8.89	10	13.87	14.26	17.49	depression	
								2.79	2.63	5.8	line	2
ASS 91/2/1/3	m3	G	Y	R	20.06	8.07	10	6.27	4.77	5.48	depression	
ASS 91/3/21/75	m3	H	Y	L	25.34	7.99	10	6.87	5.01	4.99	line	1
ASS 91/6/11/27	m3	D	Y	L	28.19	7.88	1	--	--	--		
ASS 91/9/20/41	m3	E	Y	L	38.13	7.84	4	6.38	7.39	--	depression	
ASS 91/9/20/41	m3	G	Y	R	31.39	8.57	10	5.28	4.12	5.21	depression	
ASS 91/9/20/41	m3	F	Y	R	26.86	7.68	9	5.15	6.63	7.93	depression	
ASS 91/8/19/18	m3	G	Y	R	25.93	8.22	10	5.22	4.73	2.48	depression	
ASS 91/11/2/3	m3	E	N	R	32.52	8.37	2	--	--	--		
ASS 91/11/2/3	m3	E	N	L	35.9	9.24	4	10.23	--	--	depression	
ASS 91/4/2/38	m3	F	Y	L	31.51	7.93	7	14.54	15.86	15.54	line	2
								10.3	11.85	11.69	depression	
								1.91	2.4	--	line	2
ASS 91/4/28/51	m3	H	Y	L	25.29	8.81	10	12.14	12.95	14.9	depression	

South Abydos:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
SASEE04/148/2/5	m1	F	N	L	18.05	8.19	8	6.92	--	7.86	line	1
SASEE04/150/3/1	m1	C	Y	R	27.62	7.64	2	3.7	--	2.6	line	1
SASEE04/147/3/1	m1	F	N	L	24.26	7.94	8	--	--	--		
SASEE04/147/9/4	m1	F	N	R	19.29	7.46	8	9.55	--	--	line	2
SASEE04/122/6/2	m1	G	Y	L	6.4	7.81	14	--	--	--		
SASEE04/139/22/1	m1	C	Y	R	25.31	8.15	6	11.86	--	14.67	depression	
								3.03	--	5.15	depression	
SASEE04/122/2/2	m1	F	N	L	24.82	8.1	8	11.43	--	--	depression	
SASEE04/150/14/4	m1	B	Y	L	24.04	6.69	1	--	--	--		
SASEE04/150/14/4	m1	F	Y	L	7.84	8.11	8	--	--	--		
SA99/77/9/2/	m1	G	Y	R	10.23	6.26	14	--	--	--		
SA01/101/1/4	m1	F	Y	L	25.82	7.54	8	--	--	8.35	line	1
SA01/81/12/3	m1	B	Y	R	25.28	7.88	1	--	--	--		
SA99/93/3/2	m1	F	N	R	16.13	6.85	8	--	--	--		
SA99/92/1/4	m1	G	Y	L	10.54	7.42	11	--	--	--		
SA99/95/2/3	m1	F	Y	L	17.4	7.82	8	--	--	--		
SA99/101/2/7	m1	F	Y	L	12.65	7.21	8	8.42	--	8.59	depression	
SA99/65/19/3	m1	C	Y	L	28.27	8.05	4	3.97	--	5.23	depression	
SA01/101/14/1	m1	D	Y	L	24.43	7.03	8	6.59	--	8.33	depression	
SA01/101/20/1	m1	H	Y	L	7.12	8.36	14	--	--	--		
SA01/101/14/1	m1	B	Y	L	25.45	7.37	2	2.42	--	2.49	depression	
SA01/102/12/10	m1	I	Y	L	0.59	6.33	14	--	--	--		
SA01/101/15/1	m1	D	Y	R	22.93	7.76	8	7.71	--	6.7	depression	
SA01/109/7/8	m1	G	Y	L	1.94	7.88	14	--	--	--		
SA99/64/4/2	m1	G	Y	R	1.95	7.83	14	--	--	--		
SA99/92/4/5	m1	G	Y	L	4.29	7.19	14	--	--	--		
SA01/106/10/11	m1	F	Y	R	14.93	7.57	9	4.82	--	4.61	depression	
SA01/106/10/11	m1	F	Y	L	22.11	7.87	8	10.98	--	11.3	line	1
								6.65	--	4.34	line	2
SA97/46/13/3	m1	F	Y	R	22.49	7.72	8	11.95	--	12.71	depression	
								6.23	--	8.5	line	2
SA99/92/3/2	m1	E	Y	R	16.66	7.89	8	8.61	--	9.77	depression	
SA01/101/7/4	m1	E	N	L	14.72	7.06	9	9.69	--	7.94	line	2
SA97/42/1/7	m1	F	Y	L	21.36	7.95	8	9.55	--	8.62	line	1
SASEE04/148/2/5	m2	E	N	R	22.39	6.71	7	9.18	--	--	depression	
								3.85	--	--	line	1
SASEE04/139/11/3	m2	G	N	L	19.4	7.74	8	8.49	--	8.71	depression	
								4.87	--	6.58	line	2
								--	--	1.59	line	1
SASEE04/123/2/1	m2	G	N	R	17.92	8.29	8	--	--	2.64	line	1
SASEE04/147/3/1	m2	G	N	L	24.27	7.79	8	14.21	--	--	depression	
SASEE04/134/20/1	m2	G	Y	R	10.01	7.97	8	2.7	--	3.4	line	1
SASEE04/122/6/2	m2	G	Y	L	15.53	8.95	8	6.31	--	6.39	depression	
SASEE04/139/11/6	m2	G	Y	L	27.07	8.28	8	15.28	--	15.37	depression	
SASEE04/139/22/1	m2	C	Y	R	25.11	7.83	1	--	--	--		
SASEE04/123/22/1	m2	G	Y	R	16.29	7.62	8	10.5	--	8.4	depression	
SASEE04/122/2/7	m2	G	Y	L	12.25	8.13	8	6.36	--	6.98	depression	
SASEE04/147/7/1	m2	G	Y	L	16.84	7.96	8	5.54	--	6.56	depression	
SASEE04/150/14/4	m2	D	Y	R	29.73	9.16	4	8.1	--	8.61	depression	
								3.74	--	4.18	line	2
								2.11	--	1.91	line	2

South Abydos (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
SASEE04	m2	F	Y	L	20.94	8.39	8	12.36	--	12.95	depression	
SA99/77/9/2/	m2	G	N	R	19.75	7.38	8	7.22	--	--	line	1
SA01/101/1/7	m2	E	Y	L	29.52	7.39	6	6.09	--	6.02	line	1
SA01/168/1/2	m2	E	Y	R	35.29	7.98	6	6.85	--	6.21	line	2
SA99/93/3/2	m2	F	Y	R	30.1	7.84	7	8.78	--	7.13	depression	
SA99/92/1/4	m2	G	Y	L	23.73	9.04	8	12.85	--	13.1	depression	
SA99/101/2/7	m2	F	Y	L	21.33	8.21	8	12.14	--	13.01	depression	
SA99/101/1/5	m2	G	N	R	25.85	8.79	8	--	--	--		
SA01/101/14/1	m2	D	Y	L	35.03	8.45	4	--	--	--		
SA01/101/20/1	m2	H	Y	L	10.34	8.89	10	--	--	--		
SA01/101/1/3	m2	B	Y	R	30.28	8.6	2	17.01	--	15.58	depression	
SA01/102/12/10	m2	I	Y	L	5.26	8.68	11	--	--	--		
SA01/109/7/8	m2	G	Y	L	13.22	9.53	9	--	--	--		
SA99/92/4/5	m2	G	Y	L	12.79	8.29	8	--	--	--		
SA01/106/10/11	m2	F	Y	R	27.18	8.54	8	14.21	--	14.02	depression	
SA01/106/10/11	m2	F	Y	L	29.68	7.78	7	13.4	--	--	depression	
SA99/92/3/2	m2	E	Y	R	30.44	8.25	6	18.58	--	18.57	line	1
								11.05	--	10.97	line	1
								7.77	--	6.87	line	1
SA01/101/7/4	m2	D	Y	R	38.14	8.29	4	7.94	--	8.83	line	1
SA01/101/1/3	m2	G	Y	L	27.43	6.88	8	8.85	--	8.93	line	2
								4.57	--	4.19	depression	
SA01/101/1/3	m2	G	Y	R	32.19	8.2	8	12.7	--	13.34	line	1
								9.5	--	8.81	line	2
								4.98	--	4.12	line	1
SASEE04/122/6/2	m3	G	Y	L	21.46	9.32	8	13.38	13.65	--	line	1
								8.42	6.94	8.57	depression	
SASEE04/123/22/1	m3	G	Y	R	25.12	8.5	10	10.37	12.94	--	depression	
SASEE04/122/2/7	m3	G	Y	L	18.13	8.14	10	9.6	10.52	11.48	depression	
SASEE04/147/7/1	m3	G	Y	L	27.08	7.77	8	10.02	11.19	11.48	depression	
SASEE04/150/14/4	m3	G	Y	R	25.16	8.44	10	16.37	15.52	15.53	depression	
								13.37	12.99	--	depression	
SASEE04/149/2/1	m3	G	N	R	32.32	8.98	10	8.69	8.49	5.87	depression	
SA99/77/9/2/	m3	G	Y	R	36.25	7.22	10	14.18	16.53	--	depression	
SA99/81/14/2	m3	G	Y	R	25.24	8.56	10	11.03	11.94	11.57	depression	
								2.91	3.49	3.74	depression	
SA01/97/24/6	m3	F	N	R	43.23	9.11	8	13.25	18.76	19.17	depression	
								--	5.55	3.26	line	2
SA97/42/8/1	m3	G	Y	L	18.52	9.44	10	3.99	4.01	5.69	line	1
SA97/42/8/1	m3	E	N	R	35.69	7.69	4	--	6.45	5.13	depression	
SA01/106/9/9	m3	F	N	R	31.13	8.37	6	15.2	15.48	16.42	depression	
								9.08	8.5	9.94	line	2
								2.03	2.7	3.82	line	2
SA01/97/13/11	m3	F	N	L	41.61	9.33	8	11.73	16.73	15.21	line	3
								7.46	10.85	8.96	depression	
SA99/92/1/4	m3	G	Y	L	31.03	8.63	10	14.9	17.99	17.66	depression	
								9.22	7.97	8.42	line	2

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
SA99/94/22/22	m3	F	N	R	30.92	7.87	6	11.08	11.18	10.77	depression	
SA99/98/13/2	m3	F	N	R	27.9	8.54	9	14.07	15.59	14.77	line	2
								6.95	7.55	6.95	line	2
								2.14	2.63	2.59	line	2
SA99/101/2/7	m3	F	Y	L	30.45	8.36	9	7.75	7.57	8.64	line	2
								2.5	3.26	3.43	line	2
SA01/102/12/10	m3	I	Y	L	13.92	8.05	11	4.11	5.12	6.78	depression	
								--	2.31	2.55	line	2
SA01/109/7/8	m3	G	Y	L	19.62	8.84	10	5.42	5.5	2.47	depression	
SA99/64/4/2	m3	G	Y	R	24.53	9.33	10	10.15	13.13	10.03	depression	
SA99/92/4/5	m3	G	Y	L	21.95	9.51	10	12.44	12.96	--	depression	
SA01/106/10/11	m3	F	Y	L	30.49	8.93	2	13.71	--	--	line	2
								9.79	--	--	line	2
								3.92	--	--	line	2
SA99/92/3/2	m3	E	Y	R	34.64	8.56	2	8.51	7.66	7.95	line	2
SA01/106/10/11	m3	G	N	L	30.86	8.34	10	11.67	14.2	15.52	line	2
								11.18	12.52	13.08	line	2
								3.28	2.95	2.25	line	2
SA01/108/10/1	m3	G	N	R	21.91	7.99	10	13.85	10.41	--	line	2
SA97/42/1/7	m3	E	Y	R	33.34	8.25	5	17.49	18.79	18.27	depression	
								11.47	11.7	12.04	line	2

Aswan (Middle Kingdom):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
6-25-16-2/1	m1	I	Y	R	2.77	6.41	14	--	--	--		
6-25-8-1/2	m1	E	Y	R	12.35	8.02	10	--	--	--		
6-25-17-25/1	m1	F	Y	L	19.88	8.46	8	7.96	--	7.99	depression	
6-25-16-2/1	m2	I	Y	R	5.09	7.49	14	--	--	--		
6-25-8-1/2	m2	E	Y	R	24.26	8.4	8	7.51	--	7.2	depression	
6-25-15-4/1	m2	G	Y	L	16.36	8.22	8	4.69	--	4.55	depression	
6-25-17-25/1	m2	F	Y	L	32.63	8.93	6	--	--	9.55	pit	
								6.43	--	6.56	depression	
6-25-16-2/1	m3	I	Y	R	10.35	8.43	13	--	--	--		
6-25-5-1/1	m3	G	Y	L	34.81	9.08	10	11.12	13.62	10.24	line	1
6-25-8-1/2	m3	E	Y	R	37.7	8.84	4	7.12	7.34	6.74	line	1
6-25-10-9/1	m3	F	Y	L	32.7	9.09	8	12.81	12.42	11.21	depression	

Amarna:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
TA.SV06#13 TR1(11461)	m1	C	Y	R	27.94	8.1	2	5.86	--	6.48	line	1
TA.MC05#12 TR7(11075)	m1	C	Y	L	26.75	7.77	4	7.97	--	6.58	depression	
TA.MC05#12 TR7(11075)	m1	C	Y	L	25.38	8.16	2	12.49	--	15.28	line	1
TA.MC05#12 TR8(11082)	m1	G	Y	L	18.84	7.86	8	--	--	--		
TA.MC05#12 TR6(11046)	m1	C	Y	L	28.3	8.08	8	10.08	--	10.39	depression	
TA.MC03#12(10105)	m1	C	Y	L	24.62	8.14	7	--	--	--		
TA.MC03#12(10037)	m1	D	Y	L	25.64	7.75	7	10.93	--	10.75	line	1
								5.78	--	4.56	shift	
TA.MC04#12(10672)	m1	B	Y	L	20.04	6.78	1	--	--	--		
TA.MC05#12(11087)	m1	H	Y	R	8.59	8.26	11	--	--	--		
TA.MC05#12(10954)	m1	C	Y	L	--	6.13	4	--	--	--		
TA.MC05#12(10820)	m1	D	N	L	--	--	D	--	--	--		
TA.MC05#12(10905)	m1	I	Y	R	5.5	7.7	14	2.34	--	2.55	line	2
TA.MC05#12(10818)	m1	H	Y	L	7.68	7.97	11	--	--	2.85	line	1
TA.MC05#12(10965)	m1	C	N	R	--	--	4	--	--	--		
TA.WV M12 30	m1	I	Y	L	1.01	7.59	14+	--	--	--		
TA.WV (6247)	m1	C	Y	L	24.92	7.2	7	11.88	--	12.64	depression	
TA.WV (1729A)	m1	F	Y	R	14.62	7.93	8	--	--	--		
TA.WV (6749)	m1	C	Y	R	25.35	6.64	4	11.66	--	13.68	depression	
TA.WV (1119)	m1	C	Y	L	22.67	7.88	7	--	--	--		
TA.WV (1652)	m1	D	Y	L	22.75	7.91	8	12.05	--	11.86	line	1
TA.WV (7214)	m1	C	Y	R	23.44	7.87	5	10.94	--	12.45	line	1
								5.76	--	5.39	line	1
TA.WV (16)	m1	C	Y	L	24.38	7.12	2	--	--	--		
TA.WV (5198)	m1	G	Y	L	4.02	8.28	14	--	--	--		
TA.WV (6682)	m1	C	Y	L	--	--	7	--	--	--		
TA.WV (233)	m1	H	Y	L	1.53	7.18	14	--	--	--		
TA.WV (1853)	m1	C	Y	L	--	--	2	--	--	--		
TA.WV (6836)	m1	C	Y	L	23.56	8.68	7	--	--	--		
TA.WV (7205)	m1	D	Y	R	--	--	8	--	--	--		
TA.WV (4601)	m1	B	Y	R	--	--	1	--	--	--		
TA.WV (5078)	m1	G	Y	R	1.33	8.34	12	--	--	--		
TA.WV (6657)	m1	D	Y	L	24.13	8.19	8	10.22	--	9.36	line	1
TA.WV (7234)	m1	C	Y	L	23.85	7.86	4	5.99	--	6.69	depression	
TA.WV (2234)	m1	B	Y	R	25.1	7.51	1	--	--	--		
TA.WV (3309)	m1	C	Y	L	26.77	7.22	7	7.31	--	7.46	line	2
TA.WV (7207)	m1	C	Y	L	25	7.75	4	2.66	--	2.29	line	2
TA.WV (1329)	m1	C	Y	R	26.57	7.95	4	4.72	--	4.59	depression	
TA.WV (1795)	m1	C	N	L	--	--	4	--	--	--		
TA.WV (1730)	m1	C	Y	L	24.65	7.59	7	7.32	--	6.93	depression	
TA.WV (1886)	m1	C	Y	R	--	--	7	--	--	--		
TA.WV (2142)	m1	D	Y	L	18.87	7.92	8	--	--	--		
TA.WV (2229)	m1	D	Y	R	19.67	7.55	8	10.41	--	10.26	line	1
TA.WV (2230)	m1	D	Y	R	14.01	7.82	8	2.23	--	2.73	line	1
TA.WV (6289)	m1	D	Y	L	16.07	6.93	8	6.39	--	6.4	line	1
TA.WV (2231)	m1	D	Y	R	6.42	7.91	8	12.95	--	14.56	depression	
								3.44	--	2.79	line	2
TA.WV (6897)	m1	C	Y	R	24.39	7.39	7	8.22	--	7.94	depression	
								3.76	--	3.9	line	2

Amarna (Continued):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
TA.WV (1820)	m1	C	Y	R	23.34	8.21	6	9.03	--	9.5	depression	
TA.WV (9469)	m1	C	Y	L	--	--	5	--	--	--		
TA.MC05#12 TR6(11046)	m2	C	Y	L	23.44	8.08	1	--	--	--		
TA.MC03#12(10037)	m2	D	Y	L	38.01	8.86	4	--	--	--		
TA.MC05#12(11087)	m2	H	Y	R	14.37	8.83	9	--	--	--		
TA.MC05#12(10820)	m2	D	N	L	--	--	4	--	--	--		
TA.MC05#12(10905)	m2	I	Y	R	8.05	7.97	14	--	--	--		
TA.MC05#12(10934)	m2	G	Y	R	20.35	8.55	8	4.44	--	5.54	depression	
TA.WV M12 30	m2	I	Y	L	4.25	8.69	14	--	--	--		
TA.MC87 #1 (2983)	m2	G	N	R	--	9.01	8	--	--	--		
TA.WV (1729A)	m2	F		R	28.57	8.61	7	15.92	--	17.67	line	2
								3.16	--	2.97	line	2
TA.WV (1119)	m2	C	N	L	--	--	1	--	--	--		
TA.WV (1652)	m2	D	Y	L	33.68	8.46	4	10.84	--	10.19	line	2
TA.WV (7214)	m2	C	Y	R	--	--	1	--	--	--		
TA.WV (5198)	m2	G	Y	L	12.19	9.26	8	--	--	--		
TA.WV (1328)	m2	E	Y	R	31.28	7.96	7	12.85	--	13.79	depression	
								6.59	--	5.94	depression	
TA.WV (6682)	m2	C	Y	L	--	--	1	--	--	--		
TA.WV (7205)	m2	D	Y	R	--	--	4	--	--	--		
TA.WV (5078)	m2	G	Y	R	--	--	8	--	--	--		
TA.WV (1730)	m2	C	Y	L	29.51	8.18	1	12.25	--	13.78	line	2
TA.WV (2182)	m2	F	Y	L	--	--	8	--	--	--		
TA.WV (2142)	m2	D	Y	L	29.69	8.76	6	12.3	--	13.37	line	1
								6.62	--	7.47	line	1
								5.07	--	5.87	line	1
TA.WV (131A)	m2	D	Y	L	29.16	8.01	6	7.5	--	7.96	depression	
TA.WV (2121B)	m2	D	Y	R	28.5	6.45	6	8.14	--	8.82	line	1
TA.WV (234)	m2	G	Y	L	22.92	8.82	8	15.73	--	16.74	depression	
								8.11	--	8.8	line	2
TA.WV (9469)	m2	D	Y	L	--	--	3	--	--	--		
TA.MC05#12 TR6(11028)	m3	G	N	L	14.84	8.61	9	--	--	--		
TA.MC05#12(11087)	m3	H	Y	R	17.77	8.63	10	--	--	--		
TA.MC05#12(10820)	m3	D	N	L	--	--	1	--	--	--		
TA.MC05#12(10905)	m3	I	Y	R	--	8.39	13	--	--	--		
TA.MC05#12(10934)	m3	G	Y	R	29.35	8.24	10	10.54	11.23	13.8	line	1
TA.WV M12 30	m3	I	Y	L	10.12	8.64	11	--	--	--		
TA.MC87 #1 (2983)	m3	G	Y	R	27.92	9.01	10	8.19	10.5	9.46	line	2
								1.47	3.46	4.41	line	2
TA.WV (1826)	m3	G	Y	R	20.97	7.36	10	7.35	7.44	7.39	depression	
								3.36	3.51	4.29	line	2
TA.WV (1729A)	m3	F	Y	R	35.93	8.4	8	18.9	16.65	17.47	depression	
TA.WV (5198)	m3	G	Y	L	--	9.24	10	--	--	--		
TA.WV (1328)	m3	E	Y	R	30.83	7.92	2	3.89	2.41	2.33	depression	
TA.WV (233)	m3	G	Y	L	--	--	10	--	--	--		
TA.WV (7205)	m3	D	Y	R	--	--	1	--	--	--		
TA.WV (5078)	m3	G	Y	R	--	--	10	--	--	--		
TA.WV (2182)	m3	F	Y	L	--	--	9	--	--	--		
TA.WV (6569)	m3	G	Y	L	29.07	8.53	10	14.95	12.89	12.74	line	2
								10.58	8.66	10.82	line	2
								4.33	2.45	2.64	line	2
TA.WV (2231)	m3	E	Y	R	32.97	8.05	6	18.23	18.57	16.83	line	1
								14.02	12.18	13.65	depression	
								5.99	7.86	6.15	depression	

Kom Firin:

Context	Square/Year	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
69	TAF2003	m1	E	Y	L	17.95	9.14	9	9.64	--	8.49	depression	
76	TH2003	m1	D	N	L	22.77	7.55	7	8.17	--	6.41	line	2
55	TH2003	m1	E	Y	L	26.9	8.51	8	8.37	--	8.32	depression	
55	TH2003	m1	E	Y	L	23.14	9.51	8	--	--	--		
35	TAE2003	m1	E	Y	R	16.85	8.54	8	12.34	--	13.55	line	1
35	TAE2003	m1	E	Y	L	26.17	8.03	8	11.12	--	12.6	depression	
									4.78	--	5.86	line	1
1100	CA2007	m1	E	Y	R	19.8	7.81	8	--	--	4.04	line	1
1047	CB2007	m1	C	Y	L	30.32	8.53	6	10.27	--	9.19	depression	
1049	CB2007	m1	E	Y	L	14.58	8.92	9	5.39	--	6.93	line	2
691	EE2007	m1	C	Y	R	29.74	8.51	4	5.11	--	4.58	depression	
889	EC2008	m1	D	Y	R	29.66	8.18	7	7.01	--	7.11	depression	
1637	CD2008	m1	E	Y	R	27.06	8.28	8	14.05	--	17.03	depression	
1634	CD2008	m1	E	Y	L	23.69	7.98	8	--	--	--		
69	TAF2003	m2	G	Y	L	31.05	9.7	8	21.41	--	22.11	line	2
									10.28	--	10.19	depression	
55	TH2003	m2	G	Y	L	38.84	10.1	8	8.86	--	10.46	line	1
									6.12	--	7.69	line	1
35	TAE2003	m2	F	Y	R	28.8	9.17	8	22.53	--	22.78	line	1
									15.5	--	17.52	depression	
									5.18	--	4.66	depression	
1100	CA2007	m2	F	Y	R	35.05	9.16	7	7.65	--	7.86	depression	
									--	--	3.5	line	1
1047	CB2007	m2	C	N	L	--	--	1	--	--	--		
1051	CA2007	m2	D	Y	L	34.68	9.29	6	17.3	--	15.8	depression	
563	EC2007	m2	D	N	R	34.78	8.71	4	4.84	--	--	line	2
901	EC2007	m2	D	Y	L	37.19	9.24	2	10.84	--	14.03	depression	
1637	CD2008	m2	D	Y	R	45.27	9.14	5	15.22	--	15.31	depression	
55	TH2003	m3	G	Y	L	34.38	9.4	10	11.07	11.36	9.22	depression	
35	TAE2003	m3	F	Y	R	36.66	9.19	8	8.72	9.54	6.21	depression	
1066	CB2007	m3	G	Y	R	24.2	8.51	10	9.05	8.13	9.92	line	1

Saïs:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
1000.1.3	m1	D	N	L	22.01	7.77	8	14.36	--	14.94	line	2
1000.1.3	m1	D	N	R	22.83	7.67	8	14.16	--	--	line	1
1000.2.1	m1	D	N	R	23.81	8.28	8	13.2	--	18.74	depression	
								20.52	--	21.9	line	1
1057	m1	D	N	L	21.18	7.56	8	--	--	--		
6004	m1	D	N	R	16.49	8.12	8	--	--	--		
5010	m1	C	Y	R	27.86	8.27	8	13.85	--	14.42	shift	
5010	m1	C	Y	L	29.55	8.02	8	11.21	--	12.59	shift	
1057	m1	D	N	L	21.18	7.56	8	18.77	--	20.37	line	2
								20.65	--	21.82	line	1
4001	m1	D	N	R	--	--	8	--	--	--		
1000.2.8	m1	E	N	R	27.04	7.23	9	14.5	--	13.27	depression	
1000.2.8	m1	E	N	L	21.8	7.3	9	12.09	--	14.19	line	2
								15	--	16.89	shift	
4001	m1	E	N	L	--	--	9	--	--	--		
1000.1.7	m2	E	N	L	44.08	9.38	6	32.06	--	31.71	line	3
								34.8	--	35.7	pit	
1000.1.3	m2	E	N	L	36.22	9.65	6	22.16	--	23.48	line	2
								25.27	--	26.81	line	2
1000.1.3	m2	E	N	R	35.54	8.44	6	21.54	--	20.75	depression	
								30.31	--	31.53	line	1
1000.2.1	m2	E	N	R	--	9.18	6	24.47	--	23.55	line	1
5010	m2	C	N	R	--	6.61	1	–	--	–		
5010	m2	C	N	L	28.96	9.57	1	--	--	--		
1057	m2	D	N	L	35.07	8.6	4	22.33	--	22.23	line	2
4001	m2	D	N	R	--	--	4	--	--	--		
1000.2.8	m2	E	N	R	37.16	8.28	7	22.58	--	22.04	line	1
1000.2.8	m2	E	N	L	35.55	8.7	7	22.53	--	22.08	depression	
4001	m2	E	N	L	--	--	7	--	--	--		
1000.1.5-	m3	D	N	L	--	9.45	1	--	--	8.39	line	2
1000.1.5-	m3	D	N	R	--	--	1	--	--	--		
1057	m3	D	N	L	--	7.96	1	--	--	--		
4001	m3	D	N	R	--	--	--	--	--	--		
1000.2.8	m3	E	N	R	--	--	4	23.28	23.57	20.37	line	2
1000.2.8	m3	E	N	L	--	10.3	4	10.69	10.93	--	depression	
								19.87	25.9	--	line	1
4001	m3	E	N	L	--	--	2	--	--	--		

Zawiyet Umm el-Rakham:

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
K/226(1999)K.2,7	m1	C	Y	R	23.38	8.36	N	--	--	--		
S7	m1	C	Y	R	26.62	8.18	Y	5.5	--	5.35	line	2
K/234(1999)Ko,4	m1	G	Y	R	10.71	7.68	Y	7.15	--	8.35	line	2
								--	--	2.52	depression	
K/218(1999)K.2,6	m1	G	Y	L	14.77	7.67	Y	8.41	--	9.25	depression	
K/299(1999)K.0,7	m1	G	Y	L	21.01	6.97	Y	6.02	--	--	line	1
K/226(1999)K.2,7	m2	C	N	R	--	8.6	--	--	--	--		
S7	m2	C	N	R	--	--	--	--	--	--		
K/234(1999)Ko,4	m2	G	Y	R	23.11	8.29	Y	5.23	--	4.36	line	2
K/218(1999)K.2,6	m2	G	Y	L	26.31	8.2	Y	12.25	--	10.42	shift	
K/299(1999)K.0,7	m2	G	Y	L	31.63	7.92	N	--	--	--		
K/234(1999)Ko,4	m3	G	Y	R	30.46	8.72	Y	15.07	15.9	17.5	depression	
K/218(1999)K.2,6	m3	G	Y	L	34.38	8.19	Y	11.95	11.28	11.15	depression	
								3.09	3.69	4.88	depression	
K/299(1999)K.0,7	m3	G	Y	L	--	7.69	N	--	--	--		

Aswan (Late Period):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
8-36-3-2/1	m1	D	Y	L	15.45	7.64	8	--	--	--		
6-15-36-3/1	m1	D	Y	R	28.05	8.61	8	9.91	--	7.04	depression	
6-15-284-14/1	m1	F	Y	R	17.75	8.95	8	--	--	--		
9-46-200-3/2	m1	H	Y	R	8.34	8.44	14	--	--	--		
8-36-6-2/2	m2	E	Y	L	41.81	9.05	6	12.25	--	7.36	depression	
8-36-3-2/1	m2	D	Y	L	40.79	9.73	4	--	--	--		
9-46-150-2/1	m2	G	N	L	--	8.73	8	--	--	--		
6-15-206-8/1	m2	D	Y	R	34.12	9.64	5	7.48	--	9.47	depression	
6-15-36-3/1	m2	D	Y	R	40.82	9.45	5	13.86	--	13.34	depression	
6-15-284-14/1	m2	F	Y	R	32.96	9.92	8	7.04	--	--	depression	
6-15-120-7/1	m2	E	Y	L	37.19	8.23	5	8.98	--	--	line	1
9-46-200-6/2	m2	D	Y	L	25.57	8.35	8	--	--	--		
9-46-200-3/2	m2	H	N	R	--	--	11	--	--	--		
9-46-150-2/1	m3	G	Y	L	35.39	8.76	10	7.44	9.99	3.79	depression	
6-15-360-1/3	m3	G	Y	R	32.71	9.38	10	15.94	19.95	15.03	depression	
6-15-36-3/1	m3	D	Y	R	27.91	8.3	1	--	--	--		
6-15-284-14/1	m3	F	Y	R	49.29	10.04	6	11.17	9.91	8.9	depression	
6-15-250-11/1	m3	G	Y	L	22.64	8.87	10	--	--	--		
6-15-210-2/2	m3	G	Y	L	34.13	9.39	10	--	--	--		

Aswan (Ptolemaic-Roman):

Context	Tooth	Age	Crown Complete?	L / R	Hight	Width	Wear	A Cusp	M Cusp	P Cusp	Type	Severity
9-46-140-8/1	m1	F	Y	R	24.32	9.01	8	10.68	--	11.55	depression	
9-46-141-2/2	m1	G	Y	L	15.33	9.43	9	--	--	--		
9-46-141-3/1	m1	G	Y	L	10.9	7.81	11	--	--	--		
9-46-141-7/2	m1	F	Y	L	22.48	7.72	8	14.94	--	12.81	line	1
9-46-112-8/1	m1	G	Y	R	15.04	7.78	11	--	--	--		
9-46-140-9/2	m1	G	Y	R	15.85	8.41	9	8.96	--	7.5	depression	
9-46-140-12/1	m1	I	Y	L	0.88	7.42	14	--	--	--		
9-46-140-11/1	m1	F	Y	L	25.13	8.8	8	--	--	--		
9-46-148-3/1	m1	H	Y	L	10.86	8.12	11	--	--	--		
6-15-116-3/3	m1	G	Y	R	9.45	8.22	14	--	--	--		
5-32-7-8	m1	D	Y	L	22.2	8.44	8	--	--	--		
5-13-153-4	m1	C	Y	R	25.86	7.56	4	--	--	--		
5-13-489-2	m1	E	Y	R	21.05	8.59	8	6.3	--	6.77	line	1
5-13-489-2	m1	F	Y	L	21.61	8.5	8	--	--	--		
2-1-23-7	m1	H	Y	L	3.56	8.17	14	--	--	--		
5-13-449-1	m1	D	Y	R	33.67	8.63	6	7.77	--	7.25	line	2
6-13-3-3	m1	E	Y	L	27.06	9.37	8	--	--	--		
6-13-3-1	m1	D	Y	L	29.46	7.74	7	4.12	--	8.05	line	1
6-13-3-2	m1	D	Y	R	25.03	8.51	8	--	--	--		
6-13-3-2	m1	F	Y	L	22.75	9.05	8	13.93	--	15.6	line	1
6-23-3-5	m1	I	Y	R	2.2	7.53	14	--	--	--		
9-46-140-8/1	m2	F	Y	R	36.01	10.54	8	18.46	--	19.46	depression	
9-46-141-3/1	m2	G	Y	L	26.59	8.95	8	11.15	--	14.81	depression	
9-46-141-7/2	m2	F	Y	L	37.21	8.75	7	12.94	--	14.5	depression	
9-46-112-8/1	m2	G	Y	R	31.81	9.05	8	15.08	--	14.5	depression	
9-46-140-9/2	m2	G	Y	R	33.5	9.26	8	13.14	--	15.78	depression	
								3.65	--	4.49	line	1
9-46-140-12/1	m2	I	Y	L	4.23	7.76	14	--	--	--		
9-46-140-15/1	m2	F	Y	R	39.61	8.59	6	14.25	--	14.9	depression	
6-15-116-3/3	m2	G	Y	R	22.17	9.17	8	6.84	--	8.25	line	2
								3.09	--	2.9	depression	
5-32-7-8	m2	D	Y	L	33.53	9.09	5	--	--	--		
5-32-7-8	m2	F	Y	R	30.39	7.95	8	5.45	--	4.87	line	1
5-13-489-2	m2	E	Y	R	33.25	9.74	8	6.25	--	6.2	line	2
5-13-509-2	m2	F	Y	L	28.95	9.09	8	15.07	--	14.08	line	1
								6.86	--	5.59	depression	
2-1-23-7	m2	H	Y	L	8.52	9.69	11	4.64	--	5.75	depression	
6-23-3-7	m2	D	Y	R	38.43	9.89	6	12.63	--	13.57	depression	
5-13-449-1	m2	D	Y	R	33.12	9.42	2	16.47	--	14.12	depression	
6-13-3-3	m2	E	Y	L	33.43	8.61	8	15.68	--	16.68	line	2
6-13-3-1	m2	D	N	L	31.05	--	2	--	--	--		
6-13-3-2	m2	D	Y	R	42.87	9.53	6	13.65	--	14.16	line	2
6-13-3-2	m2	F	N	L	40.19	8.63	6	--	--	4.74	depression	
6-23-3-5	m2	I	Y	R	8.88	8.76	11	--	--	--		
9-46-140-12/1	m3	I	Y	L	10.23	8.73	16	--	--	--		
9-46-140-11/1	m3	F	Y	L	42.44	10.35	6	13.09	17.53	--	depression	
9-46-140-11/1	m3	I	Y	L	6.11	6.76	16	--	--	--		
9-46-148-3/1	m3	H	Y	L	32.21	9.35	10	14.71	15.3	16.94	depression	
6-15-116-3/3	m3	G	Y	R	34.27	8.92	10	11.23	14.15	10.09	line	2
9-46-141-7/2	m3	F	Y	L	46.91	8.5	7	6.94	7.69	5.86	line	1
5-13-489-2	m3	E	Y	R	34.28	9.6	5	--	--	--		
5-13-509-2	m3	F	Y	L	38.59	8.72	6	13.48	12.34	9.43	depression	
2-1-23-7	m3	H	Y	L	26.51	9.73	10	--	--	--		
6-23-3-7	m3	D	Y	R	36.51	9.67	1	--	--	--		
6-13-3-3	m3	E	Y	L	45.71	9.37	4	--	--	--		
6-13-3-1	m3	G	N	L	30.7	9.3	10	9.69	13.98	15.83	depression	
								--	3.94	5.18	line	2
6-13-3-2	m3	D	N	R	--	--	1	--	--	--		
6-13-3-2	m3	F	N	L	37.2	9.08	9	--	--	--		

Cairo (Modern):

					M1			Hypoplasia			M2				Hypoplasia			M3				Hypoplasia			
No	Taxon	Age group	Complete?	L / R	Hight	Width	Wear Stage	A Cusp	P Cusp	type	Complete?	Hight	Width	Wear Stage	A Cusp 2	P Cusp2	type2	Complete?	Hight	Width	Wear Stage	A Cusp 3	M Cusp	P Cusp3	type3
1	OA	B	Y	L	34.23	7.33	1	--	--	--	developing														
2	OA	D	Y	L	32.14	7.17	7	15.07	13.75	depression	Y	41.74	8.71	2	--	--	--								
								6.13	5.59	depression															
3	OA	B	Y	L	35.75	8.13	1	--	--	--	developing														
4	OA	C	Y	L	37.48	8.55	2	10.69	11.61	depression	developing	--	7.06	1											
5	OA	C	Y	L	36.95	7.93	2	8.82	10.51	depression	developing	--	6.52	1											
6	CH	C	Y	L	37.41	7.92	2	10.16	10.41	depression	developing	--	6.36	1											
7	OA	C	Y	L	32.98	8.18	2	12.28	12.81	depression	developing	--	7.62	1											
8	OA	C	Y	L	30.47	8.19	2	6.94	7.56	depression	developing	--	6.65	1											
9	CH	D	Y	L	24.82	8.35	8	4.07	4.73	depression	Y	36.99	8.82	2	--	--	--								
10	CH	D	Y	L	25.22	8.4	8	5.33	5.25	depression	Y	36.05	8.91	4	10.08	9.78	line (1)	developing	--	6.26	1	--	--	--	--
11	OA	C	Y	L	36.56	8.21	3	7.63	9.74	depression	developing	--	8.43	1											
12	OA	C	Y	L	35.05	8.35	3	10.01	12.25	depression	developing	--	7.44	1											
13	OA	D	Y	L	23.75	7.63	8	13.29	15.08	line (2)	Y	41.85	9.41	3	7.36	8.62	line (2)	developing	--	7.71	1	--	--	--	--
								--	4.12	depression															
14	OA	C	Y	L	35.18	7.84	3	10.26	10.39	depression	developing	--	7.83	1											
15	OA	C	Y	L	32.02	7.42	7	7.4	4.94	depression	Y	44.42	8.61	1	11.6	7.5	depression	developing	--	--	--	--	--	--	--
16	OA	B	Y	L	33.72	7.67	1	--	--	--	developing	--	--	--	--	--	--								
17	OA	D	Y	L	30.13	7.52	7	7.02	6.68	depression	Y	42.35	8.67	2	10.76	9.7	depression	developing	--	--	--	--	--	--	--
18	CH	G	Y	L	5.46	7.49	15	--	--	--	Y	14.73	8.13	8	8.77	8.39	depression	Y	24.46	8.65	10	7.84	7.68	6.54	depression
19	OA	D	Y	L	32.66	8.1	7	7.86	9.6	line (2)															
								6.39	8.11	line (1)	Y	44.31	9.45	2	--	--	--	developing	--	--	--	--	--	--	--
20	OA	D	Y	L	30.73	8.26	7	7.99	8.07	depression	Y	44.59	9.43	2	--	--	--	developing	--	--	--	--	--	--	--
21	OA	G	Y	L	17.22	8.1	11	6.42	7.5	depression	Y	26.2	9.33	8	7.72	9.18	line (1)	Y	34.38	9.53	10	11.98	12.58	14.74	depression
																						--	4.15	4.67	depression
22	OA	I	Y	L	4.71	8.3	14	--	--	--	Y	11.33	9.77	14	--	--	--	Y	12.2	9.97	15	--	--	--	--
23	OA	H	Y	L	6.1	7.46	14	--	--	--	Y	12.08	8.99	14	--	--	--	Y	16.13	9.56	10	--	4.39	4.67	depression
24	OA	I	Y	L	3.84	7.06	14	--	--	--	Y	12.21	7.92	13	--	--	--	Y	14.25	8.22	11	--	--	--	--
25	OA	H	Y	L	8.17	8.3	14	--	--	--	Y	10.6	9.64	14	--	--	--	Y	17.05	9.64	10	9.33	9.83	12.62	line (3)
																						--	--	6.27	line (2)
26	OA	G	Y	L	6.45	8.04	14	--	--	--	Y	24.89	8.99	8	--	--	--	Y	31.91	9.22	10	--	--	--	--
27	OA	I	Y	L	7.18	7.8	14	--	--	--	Y	13.87	9.21	11	--	--	--	Y	--	--	--	--	--	--	--
28	OA	I	Y	L	2.59	7.86	14	--	--	--	Y	8.51	8.56	14	4.17	3.16	line (2)	Y	10.7	9.28	16	3.74	3.99	6.49	line (1)

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