

**Mighty Cattle: Zooarchaeological Analyses of *Bos* Husbandry
Practices in Late Bronze Age Kaymakçı, Western Anatolia**

by

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**Mighty Cattle: Zooarchaeological Analyses of *Bos* Husbandry
Practices in Late Bronze Age Kaymakçı, Western Anatolia**

Koç University

Graduate School of Social Sciences and Humanities

This is to certify that I have examined this copy of a master's thesis by

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I dedicate my thesis work to my family. A special feeling of gratitude to my loving parents, Nilgün and Hidayet Fındıklar, who have always loved me unconditionally and whose good examples have taught me to work hard for the things that I aspire to achieve. My brother, Şeref, who has always been there when I needed a personal cheerleader.

I also dedicate this thesis to two very special people. Nazlınur Koparipek, who is my best friend and sister over 10 years. Your loving and caring friendship has lifted me whenever I felt down. Ahmet Berk Özdemir, I was very lucky to have you in my life. I will always appreciate your love, friendship, companionship, and nicest heart.

ABSTRACT

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This study aims to understand Late Bronze Age (LBA) Anatolian animal management strategies, especially those of cattle, adopted by the people of Kaymakçı through a close study of subsistence patterns and symbolic importance. Of specific interest is how economic practices contributed to and sustained ongoing daily life, such as choices in diet, the management of livestock (e.g., meat, dairy, and traction), and in turn shaped perceptions of power and prestige. The results of this study establish a baseline for further research in western Anatolian LBA animal management systems and provide a comparison of proximate LBA cattle cultures. The dataset from Kaymakçı provides a compelling example of targeted provisioning practices. This analysis shows that animal economies characterize Kaymakçı as a western Anatolian community that adopted strategic behaviors towards animals, especially cattle, in accordance with its culture, environment, and sociopolitical interests.

Keywords: cattle cultures, symbology, zooarchaeology, livestock management, animal economies

ÖZETÇE

Kudretli Sığır: Batı Anadolu Geç Tunç Çağı Kaymakçı'da Sığır Yetiştiriciliği Uygulamalarının Zooarkeolojik Analizleri

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Bu araştırma, Kaymakçı halkının benimsediği hayvan yönetim stratejilerini, Kaymakçı'nın Geç Tunç Çağı (GTÇ) Anadolu'sunda nasıl konumlandığını ve sığırların önemini geçim ve semboloji açısından anlamayı amaçlamıştır. Özellikle, bu ekonomik uygulamaların, diyet seçimleri ve çiftlik hayvanlarının (et, süt ve güç) yönetimi gibi devam eden günlük yaşama nasıl katkıda bulunduğu, sürdürüldüğü ve buna bağlı olarak güç ve prestij algılarını nasıl şekillendirdiği araştırılmıştır. Bu çalışmanın sonuçları, Batı Anadolu GTÇ hayvan yönetim sistemlerinde daha detaylı araştırmalar için bir temel oluşturmakta ve Batı ve Orta Anadolu arasında GTÇ sığır kültürlerinin bir karşılaştırmasını sağlamaktadır. Kaymakçı, hayvancılık uygulamaları, kültürü, çevresi ve sosyopolitik çıkarları doğrultusunda hayvanlara, özellikle de sığırlara karşı stratejik davranış benimseyen yerel bir Batı Anadolu topluluğu olarak nitelendirilmektedir.

Anahtar Kelimeler: sığır kültürleri, semboloji, zooarkeoloji, hayvancılık yönetimi, hayvan ekonomileri

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ABBREVIATIONS

LBA	Late Bronze Age
MBA	Middle Bronze Age
EBA	Early Bronze Age
BA	Bronze Age
LSI	Logarithmic Size Index
MWS	Mandibular Wear Stage
NISP	Number of Identified Specimens
DZ	Diagnostic Zones
QNISP	Quick NISP
MAU	Minimum Anatomical Units
MNE	Minimum Number of Elements
MNI	Minimum Number of Individuals
KAP	Kaymakçı Archaeological Projects
UNF	Unfused
F	Fused
CLAS	Central Lydia Archaeological Survey
B.C.E.	Before Current Era
ha	Hectare area

Chapter 1:

INTRODUCTION

The Late Bronze Age (LBA) in western Anatolia (1650-1200 B.C.E)¹ has been increasingly studied and understood in recent decades. Most research has shed light on the Hittite and Mycenaean cultures. These two power spheres tend to be seen as the primary nodes from which scholars approach the study of western Anatolian urban centers. This research considers western Anatolia as a local culture with local practices in which have variety of influences from both Hittite and Mycenaean spheres. The main research foci that have been part of this research include ritual practices, urbanism in the hub of the centers and considerations of hierarchy, such as the rise of an elite class and the socioeconomic aspects of urban life. For the Hittite region, cuneiform texts have been a particularly valuable contribution. Here we look to iconographic implications, fortified settlements with monumental architecture, trade networks within and between Anatolia and the Aegean islands, and the competitive, military actions wielded to claim land and power.² Most material culture studied thus far, however, focuses on ceramics and monuments, including architecture. The scope of “material culture” has been extended to more “organic” aspects such as subsistence economies more recently.

Western Anatolia was an important zone of transaction between Mycenaean communities (and others in the Aegean) and the world of the Hittites, as well as other local LBA cultures. This zone interacted with both cultures and thus provides an intriguing archaeological assemblage for understanding LBA material and social cultures, economic relations and technologies at the local level, to the west with the Myceneans and to the east with the Hittites. Despite its potential, western Anatolia has remained understudied for these important questions, and it is only recently coming to light. Ongoing and past excavations of Troy, Beycesultan, Aphrodisias, Panaztepe, and Liman Tepe yield the primary data for a baseline chronology.³ Kaymakçı fills out this picture

¹ Antonio Sagona and Paul Zimansky *Ancient Turkey*. (Routledge, 2015): 253.

² Benjamin S. Arbuckle. “The Rise of Cattle Cultures in Bronze Age Anatolia.” *Journal of Eastern Mediterranean Archaeology & Heritage Studies* 2, no. 4. (2014): 277-97.; Christopher H. Roosevelt *et al.* “Exploring Space, Economy, and Interregional Interaction at a Second-Millennium BCE Citadel in Central Western Anatolia: 2014–2017 Research at Kaymakçı.” (*American Journal of Archaeology* 122, 2018), 645.; Sagona and Zimansky, 2015: 348.

³ Roosevelt *et al.*, 2018.

for the Gediz River valley, and thus considerably increases our knowledge about the region in the second millennium B.C.E.⁴

The material assemblage from Kaymakçı provides excellent evidence for the intercultural connections of the LBA. An abundance of evidence for material and subsistence economies, as well as production practices has come to light through the ongoing work of the Central Lydia Archaeological Survey (CLAS) and the Kaymakçı Archaeological Project (KAP). The results from the systematic archaeological survey, notably the LBA datasets, and excavations at Kaymakçı undertaken so far demonstrate that Kaymakçı was indeed a major site, and likely the capital of the Gediz River valley in the LBA (see Fig. 1.1).⁵ Even though the material culture of the area displays mainly local, western Anatolian patterns, there is evidence for connections to the Aegean and the Hittite spheres.⁶ The ceramic analyses show these connections well, and with absolute dating for the Middle Bronze Age (MBA) (2000-1800 BCE), Late Bronze (LB) 1 (1800-1600/1500 BCE), and LB 2 (1500-1400 BCE) phases, we can begin to pinpoint more specific periods of interaction.⁷ Furthermore, metals, too, show connections to both the Aegean and Hittite spheres. Of interest also is evidence of connections to the wider Mediterranean worlds, such as faience beads.⁸

⁴ Roosevelt *et al.*, 2018.

⁵ Christopher H. Roosevelt and Christina Luke "The Story of a Forgotten Kingdom? Survey Archaeology and the Historical Geography of Central Western Anatolia in the Second Millennium BC." *European Journal of Archaeology* 20, no. 1, (2017): 120-147.

⁶ Roosevelt *et al.*, 2018.

⁷ Roosevelt *et al.*, 2018.

⁸ Roosevelt *et al.*, 2018.

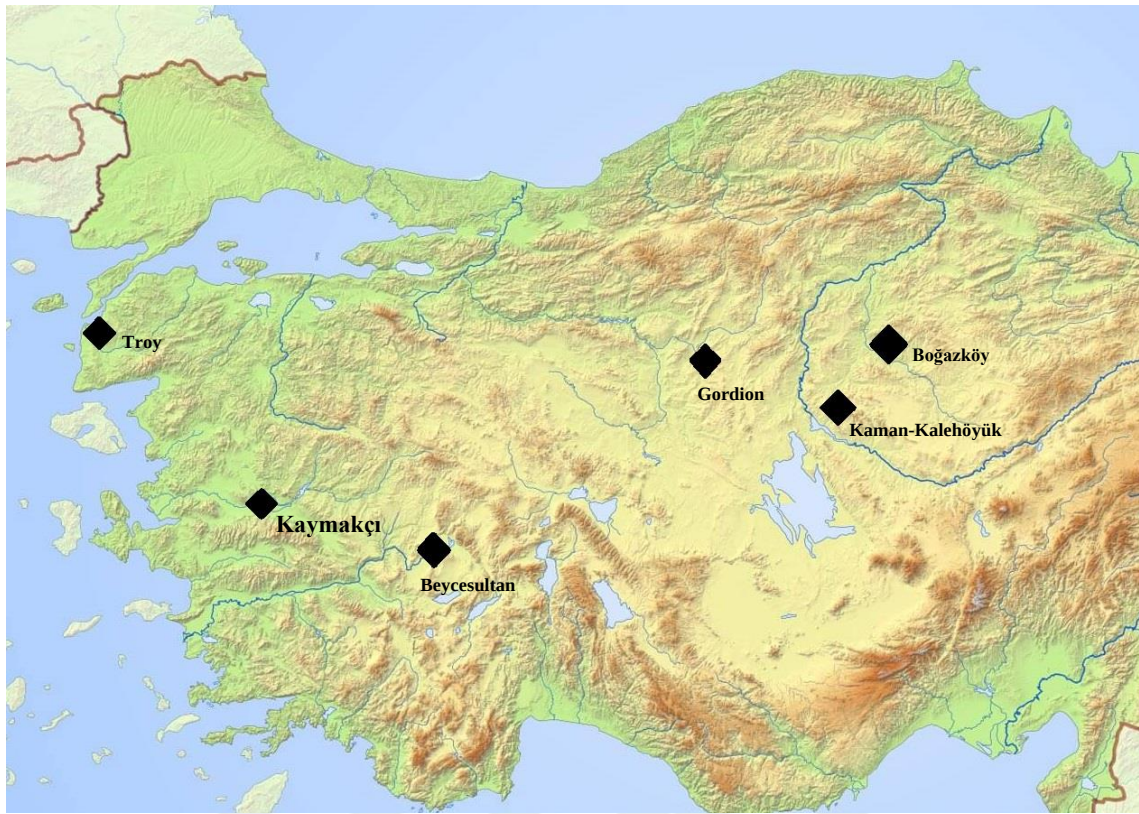


Figure 1.1. Map showing the location of Kaymakçı, and sites mentioned in the text.

The study at hand contributes to the understanding of economy, cultural affiliations, agricultural practices, and the rise of an elite class at Kaymakçı from the perspective of zooarchaeological analyses. Here my aim is to illuminate the “big picture” of Kaymakçı in the context of LBA societies in western Anatolia by looking at their subsistence economies. Of specific interest is how these economic practices contributed to and sustained ongoing daily life, such as choices in diet, and management of livestock (meat, dairy, and power). I am keenly interested in how these material correlations provide a window into the patterns of hierarchy.

Domestic animals represent the foundation of Bronze Age agricultural systems.⁹ The primary products (meat, leather, bone marrow, etc.) and secondary products (milk, dung, traction, etc.) are proxies for understanding both economic and social relations. Among the animals in this period, cattle (*Bos taurus*) were the largest and the most prestigious. The resources required to keep cattle indicate they may also have been the most valuable and thus also among the most symbolically important of all livestock.¹⁰ The combination

⁹ Arbuckle, 2014.

¹⁰ Arbuckle, 2014.

of Kaymakçı's cattle assemblage, including the analyses on its primary and secondary product usage, gives us a proxy for the selective provisioning as well as the role of cattle in local agricultural systems. It is from this perspective, that my thesis explores cattle and builds significantly on the scholarship of Benjamin Arbuckle.¹¹ Indeed, cattle constitute one of the four most exploited livestock mammals represented in Kaymakçı's zooarchaeological assemblage. My contribution to understanding Kaymakçı's cattle assemblage addresses the following questions:

1. What were the primary management systems in place for herding cattle?
2. How were cattle situated in the general picture of animal management at Kaymakçı?
3. What roles did cattle play in the wider spheres of social relations, and how might this perspective allow me to understand patterns of hierarchy?

My interest is very much along the lines of hierarchy at Kaymakçı. While research on architecture, ceramics and metals are forthcoming for Kaymakçı, my work focuses on the values of a zooarchaeological approach to explore the variation in social spheres, political groups, and economic choices. Cattle require a major investment of energy, supplies, money, and space. Given these parameters, cattle require capital on the part of the political leadership to allocate the necessary resources to develop and maintain these complex economic patterns of practice. This detailed analysis in turn allows me to contribute to the discussion about Kaymakçı's relative importance in greater LBA western Anatolia, and more precisely to lend greater weight to the importance of zooarchaeology in answering my research questions.

In the light of the current research and abovementioned research questions each chapter of this thesis contributes to presenting my arguments. Chapter 2 offers a literature review. It focuses on not only the western Anatolia, but also sites and cultures from Hittite regions to have a holistic perspective. From that point onward, the methodological framework for zooarchaeological research is addressed and the limitations are introduced to the reader in Chapter 3. The results of each analysis are explained in detail in Chapter 4. The current state of the field and the analyses I have conducted are presented in Chapter 5, and here I also address and discuss the primary research questions. Finally, Chapter 6 provides a conclusion and a brief overview of future research possibilities.

¹¹ Arbuckle, 2014.

Chapter 2:

RESEARCH IN LATE BRONZE AGE WESTERN ANATOLIA

The Late Bronze Age in Anatolia is often characterized by the impact of Hittites. Although the north central Anatolia is well known to scholars working on Mediterranean history and archaeology¹², western Anatolian settlements of the LBA remains relatively obscure.¹³ The gap of knowledge of this area during the rising LBA conflicts with the claims of the scholarly “big picture” of Myceneans in the Aegean and Hittites in the central Anatolia.

2.1 Western Anatolia: Hittite Influences and Cattle's Representation

The Late Bronze Age in Anatolia is characterized by emergence of an elite class whose widespread emergence can be related to hierarchical and competitive societies with vast territorial states.¹⁴ The characterization of complex burials with ritual goods, fortified settlements with monumental architecture, and textual remnants of second millennium B.C.E are interpreted as the evidence of complex societies where elites are marked by their notable behaviors in terms of cosmology, symbology, economy, literacy, and military activities to enhance their position in society.¹⁵ In central Anatolia Hittites were the main authority and wielded influence over other major sections of Anatolia.¹⁶ Sagona and Zimansky defined the Hittites in the LBA as evidence of an imperial power and materiality identified by “...edifices devoted to defense and control; symbols of power and persuasion, and artefacts of cosmopolitan complexity”.¹⁷ Although the Hittite powerhouse in central Anatolia is well-known and well-studied, the western Anatolian powers (majorly refers as Arzawa) were just as much important and may be powerful. Furthermore, Bryce points out that Hittite power over western Anatolian states were not always linear, in fact, at one point in fourteenth c. B.C.E., the Arzawians “may have come close to achieving political and military supremacy over much of the Anatolian region,

¹² Roosevelt and Luke, 2017: 120-147.; Roosevelt *et al.*, 2018.

¹³ Christopher. H. Roosevelt. *The Archaeology of Lydia: From Gyges to Alexander*. (New York: Cambridge University Press, 2009).

¹⁴ Arbuckle, 2014; Trevor Bryce. "The Late Bronze Age in the west and the Aegean." In *The Oxford handbook of ancient Anatolia*, eds. S.R. Steadman and G. McMahon, 363-375. 2011.

¹⁵ Arbuckle, 2014.

¹⁶ Bryce, 2011.

¹⁷ Sagona and Zimansky, 2015: 266.

even including the land of Hatti”.¹⁸ Given the Hittite powerhouse at Hattusa and their extensive arc of authority stretching to western Anatolia, as well as the western Anatolian states’ counterpower and influence against Hittites, the broad-based conceptions of Hittite lifeways form an important part of my research due to the possible cultural, political and military impact and influences over each other.

Scholars refers to western Anatolia as “the land of Arzawa” (variant Arzawiya) which appears often in the Hattusa texts, mainly its conflicts with the kingdom of Hatti.¹⁹ The scattered pieces of information about warfare and political conflicts between the Arzawa Lands and Hattusa from Hittite texts suggest that Arzawa constituted a threatening power for the Hittites.²⁰ Although our full understanding of local cultures (for now) in western Anatolia during the LBA is unclear, scholars suggest that the zone was occupied mainly by a substantial Indo-European population.²¹ The Arzawa Lands included four areas, perhaps thought of as communities, *Mira*, *Seha River Land*, *Wilusa*, and *Happala*. My research focus falls in the *Seha River Land*. The Seha River itself is identified with the land between Classical Caicus (modern Bakır) or the Hermus (modern Gediz) River.²² Although both Hittite and Mycenaean evidence in western Anatolia are scarce²³, we can determine which sites had closer connections than others to these specific spheres of influence. In western Anatolia, Myceneans mostly made their presence known through their architectural characteristics, burial practices, and ceramic characteristics²⁴ whereas for the Hittite domain the influence can be seen most clearly through rock carvings²⁵ and more culture-military based influences.²⁶ That being said, this thesis refers to western Anatolian sites as neither Hittite nor Mycenaean influenced-cultures, but it considers western Anatolia to be a local culture that appears to be situated in between those cultures.

¹⁸ Bryce, 2011: 365.

¹⁹ Bryce, 2011.

²⁰ Bryce, 2011.

²¹ Bryce, 2011; Ilya Yakubovich. *Sociolinguistics of the Luvian Language*. (Studies in Indo-European Languages & Linguistics 2. Leiden: Brill, 2010).

²² Bryce, 2011

²³ Alan M. Greaves. "The Greeks in Western Anatolia." In *The Oxford Handbook of Ancient Anatolia* edited by S. R. Steadman and G. McMahon, (2011): 500-514.; Sagona and Zimansky, 2015.

²⁴ Greaves, 2011.; Peter Pavúk and Barbara Horejs. "Ceramics, Surveys, and Connectivity in Western Anatolia: The Middle and Late Bronze Age Bakırçay/Kaikos Valley Restudied." *Ägypten und Levante* 28 (2018): 457-485.

²⁵ Sagona and Zimansky, 2015.

²⁶ Bryce, 2011.

2.1.1 Hittite Texts and Iconography of Cattle

The human-animal relationship is a crucial concept that appears with frequency in Hittite texts. A Hittite manuscript called “Prayer to Lelwanis for the healing of princess Gassuliyawiyas” which is a prayer for King Mursuli II’s wife begins with “...of the God... a fattened cow, a fat-tailed sheep... take your fill of [...] the blood [...]”, and continues with “Furthermore, your servant Gassuliyawiyas has kindly brought to you, ô God, a fattened cow, a fattened sheep, bread, beer and wine. Ô God, take these offerings.”.²⁷ In this text, cow and sheep (*Ovis aries*) are offered to their God as ritual offerings. This practice shows that in Hittite culture domesticated livestock were used not only for food, but also ritual practices, and importantly sacred offerings. Serving beef and lamb for the king’s wife’s health further indicates that they were highly valuable goods, and they held prestige that transcended royalty. Indeed, they were served to the god on behalf of one of the most important people of the kingdom, the queen. Besides their ritual meanings, cattle and sheep are frequently mentioned in the Hittite royal annals (Hattusili I, Mursuli II, Arnuwanda...) as contrabands of war.²⁸ More interestingly, in the Annals of Hattusili I, we understand that Hattusili expanded his territorial claims into Arzawa lands by raiding. The Annals devote just one sentence to this campaign, simply recording that Hattusili ‘went to the land of Arzawa and took away its cattle and sheep’.²⁹ Cattle, especially, represented wealth and the potential seizure of that wealth by an outside force was a major threat. Here I stress that by taking cattle and sheep as war booty from the Land of Arzawa, one of the main powers against Hittite Empire, not only reveals cattle’s value as material goods, but may also suggests that taking them was a way to dishonor the defeated. The zooarchaeological data from Hittite centers (especially Boğazköy-Hattusa) reveals that cattle were in high frequencies and one of the major components of the diet. In this regard, high frequency of caprines (sheep/goat) and relatively high concentration of cattle recovered from Kaymakçı point to the fact that in this place domesticated livestock were abundant, likely not only at this center, but also others and thus generally in the surrounding region. Therefore, these patterns suggest that taking away cattle was not exactly a need but is more of an ideological act.

²⁷ Itamar Singer. *Hittite Prayers*. Society of Biblical Literature, Atlanta, Georgia. (2002): 71-73.

²⁸ Trevor R. Bryce. "The Annals and Lost Golden Statue of the Hittite King Hattusili I." *Gephyra* 16, (2018): 1-12.

²⁹ Bryce, 2018: 2.

In Anatolia, cattle were used for rituals and cults as well. In the royal burials of Alacahöyük, and the sacred Hittite burial site of Yazılıkaya bear evidence of cattle remains and iconographic depictions.³⁰ In fact, in Yazılıkaya, cattle depictions were associated with the Hittite Storm God, Tešub which would only indicate the power and sacredness that was associated with cattle.³¹ Furthermore, sacrifice of cattle and deposition of cattle body parts appears in the mortuary practices across Anatolia, as part of a “cattle cult”.³² Cattle were perceived as powerful and fertile animals; they supply and assist people in multiple ways. In that manner, granting cattle for gods or deceased ones would ensure the welfare and prosperity in the afterlife.

Even today, in modern Turkey, cattle are perceived as the most valuable livestock. Cattle ownership, and beef and leather purchase are seen as indicators of wealth and welfare. Moreover, sacrificing cattle in one of the most sacred holidays, the Sacrifice Feast, is still a symbol of prestige and represents a powerful status.

2.2 Western Anatolian Cultures and Hittite Settlements: Zooarchaeological Perspective

Environmental archaeology is a crucial part of Anatolian archaeology because of its potential in understanding how people interacted with their surrounding environments and maintained their daily lives. Further, it provides insights about sustainability and why and how communities act in the way they did. Even so, the current datasets that providing the capacity for robust zooarchaeological understanding are very slim, often not yet published, or in some cases not part of the research paradigm and methodologies. Although the rise of environmental questions amongst Anatolian archaeologists is promising for understanding the ancient subsistence economies, the limited research so far makes it difficult to compare Kaymakçı’s assemblage with surrounding sites and nearby regions. The strategies that the Kaymakçı team has adopted for a systematic and informative assemblage are rare at other excavations. Indeed, it is the entire

³⁰ Aslı Özyar. “Reconsidering the “Royal” Tombs of Alacahöyük: Problems of Stratigraphy According to the Topographical Location of the Tombs”. *TÜBA-AR: Türkiye Bilimler Akademisi Arkeoloji Dergisi* 2. (1999): 79–85.; Jürgen Seeher. *Gods Carved in Stone: The Hittite Rock Sanctuary of Yazılıkaya*. Translated by G. Shepard, from German. (Istanbul: Ege Yayınları. 2011).; Thomas Zimmermann and Evren Y. Genç. "Pastoralist Pride: a Footnote on Symbols, Cattle and Community in Third-millennium BC northern Central Anatolia." *Antiquity* 328.85 (2011).

³¹ Seeher, 2011.

³² Zimmermann and Genç, 2011.

zooarchaeological assemblages from robust research programs that then becomes a proxy for understanding what animal economies were for second millennium B.C.E in western Anatolia. Even this limited information currently available from other sites is extremely valuable; it allows zooarchaeological experts to establish a subsistence model for western Anatolia and situate Kaymakçı as one of the major sites from the perspective of environmental archaeology.

Western Anatolian settlements are considered as the subject of constant conflicts between Balkan, Aegean, and Anatolian polities, vacillating between being innovation centers and buffer zones.³³ Most of the zooarchaeological studies in the region have been site-based,³⁴ which means there are gaps for understanding the general picture in prehistoric environments, subsistence, and communities in western Anatolia. Moreover, although the focal period for this type of research has been mainly the Neolithic for western Anatolian zooarchaeologists³⁵, the later periods also yield an invaluable perspective for the region.³⁶ More Hittite sites, on the other hand, have been systematically studied, and further there is a textual evidence; therefore, there is a more comprehensive understanding about a Hittite framework for human-animal relationships.³⁷ Having said this, I emphasize the importance of the datasets from Troy, Beycesultan, Gordion, Kaman-Kalehöyük, and Boğazköy. These assemblages and the resulting interpretations have been used to present an overview of zooarchaeological studies for the LBA in Anatolia. Importantly, they form the comparative assemblage that I use to interpret the assemblage from Kaymakçı, and in turn provide analyses of the relative spheres of interaction and influence.

³³Canan Çakırlar and Levent Atıcı. "Patterns of animal exploitation in western Turkey from Palaeolithic molluscs to Byzantine elephants." *The Oxford Handbook of Zooarchaeology* eds. Albarella et al. (Oxford Handbooks, 2017): 266-79.

³⁴Çakırlar and Atıcı, 2017.

³⁵A. Levent Atıcı, Suzanne E. Pilaar Birch, and Burçin Erdoğu. "Spread of domestic animals across Neolithic western Anatolia: New zooarchaeological evidence from Uğurlu Höyük, the island of Gökçeada, Turkey." *PloS one* 12, no. 10: e0186519 (2017).; Canan Çakırlar. "The evolution of animal husbandry in Neolithic central-west Anatolia: the zooarchaeological record from Ulucak Höyük (c. 7040-5660 cal. BC, Izmir, Turkey)." *Anatolian Studies* (2012): 1-33.

³⁶John M. Marston, et al., "Agropastoral Economies and Land Use in Bronze Age Western Anatolia." *Environmental Archaeology* (2021): 1-15.; Nami Shin et al., "Agricultural practices at Bronze Age Kaymakçı, western Anatolia." *Journal of Archaeological Science: Reports* 36 (2021).; Francesca G. Slim, Canan Çakırlar, and Christopher H. Roosevelt. "Pigs in Sight: Late Bronze Age Pig Husbandries in the Aegean and Anatolia." *Journal of Field Archaeology* 45, no. 5 (2020): 315-333.

³⁷Walter Dörfler et al., "Environment and economy in Hittite Anatolia." *Insights into Hittite history and archaeology* (2011): 99-124.; B.J. Collins. "Hero, Field Master, King: Animal Mastery in Hittite Texts and Iconography." *The Master of Animals in Old World Iconography* eds Derek B. Counts and Bettina Arnold, (Budapest 2010): 59-74.

Troy is one of the best-known sites in western Anatolia which dates from the Early Bronze Age to Roman times. The historic Troy region is in today's Çanakkale, south of the Dardanelles and northwest of Mount Ida. The advantageous location of Troy allowed this city to become a vibrant center for trade between the Aegean, Black Sea, Mediterranean, Anatolian and even regions of the Levant.³⁸ The first excavations at the site were undertaken by the archaeologist Heinrich Schliemann in 1870 and they were continued by Dörpfeld, Blegen, Korfmann and now Arslan – all German-trained and thus also an indication of the transnational research approaches to this site. For this thesis, it is Troy VI that is relevant. It is concurrent with the first part of the Late Bronze Age and thus significant for my work at Kaymakçı. Troy not only benefited from sea, but also nearby rivers and springs provided fertile agricultural soils. Fairly large numbers of cattle and horse (*Equus sp.*) bones, fish remains, and cultivated plants were excavated from Troy VI.³⁹ Including cattle and horse, domesticated livestock and wild species (mainly fallow deer (*Dama dama*)) give us a window into the models of sustainability and the diversity in the subsistence economies.⁴⁰ What the data show is that Troy was a well-structured and populated settlement during the second millennium B.C.E. Evidence indicates that the site was a major regional power,⁴¹ with an established hierarchical systems complemented by trade and material wealth. Such a hierarchical system would have benefited from the range of values attributed and the symbology associated with animals too.

The most prominent domesticated livestock in Troy were sheep and goat (*Capra hircus*). The largest domesticated animals that required significantly more investment in energy and land (fertile soils) thus also indicators of wealth were cattle and horse. At Troy both cattle and caprids outnumber pigs (*Sus domesticus*). The high abundance of horse is notable given that the horse was introduced to the region for the first time at the beginning of Troy VI⁴² and this correspondence has made it a focal point for researchers studying the animal assemblage of the site.

³⁸ Manfred Korfmann. "Troia, an ancient Anatolian palatial and trading center: archaeological evidence for the period of Troia VI/VII." *The Classical World* 91, no. 5 (1998): 369-385.

³⁹ Hans-Peter Uerpmann. "Environmental Aspects of Economic Changes in Troia." *Troia and the Troad*. (Springer, Berlin, Heidelberg, 2003): 251-262.

⁴⁰ Uerpmann, 2003; 255.

⁴¹ Peter Jablonka and C. Brian Rose. "Forum Response: Late Bronze Age Troy: A Response to Frank Kolb." *American Journal of Archaeology* 108, no. 4 (2004): 615-630.

⁴² Peter Jablonka. 'Troy in Regional and International Context', in *The Oxford Handbook of Ancient Anatolia* eds. S. Steadman and G. McMahon, (Oxford University Press. 2011). 717-733.

Moving inland from Troy, to the southwest, Beycesultan is one of the most important sites for understanding central western Anatolia. It is located in the vicinity of Çivril, Denizli. It was occupied from Late Chalcolithic to Byzantine periods. The first archaeological work started in 1954 under the direction of the now infamous James Mellaart. Given the site's internal location, Beycesultan is an important node for understanding the peripheral zone between the Aegean islands, the western coastal zones of Anatolia and interior Anatolian settlements. Like at Troy, the stratigraphy here has become integrated into a common archaeological language. The Bronze Age layers (V-II) have been intensively studied to reveal it has similar characteristics with the central Anatolian Bronze Age, particularly in terms of architecture and ceramic typology.⁴³ Although zooarchaeological assemblages were collected at Beycesultan, the published data is limited.⁴⁴ It is also important to note that Beycesultan' assemblage that I am presenting was published in 1965.⁴⁵ This early study and excavation strategies such as collecting only hand selected samples could have been affected this assemblage. Not surprisingly, the assemblage consisted of sheep, goat, cattle, and pig as well as small numbers of deer, horse, fox (*Vulpes vulpes*), dog (*Canis familiaris*), turtle, and avifauna. There is an increase of both cattle and pig during the Middle Bronze Age. Scholars here analyzed the mortality profiles and observed a certain culling pattern for cattle: 60% of the cattle during the Late Bronze Age were kept until the age of four.⁴⁶ This practice suggests that cattle were prized for secondary products, such as milk as well as energy for traction in tilling fields. Compared to cattle, the survivorship for sheep and goat here is relatively lower. Most of the sheep and goat were culled before they reached 12 months of age⁴⁷, and this is indicative of meat consumption. In addition to these domesticates, quite a few wild species were also recovered. From the general summary, we can say that Beycesultan was a self-sufficient settlement in terms of its animal economies.

Now I turn to the Hittite centers in central Anatolia. Gordion is an ancient settlement located in modern Ankara, in the immediate vicinity of the current district of

⁴³ Seton Lloyd and James Mellaart. "Beycesultan excavations: first preliminary report." *Anatolian Studies* 5 (1955): 39-92.; Eşref Abay and Fulya Dedeoğlu. *Beycesultan 2013-14 Yılı Kazı Çalışmaları* (37. Kazı Sonuçları Toplantısı 3. Cilt, 2015) 183-98.; Roosevelt *et al.*, 2018.

⁴⁴ Beycesultan Kazıları, 2019.

⁴⁵ Pierre Ducos. "La faune de Beycesultan", in *The Middle Bronze Architecture and Pottery. Vol. 2 of Beycesultan*, eds. S. Lloyd and J. Mellaart. (British Institute of Archaeology at Ankara Occasional Publications 8, London, British Institute of Archaeology at Ankara, 1965): 139-154.

⁴⁶ Beycesultan Kazıları, 2019.

⁴⁷ Beycesultan Kazıları, 2019.

Polatlı, near the confluence of the Porsuk and Sakarya rivers. The ancient city was distinguished for being the home of the infamous Phrygian King Midas and as the place where Alexander the Great cut the Gordion knot before he conquered Asia.⁴⁸ My interest in this site pertains to the earliest levels. At Gordion, evidence shows that the initial occupation was Early Bronze Age⁴⁹ and there was continual habitation through to the Medieval period.⁵⁰ Gordion was renowned for its warfare throughout its history and depicted as one of the military centers in Anatolia. The research at Gordion has mainly focused on the Phrygian period and Roman occupation.⁵¹ Gordion, actually, rose with the fall of Hittite kingdom and became the capital of ancient Phrygia.

In contrast to its later flourishing, during the Late Bronze Age, Gordion was a rather small settlement, operating in the shadow of the Hittite kingdom.⁵² According to Zeder and Arter who conducted a comprehensive zooarchaeological research on the LBA levels, the assemblage is distinguished by the high numbers of caprids.⁵³ Cattle seem to have been the second most prominent taxa at Gordion, followed by pig. Thus, the major protein contributors in meat and dairy for Gordion were caprids, cattle and pigs. Nonetheless, the favorable environment⁵⁴ around Gordion provided a rich variety of wild species, with high proportions of bird, fish, and deer. However, when compared to the domesticates, the wild taxa were not the primary focus, but more along the lines of opportunistic or supplemental protein.

Moving southeast, I now discuss Kaman Kalehöyük. The site is situated near the city of Kaman in the Kırşehir province, approximately 100 km southeast of Ankara. The excavations have been conducted by Sachihito Omura since 1986. The site's stratigraphy tells us that it has been occupied continuously from the Early Bronze Age to the Ottoman period. According to the material evidence and the architectural remains, the stratigraphy is subdivided broadly into four strata. Stratum III corresponds to the Middle to Late

⁴⁸ Naomi F. Miller. *Botanical Aspects of Environment and Economy at Gordion, Turkey*. Vol. 131. (University of Pennsylvania Press, 2011).

⁴⁹ C. Brian Rose. "Fieldwork at Phrygian Gordion, 2013–2015." *American Journal of Archaeology* 121, no. 1 (2017): 135–78. <https://doi.org/10.3764/aja.121.1.0135>.

⁵⁰ The Gordion Archaeological Project. "Medieval Gordion". Penn Museum.

⁵¹ C. Brian Rose. "Recent Fieldwork at Gordion". In *The Archaeology of Anatolia: Recent Discoveries (2011-2014) Volume I*. eds. Sharon R. Steadman and Gregory McMahon. (Cambridge Scholars Publishing, 2015): 180-200.; Canan Çakırlar and John M. Marston. "Rural agricultural economies and military provisioning at Roman Gordion (central Turkey)." *Environmental Archaeology* 24, no. 1 (2019): 91-105.

⁵² Rose, 2015.

⁵³ Melinda A. Zeder and Susan R. Arter. "Changing patterns of animal utilization at ancient Gordion." *Paléorient* (1994): 105-118.

⁵⁴ Miller, 2011.

Bronze Ages, and here we have three additional subdivisions: IIIc/Assyrian Colony Period – IIb/Old Hittite Period – IIIa/Hittite Kingdom.⁵⁵ As the names indicate, Kaman Kalehöyük was a significant settlement from the Assyrian Colony through the Hittite period. For these reasons, it is very important to archaeologists seeking to understand better the diverse and rich cultural interactions between central Anatolia and the Hittites with the Near Eastern cultural spheres.

During the second millennium B.C.E, one of the main features at Kaman Kalehöyük is their storage pits.⁵⁶ The evidence for cereal remains in these pits gives us important information about the socio-political organization; the quantity of grains indicates significant production and management of agricultural practices.⁵⁷ There is a notable similarity here between the numerous storage pits of Kaman Kalehöyük and those at Kaymakçı.⁵⁸ What is more, the animal economies of Kaman Kalehöyük slightly differs from Gordion and Hattusa -other sites in the Hittite realm, by having respectively higher proportions of pig remains.⁵⁹ However, similar to Gordion, Kaman Kalehöyük kept caprids more than cattle or pig. After the caprids, cattle represented the most abundant taxon. Finally, among the domesticates, pigs were still the least encountered taxa in Kaman Kalehöyük (for %NISP see Chapter 4). I end this summary by noting that for Kaman Kalehöyük, the high proportions of equid and low proportions of wild taxa⁶⁰ show similar patterns with Gordion.

Boğazköy-Hattusa was the capital of the Hittite Empire in the LBA. It was the essence of Hittite culture which stretched and dominated widespread regions of Anatolia and northern Syria, from the Euphrates in the East to the Aegean in the West. While there were fluctuations, the Hittite Imperial reign held sway in this territory until its collapse at the end of the 12th century BCE.⁶¹ Today, the ruins lie near the current city of Çorum. It has a long line of excavations and expeditions, most done by German scholars.

⁵⁵Sachihiro Omura. "Kaman-Kalehöyük Excavations in Central Anatolia." in *The Oxford Handbook of Ancient Anatolia* eds S. Steadman and G. McMahon. (Oxford University Press. 2011): 1095-1111.

⁵⁶ Andrew Fairbairn and Sachihiro Omura. "Archaeological identification and significance of ÉSAG (agricultural storage pits) at Kaman-Kalehöyük, central Anatolia." *Anatolian Studies* (2005): 15-23.

⁵⁷ Fairbairn and Omura, 2005.

⁵⁸ Fairbairn and Omura, 2005; Roosevelt *et al.*, 2018.

⁵⁹ Hitomi Hongo. "Patterns of animal husbandry in central Anatolia from the second millennium BC through the Middle Ages: Faunal remains from Kaman-Kalehöyük, Turkey." (Ph.D. Diss., Harvard University, 1996).

⁶⁰ Hongo, 1996.

⁶¹ Trevor Bryce. "The Last Days of Hattusa: The Mysterious Collapse of the Hittite Empire." *Archaeology Odyssey* 8 (2005): 32-41.

Boğazköy-Hattusa was the largest settlement within the realm of LBA Anatolia⁶² with cuneiform tablets, monumental gates, palace complexes, temples, colossal storage units, and further features. The comprehensive studies over the years portray a clear picture about political activities and warfare, about religion, and about daily lives. We know so much about this culture due to the vast number of cuneiform tables, which have provided extremely fruitful research.⁶³ Because Boğazköy-Hattusa was the heart of the Hittite Empire, when scholars consider the imperial reach of Hittite-related cultural influences, they turn to the datasets from Boğazköy-Hattusa.⁶⁴ Indeed, such a monumental political and cultural center has yielded a rich material assemblage that tells us a lot, including about subsistence economies. As we might expect given the region, the animal economies of Boğazköy-Hattusa were based on caprines. Pigs were scarce, yet cattle were exceptionally abundant. In the Hittite cuneiform tables it is clearly stated that sheep and cattle were significant for their by-products, but also as symbol of power and welfare of the Empire.⁶⁵

2.3 Kaymakçı

Kaymakçı is situated above and along the western shore of Lake Marmara (Gölmarmara, in antiquity known as the Gygaean Lake), about 100 km inland from the modern Aegean coastal city İzmir⁶⁶ (see Fig. 2.1). Kaymakçı expands over a minimum area of 25 ha.⁶⁷ It consists of an internal 8.6 ha core citadel and then a dispersed extramural settlement, including at least one cemetery and sites abutting what would have been either lakeshore or wetlands. The citadel with fortified architecture including several main gates and juncture points between different citadel zones demonstrate that

⁶² Jürgen Seeher, D. P. Mielke, and U. D. Schoop. "Chronology in Hattusa: new approaches to an old problem." *Strukturierung und Datierung in der hethitischen Archäologie* 197 (2006): 213.

⁶³ Dirk P. Mielke. "Key sites of the Hittite Empire." in *The Oxford Handbook of Ancient Anatolia* edited by S. Steadman and G. McMahon (Oxford University Press, 2011): 1031-1054.; Sagona and Zimansky, 2015.

⁶⁴ Mielke, 2011; Sagona and Zimansky, 2015; Trevor Bryce. *Life and Society in the Hittite World*. (Oxford: Oxford University Press, 2002)

⁶⁵ Gary Beckman. "Herding and herdsmen in Hittite culture." *Documentum Asiae minoris antiquae: Festschrift für Heinrich Otten zum 75. Eds. Neu, E. and C. Rüster. (Geburtstag, 1988): 33.*

⁶⁶ Roosevelt *et al.*, 2018.

⁶⁷ Christopher H. Roosevelt, Sinan Ünlüsoy and Christina Luke. "Kaymakçı Arkeoloji Projesi: 2016–2017 Yılları Kazı ve Araştırma Sonuçları." *Kazı Sonuçları Toplantısı* 40(1) (2018): 487–504.; Christina Luke and Christopher H. Roosevelt. "Cup-Marks and Citadels: Evidence for Libation in 2nd-Millennium BCE Western Anatolia." *Bulletin of the American Schools of Oriental Research* 378 (2017).

Kaymakçı was indeed a major site.⁶⁸ The settlement pattern mirrors a typical characteristic layout for a citadel hilltop settlement: an inner citadel enclosed with walled structure, a southern terrace just outside of the inner citadel, and that all enclosed by a strong fortification wall⁶⁹ (Fig. 2.2). In antiquity, a fortification system with concentric 2-m curtain walls, bastions and towers, and multiple gates enclosed and protected the Kaymakçı inhabitants.⁷⁰

There are three zones excavated at Kaymakçı to date: the inner citadel area, the southern terrace, and the fortification system. The inner citadel area is thought to be the residential zone for elites or high-status people. The material evidence, architectural features, and the general “rise of elite class” trend of LBA Anatolia supports this idea.⁷¹ The southern terrace area is highlighted with possible production zone along with the residential zone for community. The fortification system encompasses the site with bastions and thick walls similar to its contemporary fortification systems in Anatolia.⁷²

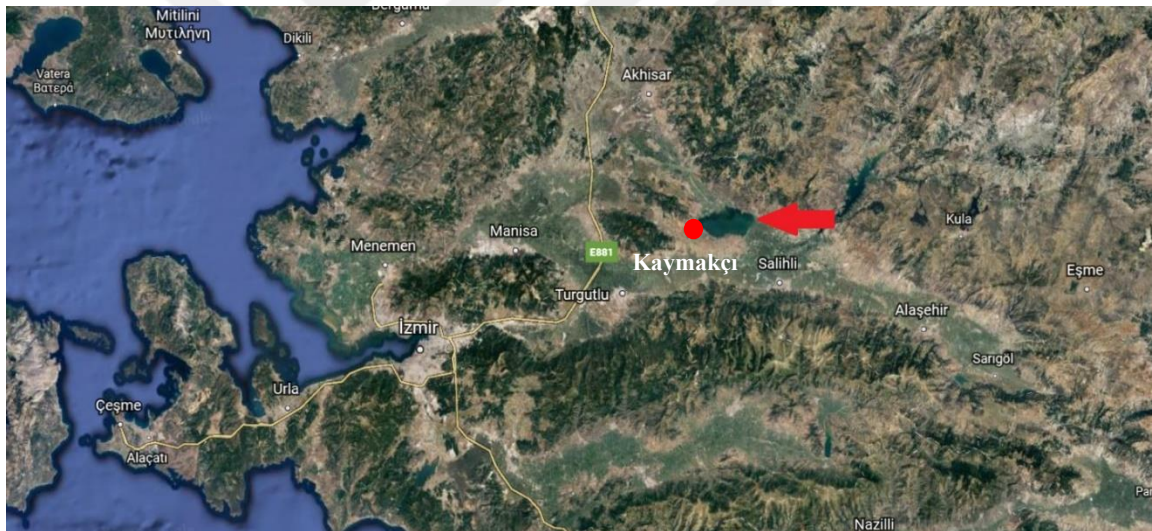


Figure 2.1. Satellite view of the Gediz River valley, the Lake Marmara (the ancient Gygaean Lake) (indicated with red arrow), Kaymakçı (indicated with red circle) the surrounding mountains and the Aegean coastline. Image: Google Earth.

The area is already distinguished by ancient mentions of the lake, Thousand Mounds (Bin Tepe) area, and the excavations at Sardis; signal to the long history of the

⁶⁸ Luke and Roosevelt, 2017.

⁶⁹ Roosevelt *et al.*, 2018.

⁷⁰ Luke and Roosevelt, 2017.

⁷¹ Roosevelt *et al.*, 2018.; Arbuckle, 2014: 277-278.

⁷² Roosevelt *et al.*, 2018.

valley.⁷³ Kaymakçı was only one of at least six citadels ringing the lake, five apparently unfortified lowland settlements, and at least 23 smaller sites of more ephemeral activities, all of second millennium B.C.E. date⁷⁴ (fig. 2.3). Geophysical and microtopographical surveys, surface collections, and excavation data from Kaymakçı confirm its prominence in the 2nd millennium B.C.E. landscape.⁷⁵ Another important highlight is after the abandonment of the site at the end of Late Bronze Age; the site was not occupied by another community. Evidence indicates no major destruction level, either from the inhabitants or outsiders.⁷⁶ The occupation in one major cultural narrative in time and space provides a unique opportunity to understand how the settlement was without any further disturbance *per se*.



⁷³ Christina Luke and Christopher H. Roosevelt. “Memory and Meaning in Bin Tepe, the Lydian Cemetery of “Thousand Mounds””, in *Tumulus as Sema: Proceedings on an international conference on space, culture, politics and religion in the first millennium BC*. eds. O. Henry and U Kelp. (Berlin: De Gruyter, 2015): 403–424.

⁷⁴ Roosevelt *et al.*, 2018.

⁷⁵ Luke and Roosevelt, 2017.

⁷⁶ Sinan Ünlüsoy, Christopher Roosevelt, and Christina Luke. “Gediz Vadisinde Bir Orta ve Tunç Çağı Kalesi: Kaymakçı” *Ege Üniversitesi Edebiyat Fakültesi Yayınları, Arkeoloji Dergisi* 23, (2018):1-17.

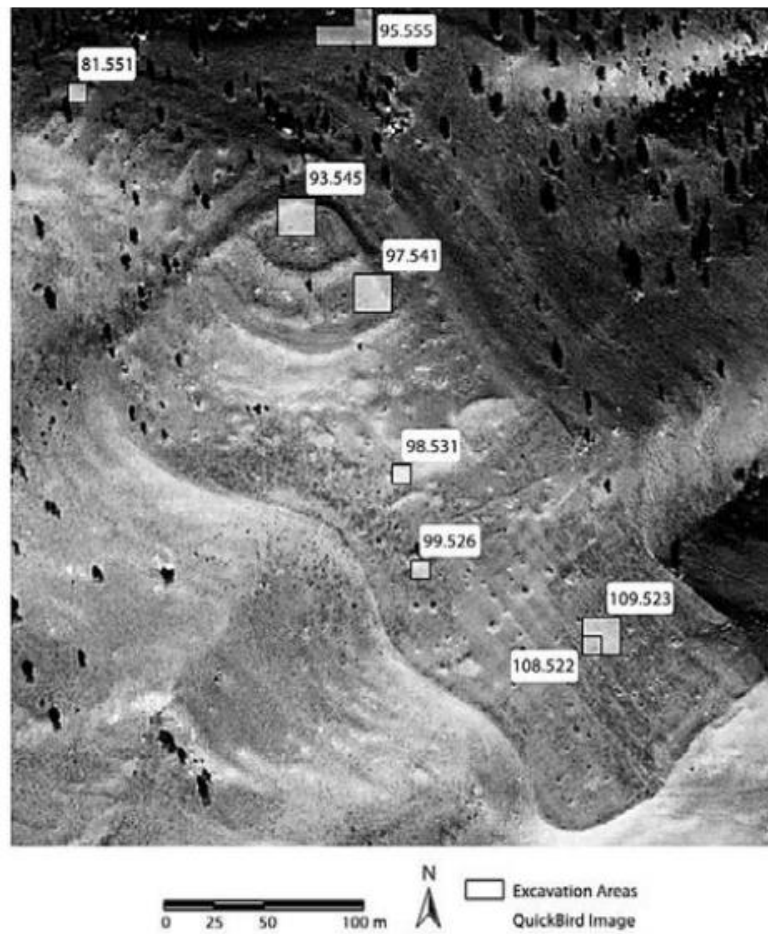


Figure 2.2. Quickbird satellite image of Kaymakçı showing 2014-2019 excavation areas (©Gygaia Projects)

Not only the human community but also animals in Kaymakçı would have enjoyed a favorable environmental setting with rich vegetation, close proximity to Lake Marmara and the Gediz (ancient Hermus river) and thus also marshlands, scrub oak along the Gür Mountains. A considerable approximately 120 m elevation gave the site great visibility as well as a favorable positioning for winds. Current climate analysis from the past 90 years shows that summers are warm, often reaching 45.5°C, and winters are wet and temperate, dipping below freezing during cold cycles, yet never sufficient to freeze for days, unlike the snowy peaks and upland valleys of the Bozdağı Mountains that rise above the valley floor to the south. This climate affords three agricultural cycles per year

in terms of modern agriculture, and the uplands and vast valley, were attractive to transhumant communities until the mid-1940s.⁷⁷

Among the main objectives of the excavations has been to understand the developments throughout the Middle and Late Bronze Age, settlement patterns, and economy.⁷⁸

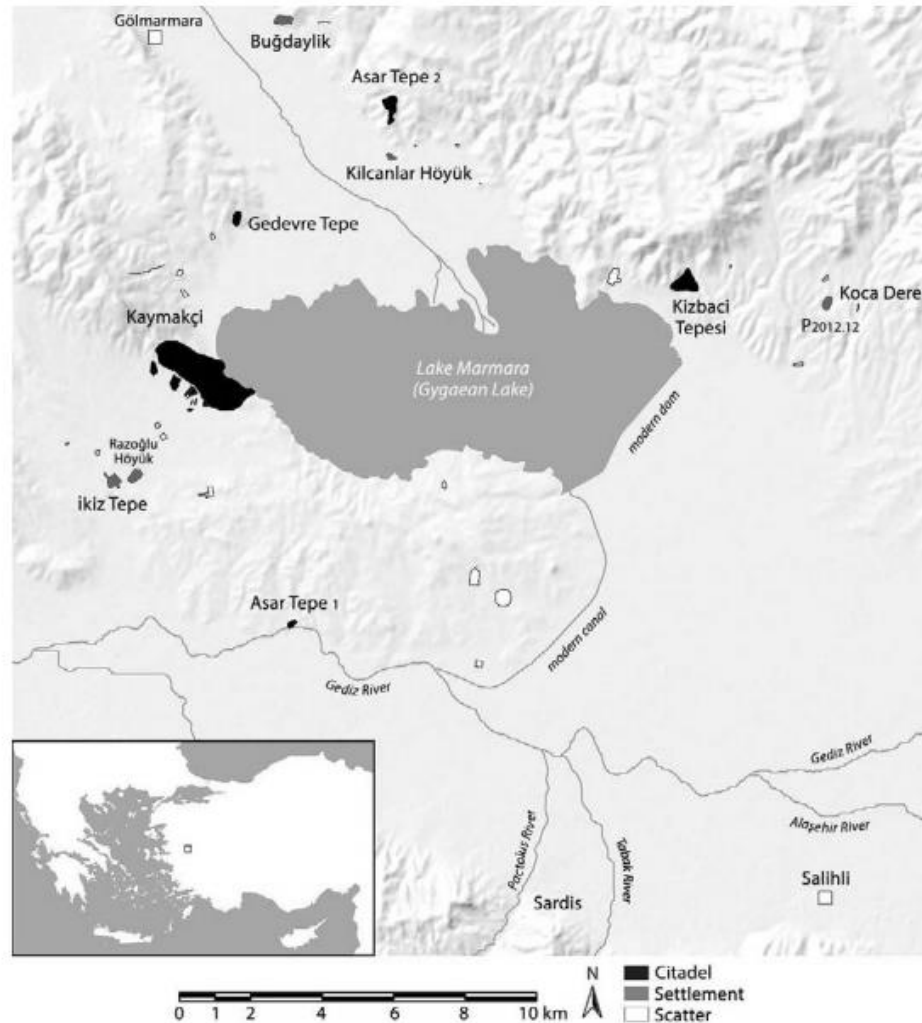


Figure 2.3. Map showing the location of Kaymakçı and nearby sites in the Marmara Lake Basin, western Turkey. Inset shows broader eastern Mediterranean setting. (© Gygaia Projects)

Kaymakçı is a great example of abundance and interconnections of substance and material cultures particularly in the Late Bronze Age: material and subsistence

⁷⁷Christina Luke, Christopher. H. Roosevelt, and Catherine. B. Scott. “Yörük Legacies: Space, scent, and sediment geochemistry.” *International Journal of Historical Archaeology*, 21(1) (2017): 152-177.

⁷⁸ Ünlüsoy *et al.*, 2018.

economies, and abundant production practices. Materials recovered from Kaymakçı reflect a variety of raw materials (e.g., ceramic, terracotta, metal, stone), architectural functions (e.g., residential, household production, industrial), and inspiration (both local and foreign).⁷⁹ Evidence shows that traditions of production were mainly local, yet there is evidence of connections between local communities and other broader traditions and networks of exchange in the Aegean and at least northwestern and central Anatolia.⁸⁰ The main focus of production and the most abundant LBA material are ceramics. Interestingly, while no kiln or specific ceramic production area has yet to be discovered, the ceramic material demonstrates local production.⁸¹ Analysis shows that the LBA ceramics were used for transport, storage, preparation, cooking, and consumption of food and drink.⁸² Ceramic styles are most closely related to those of central western Anatolia and sites such as Panaztepe, Limantepe, and Bademgediği Tepe; sites in the Bakırçay valley; and sites farther afield such as Aphrodisias, Beycesultan, and Troy.⁸³ The abandonment of a burnished ceramic style at an early stage of the LBA, unlike what is seen for areas farther west and north is distinctive to Kaymakçı and is possibly linked to the increased use of regionally characteristic gold and silver washes.⁸⁴ Worked materials such as spindle whorls, loom weights and needles are the second most abundant material at Kaymakçı.⁸⁵ These point to textile production; and preliminary analyses of how the material varies in form, decoration and weight indicates different types and qualities of textiles, most certainly including those produced from wool, and thus also a valued proxy for the zooarchaeological dataset.⁸⁶ Another abundant material is metal, and evidence for metalworking activities have been recovered. Elemental analyses show copper, arsenic, and tin in the vitreous material.⁸⁷ This material is consistent with LBA metal evidence

⁷⁹ Roosevelt *et al.*, 2018.

⁸⁰ Roosevelt *et al.*, 2018.

⁸¹ Roosevelt *et al.*, 2018.; Christina Luke *et al.*, "Composing communities: Chalcolithic through Iron Age survey ceramics in the Marmara Lake basin, western Turkey." *Journal of Field Archaeology* 40, no. 4 (2015): 428-449.

⁸² Roosevelt *et al.*, 2018.

⁸³ Roosevelt *et al.*, 2018.; Tunç Kaner. "Kaymakçı Arkeoloji Projesi Altın Mika Astarlı Keramiklerin Yapım Tekniği" (M.A. Thesis), İzmir, Ege University. 2018.; Tunç Kaner. "Dressing a Pot Surfaces in the Marmara Lake Basin during the Second Millennium BCE" *Annual Meetings of the American Schools of Oriental Research*, November 2020.

⁸⁴ Roosevelt *et al.*, 2018.; Kaner, 2018.

⁸⁵ Roosevelt *et al.*, 2018.

⁸⁶ Roosevelt *et al.*, 2018.

⁸⁷ Roosevelt *et al.*, 2018. Magda Pieniążek *et al.* "Of Networks and Knives: a Bronze Knife with Herringbone Decoration from the Citadel of Kaymakçı (Manisa İli/TR)." *Archäologisches Korrespondenzblatt* 49.2 (2019): 197-214.; Dalila M. Alberghina. "Before Croesus' Gold: Metals in the

from Boğazköy-Hattusa and Kerkenes Dağ.⁸⁸ All these attributes reveal much about social behavior and the material economies of Kaymakçı.

Due to the emergence of an elite class, vassal states, and a variety of specialized production activities discussed above, we can also be confident that this pattern is also indicative of intensive animal consumption and/or production; in fact, it was likely the social meaning of these specialized production activities that control over animals may became indicative of emerging political distinction. Animal trade was not only practiced for food, but also for symbology (e.g., gifts and ornaments) and prestige competition. Regional micro-climates were also quite convenient for animal husbandry in Anatolia. Especially, around Kaymakçı landscape and environment were ideal for grazing and browsing livestock.⁸⁹ Cattle, sheep, goat, and pig represent the main domestic mammals consumed in Kaymakçı.⁹⁰ Moreover, current faunal analyses from Kaymakçı show a large taxonomic diversity, not only domesticated mammals, but also a range of wild species such as deer (*Cervus elaphus*, *Dama dama*, *Capreolus capreolus*), wild boar (*Sus scrofa*), hare (*Lepus europaeus*), dog (*Canis sp.*), badger (*Meles meles*), and fox; ichthyofauna such as cyprinids (the carp family) and *Siluris glanis* (catfish); as well as avifauna, rodents, reptiles, and amphibians.⁹¹ Indeed, there is a wide range of ichthyofauna and invertebrates representative of various environments: terrestrial, freshwater, and even marine mollusks.⁹² The abundant species such as pig, deer and invertebrates may be further explained by the environment around Kaymakçı: marshlands and oak forests, as well as riverine/lacustrine landscape.

Animals were a fundamental part of the agricultural system that moves well beyond provisioning for food, indicating status, promoting trade, and supporting ritualistic practices. Animals' skins and fur were used for clothing and housing; their bones and horns were used for tools and ornaments; and their physical power, when

Gediz River Valley during the 2nd Millennium BCE" *Annual Meetings of the American Schools of Oriental Research*, November 2020.; Dalila M. Alberghina and Miloš Roháček "Of Types and Elements: A Combined Assessment of Western Anatolian Metallurgical Industries in the 2nd Millennium BCE" *Western Anatolia in the Second Millennium BCE: Recent Developments and Future Prospects (WANAT) Symposium*, April 2021.

⁸⁸ Roosevelt *et al.*, 2018.

⁸⁹ Luke and Roosevelt, 2017.

⁹⁰ Marston *et al.*, 2021; Slim *et al.*, 2020; Roosevelt *et al.*, 2018; Çakırlar and Atıcı, 2017.

⁹¹ Roosevelt *et al.*, 2018.

⁹² Marston *et al.*, 2021; Slim *et al.*, 2020; Roosevelt *et al.*, 2018.

harnessed effectively, was used for traction⁹³. Moreover, animals, especially cattle, were part of the religious endeavors as well, which are well- described in Hittite texts.⁹⁴ It is precisely the sheer abundance of faunal evidence from Kaymakçı that reveals not only what strategies and practices that society employed to survive every day, but also details concerning the landscapes in which they lived, and finally, how people interacted with animals beyond subsistence.⁹⁵



⁹³ Arbuckle, 2014; Nerissa Russell “Social Zooarchaeology: Humans and animals in prehistory”. (*Cambridge University Press*, 2011), Chapter 6.

⁹⁴ Beckman, 1988: 33; Singer, 2002: 71-73; Bryce, 2018: 2.

⁹⁵ Roosevelt *et al.*, 2018.

Chapter 3:

MATERIALS AND METHODS

3.1 *Materials*

The faunal assemblage at hand from Kaymakçı is an extensive assemblage that consisted of domestic, wild, and even exotic species. The assemblage consists of over 13.000 samples with over 40 different species. The faunal assemblage of Kaymakçı has been studied by a team including myself which led by Canan Çakırlar and Francesca Slim.⁹⁶ The remains come from three excavation zones: inner citadel, southern terrace, and fortification systems (see Chapter 2). Among these three zones there are seven excavation areas that have been excavated. Faunal remains were collected from all excavation areas, associated with extremely detailed recording methods that allow for volumetric analyses as well as micro-details from excavation, sieving, and flotation (heavy fraction analysis included). This sampling strategy and the database were designed and devised by Çakırlar, DiBattista, Marston and Roosevelt in 2014 and refined over the years with the help of Francesca Slim. The assemblage used in this thesis derives from materials recovered from the 2014-2019 excavations (excluding 2017, a study season) across the site. The data includes all bones recovered from excavations, both hand-picked and dry sieved, yet only a sampling of that from flotation and heavy fraction – that work is still ongoing. Almost all of the bones have been recovered from secondary or tertiary contexts, however, partial skeletons recovered from the site suggests primary contexts as well. Although the occupation at Kaymakçı stretches across most of the 2nd millennium B.C.E, the faunal remains have not yet been dated or categorized in respective phases.

3.2 *Primary Data Collection & Faunal Analysis*

The faunal remains yield unique insight about past environments. Even so, in the archaeological assemblages taphonomic and anthropogenic processes often alter this image.⁹⁷ Thus, methodologies and strategies for data collection are crucial. Not only

⁹⁶ Dr. Çakırlar's expertise and efforts, Drs. Slim's input in raw and secondary data, and Dr. Lau's assist has made this data compatible and reliable.

⁹⁷ Elizabeth J. Reitz and Elizabeth S. Wing. *Zooarchaeology*. (Cambridge University Press, 2008): 117-152.

should they be approached in a way to achieve data compatibility, but also one should be explicit about their methods and data collection strategies so that the audience understands the potential of the dataset. For these reasons over the course of zooarchaeological research history, specialists have established standardized instruments for data collection and its analysis to mitigate biases and to provide universal, comparative benchmarks.⁹⁸ In addition, methodologies and strategies are adopted in the light of project-specific conditions. For example, given the extreme encrustations on the surface of bones from Kaymakçı as well as the large assemblages of broken bones, care is taken to sort carefully and choose the best quality (in terms of preservation and condition) material from the entire assemblage. Working with encrusted and broken materials presents challenges, and the heavy encrustations of material from KAP is a real hurdle.

Considering potential changes over time, allows the researcher to apply the most appropriate approaches for data analyses and to focus their research questions accordingly. Given the long-term impact from deposition in the soil through extraction, archaeologists need to make multiple decisions prior to the excavation. Importantly, anthropogenic changes happen over the course of excavation too: excavating, sampling, analyzing, and storing;⁹⁹ while taphonomic changes in the archaeological record may also have been altered by climatic conditions (temperature, humidity, etc.) or bioturbation. Such standardized methods of recording are crucial to ensure data representativeness and consistency. With these considerations in mind, one always should be aware that the recovered faunal assemblages from excavation will only be (at best) a relatively poor representation of the past living animal populations (see Fig 3.1).

Following known and established scholarship and identification methods provide a baseline for studying a faunal assemblage. There are certain strategies of primary data collection that guide high-quality research and mitigate bias. Best practice for zooarchaeological scholarships consists of three parts: (1) identification, (2) analysis, and (3) interpretation.¹⁰⁰ The fundamental difference between primary and secondary data is

⁹⁸ Terence P. O'Connor and Terry O'Connor. *The archaeology of animal bones*. No. 4. (Texas A&M University Press, 2008): 19-25.

⁹⁹ Reitz and Wing, 2008: 123-134.

¹⁰⁰ Reitz and Wing, 2008: 153.

that primary data covers the identification and secondary data covers the analysis.¹⁰¹ While primary data is the observations of the study assemblage, secondary data is derived from primary data by means of indices and other qualification methods.¹⁰² This chapter presents primary and secondary data collection strategies that have been established by KAP specialists over the years. I explain the methodological framework of these strategies and introduce our study assemblage.

The processes that impact the taphonomy of archaeological contexts have been studied by a number of zooarchaeological specialists.¹⁰³ The essential point is to describe what happened to the bone overtime as part of the research process. An idealized representation is shown in Figure 3.1. This type of objective process embedded in the research agenda helps to avoid biases and misguided interpretations. Once the zooarchaeologist understands the taphonomic alterations and what caused them, then the specialist can begin a detailed study of the assemblage. For KAP, there are clear protocols involved in the collection of taphonomic data in the field, and further, approaches for recording additional considerations of contextual disturbance during laboratory analysis.¹⁰⁴ In this way, we ensure uniformity of the data, while mitigating bias as much as possible.

¹⁰¹ Reitz and Wing, 2008: 153.; Anneke T. Clason. "Some Remarks on the Use and Presentation of Archaeozoological Data". *Helinium* 12(2) 1972:139–53.

¹⁰² Reitz and Wing, 2008: 153.

¹⁰³ R. Lee Lyman. "What taphonomy is, what it isn't, and why taphonomists should care about the difference." *Journal of Taphonomy* 8, no. 1 (2010): 1-16.; O'Connor and O'Connor, 2008; Polydora Baker, and Fay Worley. *Animal bones and archaeology: Guidelines for best practice*. (Swindon: English Heritage, 2014): 3-50.

¹⁰⁴ Kaymakçı Archaeological Projects. "Kaymakçı Faunal Protocol" eds. Canan Çakırlar and Francesca Slim. *Kaymakçı Archaeological Projects*. 2018.

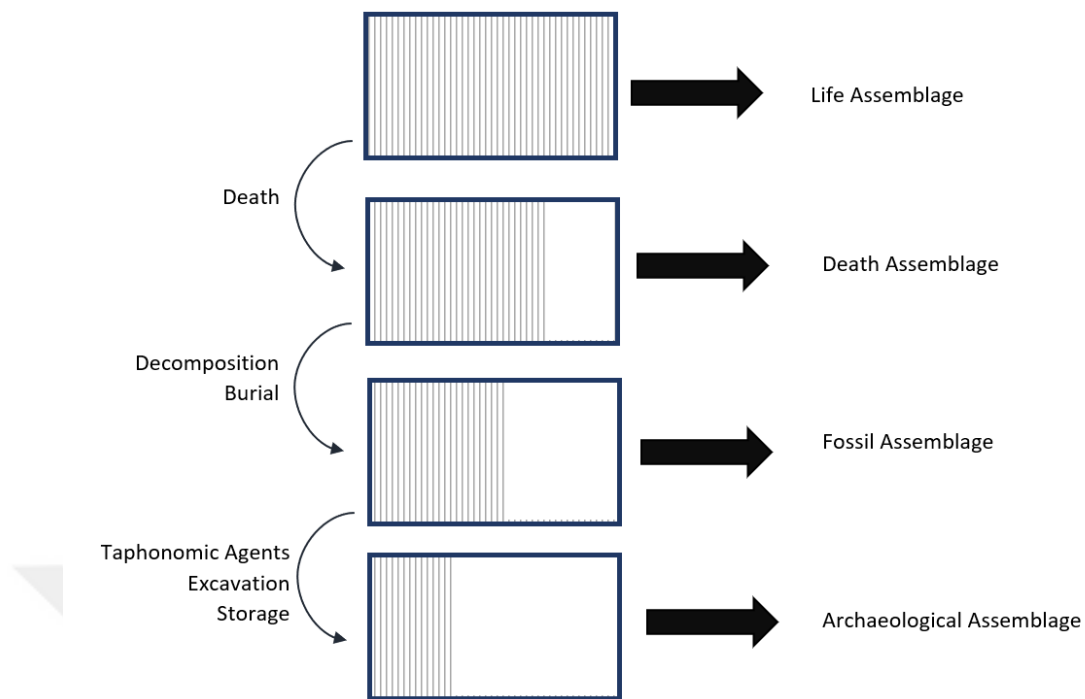


Figure 3.1: Modeled taphonomic history of a biotic community or life assemblage (after Lyman, 1994:19)

3.2.1 Identification of the Faunal Remains

To identify the material from its taxonomic composition by looking at bone morphology we, as KAP researchers, use different reference materials. Most importantly, our reference collection on-site includes a variety of species of both domestic and wild animals. Its diachronic nature allows us to have excellent baselines for species over time as well as gender (i.e., modern vs ancient). We consult established identifications from the ongoing literature including the work of expert Schmid (for mammals), Brinkhuizen, Radu (for fish), Cohen and Serjeantson (for birds), Claassen (for mollusks), and Prummel (for foetal bones)¹⁰⁵. We also follow best practices for negotiating the differences between

¹⁰⁵ Elisabeth Schmid. *Atlas of animal bones*. (Elsevier. 1972).; Alan Cohen and Dale Serjeantson. *A manual for the identification of bird bones from archaeological sites*. (Archetype Publications, 1996).; Dick Constantijn Brinkhuizen. "Ichthyo-archelologisch onderzoek: methoden en toepassing aan de hand van Romeins vismateriaal uit Velsen (Nedeland)." (1989).; Cheryl Claassen. *Shells*. (Cambridge University Press, 1998).; Wietske Prummel. "Atlas for Identification of Foetal Skeletal Elements of Cattle, Horse, Sheep and Pig Part 2" *Archaeozoologia*. (1987): 11-41.; Valentin Radu "Atlas for the Identification of Bony Fish Bones from Archaeological Sites." *Contrast*, 2005.

sheep and goat through the expertise of Zeder and Lapham¹⁰⁶ for postcranial bones, and Zeder and Pilaar¹⁰⁷ for teeth.

The identification procedure consists of 2 main phases: first, we record all the specimens in terms of their taxonomic identification into the database form called “Quick NISP” (QNISP). The data in the QNISP tables show the excavation contexts’ taxonomic diversity and provide rough NISP data. Secondly, we analyze bones in detail. This process includes taxonomic description, element, portion, side, fusion, sex, age estimation, tooth wear, pathologies, burning, butchery or gnawing marks, and taphonomy.

3.2.2 Age at Death

Age at death is one of the fundamental baselines for studying ancient animals. The growth rate of a population can be used to construct mortality profiles.¹⁰⁸ The epiphyseal fusion, tooth eruption, tooth wear, and growth increments are the main proxies yielding information on age at death.¹⁰⁹ This primary data is used to construct mortality profiles.

As bones grow, the epiphyses and diaphysis fuses together and eventually the fusion lines become near invisible. Even so, we can see these through macro and microscopic analyses and importantly the fusion lines yield the age or the relative stage of growth of the respective individual. The fusion of the bones across mammals is generally consistent, although the sequence of timing of the fusion varies remarkably by species.¹¹⁰ There are three categories for the status of fusion: unfused (two separate fusion lines), fusing (fusion line visible), and fused (no fusion line, one compact bone).¹¹¹ Many bones fuse in a different range of time due to the bone structure, formation, and ossification.¹¹² The general estimation of the age is also possible by looking at the relevant stage of fusion as well. Specialists most often use bone fusion baselines to assess the early stages of life -- usually bones fuse within the first 36 months of life in mammals¹¹³.

¹⁰⁶ Melinda A. Zeder and Heather A. Lapham. "Assessing the reliability of criteria used to identify postcranial bones in sheep, Ovis, and goats, Capra." *Journal of Archaeological Science* 37.11 (2010): 2887-2905.

¹⁰⁷ Melinda A. Zeder and Suzanne E. Pilaar. "Assessing the reliability of criteria used to identify mandibles and mandibular teeth in sheep, Ovis, and goats, Capra." *Journal of Archaeological Science* 37, no. 2 (2010): 225-242.

¹⁰⁸ Reitz and Wing, 2008: 192-199.

¹⁰⁹ Reitz and Wing, 2008: 192-199.

¹¹⁰ Reitz and Wing, 2008: 72-73

¹¹¹ Reitz and Wing, 2008: 197.

¹¹² Simon J. M. Davis. *The Archaeology of Animals (1st ed.)*. (Routledge. 1987): 47-53.

¹¹³ Reitz and Wing, 2008: 72.

Tooth eruption and wear patterns are another excellent way study an individual's life. Not only wear, which increases with aging due to usage, but also deciduous and permanent tooth presence yields the age range of the individual. The teeth of domestic ruminants (e.g., goats, sheep, cattle) are incremental tissues that form from cusp to cervix over the course of the first one to two years of life, with the exception perhaps of the third molar which can form later in pre-adulthood.¹¹⁴ For tooth wear, we follow Grant's¹¹⁵ wear schemes.

In turn, it is possible to reconstruct age classes in a given assemblage. The different patterns in age classes display animal management patterns eventually; in domestic mammals, for example, if a wide range of age is present it would indicate that animals were raised and consumed at the site, if a restricted age class is present it would indicate that animals were imported, or if prime-aged animals were missing it would indicate that animals were raised and/or consumed elsewhere.¹¹⁶ Although the exact age for animals to determine is impossible because it would be necessary to know when the animal was born¹¹⁷, for the secondary data analyses we use different age range manuals along with Grant (see 3.3.3.) which allows us to have a broad understanding towards the possible age classes.

3.2.3 Sex

Many animals show size differences between male and female populations which is called the sexual dimorphism.¹¹⁸ We use biometric measurements and size, if possible, to distinguish between male and female specimens, ergo sexual dimorphism. Biometric measurements and size allow us to estimate sex ratios within a population and across different populations. For biometric measurements we follow Von den Driesch.¹¹⁹ We also attest sex through pelvis, if present.

¹¹⁴ Julia A. Lee-Thorp. "On isotopes and old bones." *Archaeometry* 50, no. 6 (2008): 925-950.; Simon Hillson. *Teeth*. (Cambridge University Press, 2005).

¹¹⁵ Annie Grant. "The Use of Tooth Wear as a Guide to the Age of Domestic Animals." In *Ageing and Sexing Animal Bones from Archaeological Sites*, eds. B. Wilson, C. Grigson, and S. Payne. (1982): 91–108.

¹¹⁶ Reitz and Wing, 2008: 192.

¹¹⁷ Reitz and Wing, 2008: 192.

¹¹⁸ Reitz and Wing, 2008: 64.

¹¹⁹ Angela von den Driesch. *A guide to the measurement of animal bones from archaeological sites: as developed by the Institut für Palaeoanatomie, Domestikationsforschung und Geschichte der Tiermedizin of the University of Munich*. Vol. 1. (Peabody Museum Press, 1976).

3.2.4 Measurements

Taking osteometric measurements is a crucial part of our work at KAP. The data obtained from the osteometric measurements provide a wide range of baselines to understand further variations in domestic vs wild species, relative sexual dimorphism, and demographic sex reconstruction – even castration. We follow von den Driesch¹²⁰ for all ungulates.

3.2.5 Pathologies

The aim of the exploration of the paleopathology of the animals is to understand their relationship(s) with their natural environment and humans. This allows for an analysis of the diseases and injuries that impact their lives.¹²¹ The data obtained from archaeological animal pathologies provides an in-depth understanding of hunting strategies and butchering practices. For the KAP assemblage, we record and describe the pathologies. For an in depth understanding, we consult the expert studies on animal paleopathology such as Bartosiewicz¹²², and Bartosiewicz and Gál.¹²³ For cattle autopodia parts we follow Bartosiewicz and colleagues.¹²⁴

3.2.6 Butchering Marks

Recording butchering marks, or cut marks, is one of the key points to understand how people exploited animals. The aspects of carcass processing yield information about economic and social aspects of human behavior. These patterns provide chronological assessments of intra- and inter-settlement variations.¹²⁵ For this reason, the evidence of butchering and bone working is a critical component of analysis in conjunction with the relative abundance of the skeletal elements.¹²⁶ In KAP, our basis for butchering marks is the scholarship of Binford¹²⁷.

¹²⁰ Von den Driesch, 1976.

¹²¹ Baker and Worley, 2014.

¹²² László Bartosiewicz. "Taphonomy and Palaeopathology in Archaeozoology." *Geobios* 41, no. 1 (2008): 69-77.

¹²³ László Bartosiewicz and Erika Gál. *Shuffling nags, lame ducks: The archaeology of animal disease*. (Oxbow books, 2013).

¹²⁴ László Bartosiewicz, Willem Van Neer, and An Lentacker. *Draught cattle: their osteological identification and history*. Verturen, V. 281. 1997.

¹²⁵ Baker and Worley, 2014.

¹²⁶ Baker and Worley, 2014.

¹²⁷ Lewis R. Binford, *Bones: Ancient men and modern myths* (Academic Press, Inc., 1981).

3.3 Secondary Data Analysis & Interpretation

As emphasized, gathering data and reconstructing past animal populations requires several steps. Primary data gathering is the first step. Deriving secondary data to estimate relative proportions or specific indices from primary data is also fundamental.¹²⁸ In other words, secondary data are the methods of interpretations of the primary data; so, it is not direct measurements.¹²⁹ Hence, relative to primary data, secondary data are less descriptive and more subjective; it involves major statistical analyses from primary data.¹³⁰ By its nature, secondary data are about summaries, observations, explanations, and interpretations which have been causing numerous disagreements and critiques among zooarchaeologists about credibility and accuracy.¹³¹ However, for the sake of grasping a bigger picture, secondary data analyses are a fundamental part of zooarchaeological research.

This section explains the methods that have been used for the analyses of the assemblage presented in this thesis: estimates on relative taxonomic abundances, skeletal part distribution, reconstructing mortality profiles, and estimates on body dimensions and biometry. All of these concepts are interrelated and enlightens my research questions. The secondary data analyses depend on modern, ethnographic, and experimental methods¹³² due to the fact that archaeological assemblages not always statistically reliable (i.e., taphonomy, excavation strategies). However, those ethnographic studies should be taken in careful consideration in terms of their distinctive aspects in contrast to the archaeological assemblage; archaeological assemblages mirror a relatively small range of environmental diversity, over a relatively short time span, and oscillations among samples

¹²⁸ Reitz and Wing, 2008: 182-83.

¹²⁹ Reitz and Wing, 2008: 182-83.

¹³⁰ Reitz and Wing, 2008: 182-83.

¹³¹ Reitz and Wing, 2008: 182-83.

¹³² Melinda A. Zeder. "A Metrical Analysis of a Collection of Modern Goats (*Capra hircus aegargus* and *C. h. hircus*) from Iran and Iraq: Implications for the Study of Caprine Domestication." *Journal of Archaeological Science* 28, no. 1 (2001): 61-79.; Zbigniew M. Bocheński, and Teresa Tomek. "Identification of bones of galliform hybrids." *Journal of archaeological science* 27, no. 8 (2000): 691-698.; Frank J. Dirrigl Jr. "Bone mineral density of wild turkey (*Meleagris gallopavo*) skeletal elements and its effect on differential survivorship." *Journal of Archaeological Science* 28, no. 8 (2001): 817-832.; Brian W. Hoffman, Jessica MC Czederpiltz, and Megan A. Partlow. "Heads or tails: the zooarchaeology of Aleut salmon storage on Unimak Island, Alaska." *Journal of archaeological science* 27, no. 8 (2000): 699-708.; Patrick M. Lubinski and Christopher J O'Brien. "Observations on Seasonality and Mortality from a Recent Catastrophic Death Assemblage" *Journal of archaeological science* 28, no. 8 (2001): 833.

regarding their biological, chemical, and physiological facets.¹³³ Therefore, all the applications explained below were used cautiously to minimize bias.

3.3.1 *Estimating Relative Taxonomic Abundances*

The aim of estimating taxonomic abundances is to establish the relative frequency of all the species introduced in the site.¹³⁴ Such understanding would not only reveal the prominent taxa, but also stimulate synchronic and diachronic apprehension of environmental conditions, species succession, people's diet, and in turn impact how we come to understand subsistence strategies.¹³⁵ Changes on the taxonomic abundance may indicate a shift in the population and culture, domestication, and climate change.¹³⁶ In this study, two units of quantification were used: the Number of Identified Specimens (NISP) method¹³⁷, which is determined by specimen count, and the Diagnostic Zones method (DZ)¹³⁸, which is determined by specimen selection strategies to reconstruct relative frequencies of taxa.

The fundamental facet of NISP is to count only *identifiable* specimens.¹³⁹ Although NISP is generally considered as method for assessing primary data which has been subject to ongoing scholarly debates¹⁴⁰, here I consider NISP as a method for assessing secondary data because it involves a certain degree of manipulation of the data. In a faunal assemblage, bones are likely to have been either shattered or broken overtime. Consequently, these specimens have essentially lost their diagnostic elements to determine identification at the species level. These fragmentary specimens are generally recorded as *unidentifiable* or *indeterminate* – at least at the initial phase of gross assessment for a general view of the entire zooarchaeological assemblage. The biggest advantage of NISP over other analyses is that it is additive; in other words, it does not require to recalculate NISP in every new bone record.¹⁴¹ It is considered a foundational

¹³³ Reitz and Wing, 2008: 182-83.

¹³⁴ R. Lee Lyman. *Quantitative paleozoology*. (Cambridge University Press, 2008): 21-26.

¹³⁵ Reitz and Wing, 2008: 202-210.

¹³⁶ Reitz and Wing, 2008: 202.

¹³⁷ Reitz and Wing, 2008: 202-205.; Lyman, 2008.

¹³⁸ J. P. N. Watson, 'Fragmentation Analysis of Animal Bone Samples From Archaeological Sites' *Archaeometry*, 14(2), (1972): 221–228.; J. P. N. Watson. 'The estimation of the relative frequencies of mammalian species: Khirakitia 1972', *Journal of Archaeological Science*, 6(2), 1979): 127–137.

¹³⁹ Reitz and Wing, 2008: 202-205.

¹⁴⁰ O'Connor and O'Connor, 2008.

¹⁴¹ Lyman, 2008.

analysis, and in one way or another all the faunal analyses require a baseline assessment that follows a NISP approach.¹⁴² Even so, there are problematic considerations for NISP. Using identifiable specimen count to estimate taxonomic abundance does not reflect the actual living assemblage.¹⁴³ One should always be aware that all taxa and elements have different recovery rates and count opportunities. For example, the spongy ends of long bones are less likely to survive in taphonomic agents while shafts are more concrete and likely to survive.¹⁴⁴ Therefore, interpreting NISP datasets requires this type of consideration. To be sure, even some of the elements from the same individual are more likely to survive while some are not.¹⁴⁵ Such differences from the individual level to site-specific characteristics of bone preservation and taphonomy are crucial to remember.

The Diagnostic Zone method is applied *sensu* Watson¹⁴⁶ and it is embedded in KAP's faunal analysis protocol. This approach is embraced to have more uniform and equally represented data while avoiding possible biases. Moreover, the DZ method corrects the personal interpretations during recording bones into the database by only counting bones that have proximal and/or distal ends. The surface of the articular end(s) must be intact enough so that one would avoid counting the same specimen more than once. In theory, the end results and corresponding percentages of both NISP and DZ are expected to be positively correlated in mammals.¹⁴⁷

3.3.1.1: Sheep Equivalent Factor

Proportional changes among species might affect the perception towards importance and their contribution to the diet. Analyzing the potential meat contribution of domestic species at Kaymakçı is an important tool to understand human diet and initial choices. Cattle yield far more meat than sheep, goat, and pigs, thus their contribution in human diet is far more than their number of bones would suggest.¹⁴⁸ Sheep equivalent

¹⁴² Lyman, 2008; Reitz and Wing, 2008: 202-205.

¹⁴³ Richard H. Meadow. "Animal bones: problems for the archaeologist together with some possible solutions." *Paléorient* (1980): 65-77.

¹⁴⁴ Meadow, 1980: 68.

¹⁴⁵ Reitz and Wing, 2008: 202-205.; Lyman 2008.

¹⁴⁶ Watson, 1972; Watson 1979.

¹⁴⁷ Reitz and Wing, 2008: 213-19.

¹⁴⁸ Nerissa Russell *et al.*, "More on the Çatalhöyük Mammal Remains." In the *Humans and Landscapes of Çatalhöyük: Reports from the 2003-2009 Seasons at Çatalhöyük* eds. Ian Hodder. (Cotsen Institute, 2012): 213-258.

factor analysis corrects the proportions of live weight of each species.¹⁴⁹ It considers sheep's live weight percentage as 1, and calculating each species actual weight (for cattle: 700 kg; sheep: 25 kg; goat: 25 kg; pig: 30 kg) by multiplying sheep equivalent factor, it is possible to have a relative meat contribution model of an assemblage.¹⁵⁰ The model calculations are based on DZ values, as applied by Russel and Martin, and Kamjan *et al.*¹⁵¹

3.3.2 Body Part Distribution

Skeletal frequency is the distribution of body parts within an archaeological context as well as across the settlement(s). The potential outcome of this analysis is to comprehend the variations of how animal remains come to be part of the archaeological record. This involves understanding the social contexts of human-animal relationships and the conditions and moments of an animal's death. These include variation among commensal animals, food supplier animals, animals having ritual purposes, and other non-food suppliers¹⁵²; along with the reconstruction of socioeconomic profiles. The concept in this type of analysis also underlies assessment of postmortem changes.¹⁵³ The basic approach is that individuals that died from natural causes, lived in or near site, or did not serve food purposes are expected to have more complete skeletons. Individuals that were provisioned for food and/or kept outside of the site, as well as wild animals (i.e., those that were hunted) are expected to be less skeletally complete in the archaeological record.¹⁵⁴ We must also keep in mind that the economic value of the certain portions of the bones (e.g., meat yielding parts like limbs) would have been higher than others, and thus we may not see these in the archaeological record (i.e., cooked for stews, etc.). Let's

¹⁴⁹ Anneke T. Clason. "Some aspects of stock-breeding and hunting in the period after the Bandceramic culture north of the Alps." In *Domestikationsforschung und Geschichte der Haustiere Internationales Symposium in Budapest*. (1973): 205-212.

¹⁵⁰ Clason, 1973: 207-208; Russel et al., 2013: 216-218.

¹⁵¹ Nerissa Russell and Louise Martin. "The Çatalhöyük Mammal Remains". In *Inhabiting Catalhöyük: reports from the 1995-1999 seasons*. Eds. Ian Hodder. (McDonald Institute Monographs series: Excavation Reports (4). McDonald Institute for Archaeological Research, Cambridge, UK. 2005): 33-98.; Safoora Kamjan *et al.*, "The emergence and evolution of Neolithic cattle farming in southeastern Europe: New zooarchaeological and stable isotope data from Džuljunica-Smārdeš, in northeastern Bulgaria (ca. 6200–5500 cal. BCE)." *Journal of Archaeological Science: Reports* 36 (2021).

¹⁵² Reitz and Wing, 2008: 213-16.

¹⁵³ J. Arnold Shotwell. "An Approach to the Paleoecology of Mammals". *Ecology*, 36 (1955): 327-337.

¹⁵⁴ Michael R. Voorhies. *Taphonomy and population dynamics of an early Pliocene vertebrate fauna, Knox County, Nebraska*. Vol. 1. (Laramie: University of Wyoming, 1969).

consider this further. For example, when an animal is killed far from a site, the logical approach is to transport home only what is needed. Of course, depending on the end goal, the portions of the animal transported will vary. This includes whether the animal was primarily coveted for meat, ritual related elements, or other needs. For example, if the individual were of economic value (including for trade), even if it was culled within the site, the disarticulated portions would have likely been separated. Keep in mind that there was great value – from intra-settlement use and prestige to external trade- in all parts of the animal, not merely the meaty parts; these include hooves, tails, fur and skins as well as ideal parts for tools, ornaments, and even gaming pieces.¹⁵⁵

In addition the interpretations of skeletal distribution and completeness must also consider the site's environmental and cultural structure: more intact skeletons would indicate the animals' habitat was close by, and thus it was more likely that they were killed nearby and thus could have been transported and delivered on site in their entirety for ritual purposes; more scattered skeletons are believed to indicate the provisioning, trade and transport, specialized work distribution, such as butchering or extensive taphonomic agents.¹⁵⁶ Although such interpretations do not include information on the dietary contributions, with some further analysis, this data premises a certain level of dietary contribution understanding.

The skeletal frequency is analyzed with the Minimum Anatomical Units (MAU) and Minimum Number of Elements (MNE) values *sensu* Binford.¹⁵⁷ DZ values are used as the moderator, rather than NISP. The five anatomical units are followed by the definition of Arbuckle.¹⁵⁸

MNE is considered as base quantitative unit for MAU.¹⁵⁹ MNE values are calculated through examining number of sides in paired elements. For example, if there are 10 humeri, the MNE would be 5 and if there are 10 atlases, the MNE would be 10. MAU calculates the frequency with which skeletal part or element is present in an assemblage, and it presents more interpretable results since it has fundamentally

¹⁵⁵ Reitz and Wing, 2008: 213-16.

¹⁵⁶ Reitz and Wing, 2008: 213-16.

¹⁵⁷ Lewis R. Binford, *Faunal Remains from Klasies River Mouth: Monograph*. (Academic Press, Inc., 1984): 50-51.

¹⁵⁸ Benjamin S. Arbuckle, Aliye Öztan, and Sevil Gülçür. "The evolution of sheep and goat husbandry in central Anatolia." *Anthropozoologica* 44, no. 1. (2009): 129-157.

¹⁵⁹ Lyman, 2008: 214.

standardized from MNE.¹⁶⁰ Therefore, MAU facilitates the frequency of the skeletal parts, rather than the number of times the skeletal part or element is appeared.¹⁶¹ For example, if there is a proximal femur present, MAU calculates it as a 0.5 value, whereas other frequency units may calculate a proximal femur as an individual (e.g., Minimum Number of Individuals - MNI).¹⁶² MAU(MNE) values are calculated by dividing MNE for each element by the number of times each element appears in a complete skeleton.

MAU(MNE) = (MNE value for that specific element -e.g., tibia, metapodials, phalanges) / (# of times that element is present in a skeleton -e.g., 2 for tibia, 4 for metapodials, 24 for phalanges).

3.3.3 Mortality Profiles and Kill-Off Patterns

Constructing mortality profiles is a useful tool to understand husbandry strategies. Such profiles shed light on the questions about seasonality, secondary product exploitation (e.g., milk exploitation, wool accumulation, and traction power), breeding strategies, domestication processes, value of the animal as wealth, and even wildlife management.¹⁶³ The targeted age of death of the animals is a choice made by people, unless of course animals die from natural causes. However, as most of the secondary data analyses, one should be aware of the absence of patterned culling ages does not necessarily mean that there were no strategies. In fact, it is almost impossible to construct bias-free profiles from only taphonomic and anthropogenic reasons as well as the conditions of the bones.¹⁶⁴ Taphonomic agents and the distribution of the bones across the site likely conceal the full picture. Therefore, one should be aware of the full opportunities and pitfalls represented in the respective dataset.

There are two major approaches in mammalian zooarchaeology to construct mortality profiles: epiphyseal fusion and tooth wear, tooth eruption and growth increments.¹⁶⁵ For epiphyseal fusion, the definition and analysis methods of Reitz and

¹⁶⁰ Benjamin S. Arbuckle. "The evolution of sheep and goat pastoralism and social complexity in Central Anatolia". (*Harvard University*, 2006): 146-154.

¹⁶¹ Binford, 1984: 77-84, Arbuckle 2006: 146-154.

¹⁶² Binford, 1984: 82.

¹⁶³ Bea De Cupere, Refik Duru, and Gülsün Umurtak. "Animal husbandry at the Early Neolithic to Early Bronze Age site of Bademağacı (Antalya province, SW Turkey): evidence from the faunal remains." *MOM Éditions* 49, no. 1 (2008): 367-405.; Reitz and Wing, 2008: 70-73, 192-96.

¹⁶⁴ Sebastian Payne. "Kill-off patterns in sheep and goats: the mandibles from Aşvan Kale." *Anatolian studies* 23 (1973): 281-303.

¹⁶⁵ Reitz and Wing, 2008: 70-73.

Wing¹⁶⁶ is followed. Mandibular Tooth Wear (MTW) is measured according to Grant¹⁶⁷ and analyzed more specifically accordingly to Jones and Sadler.¹⁶⁸ In this study, I used mandibular premolar 4 and mandibular deciduous premolar 4 in order to mitigate biases regarding intrapopulation physiological differences (e.g., diseases, nutrition availability). Following Jones and Sadler, I assess age classes, and apply even more rigor with the approaches outlined by Halstead¹⁶⁹ and Legge.¹⁷⁰ In turn, I hope to have as comprehensive model as possible.

3.3.4 Estimating Body Dimensions and Using Biometry

Estimates of body dimensions unveil numerous vital aspects of animal management strategies, namely: herding practices, changes in hunting strategies, predation by nonhuman agents, environmental changes (food availability, climate, sexual dimorphism) and domestication.¹⁷¹ Body size reflects human behavioral practices such as capturing strategies, selective hunting, exploitation, and animals' reactions towards them.¹⁷² To understand the changes in body size over time, and within the same herd, one should consider a range of variables including age, sex, nutrition availability, geographical constraints, and individual differences.¹⁷³ Ideally, in a single population, a normal distribution is expected with age and sex differences.¹⁷⁴ In certain cases of cattle castration practices, we would predict one peak overlapping or higher than the male average; and if there were two distinct non-lapping peaks, this pattern would be an indicator of separate husbandry practices¹⁷⁵. This data, coupled with paleo-ethnobotany

¹⁶⁶ Reitz and Wing, 2008: 70-73.

¹⁶⁷ Grant, 1982: 91-108.

¹⁶⁸ Gillian G. Jones and Peta Sadler. "Age at death in cattle: methods, older cattle and known-age reference material." *Environmental Archaeology* 17, no. 1 (2012): 11-28.

¹⁶⁹ Paul Halstead. "A study of mandibular teeth from Romano-British contexts at Maxey." In *The Fenland Project: Archaeology and Environment in the Lower Welland Valley, Volume 1. East Anglian Archaeology Report, No. 27*. Eds. F. Pryor et al., (The Fenland Project Committee, Cambridgeshire Archaeological Committee. 1985): 219-224.

¹⁷⁰ Anthony J. Legge. *Excavations at Grimes Graves, Norfolk, 1972-76: Fascicule 4 Animals, Environment and the Bronze Age Economy*. (London: British Museum Press, 1992).

¹⁷¹ Reitz and Wing 2008: 183-86; R. Lee Lyman. "Quantitative units and terminology in zooarchaeology." *American Antiquity* 59, no. 1 (1994): 36-71.

¹⁷² Reitz and Wing, 2008: 183-86.

¹⁷³ Reitz and Wing, 2008: 183-86.

¹⁷⁴ David C. Orton. "Biometry in Zooarchaeology". In *Encyclopedia of Global Archaeology* edited by C. Smith. (Springer, New York, NY. 2014)

¹⁷⁵ Michael MacKinnon. "Cattle 'breed' variation and improvement in Roman Italy: connecting the zooarchaeological and ancient textual evidence." *World Archaeology* 42, no. 1 (2010): 55-73.; Umberto

and isotope evidence, such as fodder provisioning, would strongly indicate the nutritional changes or maintenance tactics.¹⁷⁶ Importantly, if these practices are found to be positively correlated with demographic age data, it would indicate culling practices.¹⁷⁷ In turn, this proxy would serve as greater data for primary and secondary products; if a correlation is found with demographic sex data, it would show the animal domestication relevant to the sexual dimorphism.¹⁷⁸

With this broad outline of zooarchaeological methodological approach, I chose to hone my expertise further. My approach to an investigation of sex ratios among cattle drew from the Logarithmic Size Index (LSI) method.¹⁷⁹ Calculation of the LSI [$\log x - \log m = \log (x/m)$, where x corresponds the measurement of the sample and m corresponds the measurement of the standard reference] is one of the elemental methods of osteometric analyses used by zooarchaeologists.¹⁸⁰ LSI was used to assess the adult and subadult cattle populations from Kaymakçı. Importantly, for this analysis, I used only postcranial elements' measurements, following Degerbøl.¹⁸¹

Albarella. 'Size matters: how and why biometry is still important in zooarchaeology', in Dobney, K. and O'Connor, T. (eds) (*Bones and the man. Studies in honour of Don Brothwell*. Oxbow Books 2002): 51–62.

¹⁷⁶ Reitz and Wing, 2008: 82-87; Mark S. Copley *et al.*, "Short-and long-term foraging and foddering strategies of domesticated animals from Qasr Ibrim, Egypt." *Journal of Archaeological Science* 31, no. 9 (2004): 1273-1286.

¹⁷⁷ Reitz and Wing, 2008: 183-194.

¹⁷⁸ Reitz and Wing, 2008: 183-194.

¹⁷⁹ Richard H. Meadow. "The Use of Size Index Scaling Techniques for Research on Archaeozoological Collections from the Middle East." In *Historia Animalium ex Ossibus: Beiträge auf Paläoanatomie, Archäologie, Ägyptologie, Ethnologie und Geschichte der Tiermedizin*, eds. C. Becker, H. Manhart, J. Peters, and J. Schibler, (Rahden/Westf: Verlag Marie Leidorf, 1999): 285-300.

¹⁸⁰ Meadow, 1999.

¹⁸¹ Magnus Degerbøl. "Urus (*Bos primigenius bojanus*) and neolithic domesticated cattle (*Bos taurus domesticus* Linne) in Denmark with a revision of *Bos*-remains from the Kitchen Middens." (AGRIS, 1970).

Chapter 4:

RESULTS

The results presented here complement the preliminary review of animal management systems in western Anatolia in the Late Bronze Age in Chapter 2 with detailed analyses of the cattle of Kaymakçı. As discussed in Chapter 1, an investigation of Kaymakçı cattle offers a proxy to our understanding of herd management strategies for western Anatolia. Animal economies at Kaymakçı are investigated through taxonomic diversity and relative abundance analyses. Specifically, the NISP and DZ methods (see Chapter 3) are used. Kaymakçı cattle are compared in terms of abundance to neighboring cultural zones, all known to have been influenced by Hittite cultural traditions. Body part representation and skeletal frequencies of cattle are investigated to explore spatial distribution of the cattle's body parts. Importantly, I draw on analyses of survivorship and mortality profiles of cattle through investigation of tooth wear and epiphyseal fusion. These data provide a window into herd management activities, which in turn are possible proxies for the social and political structure of the community. Finally, osteometric analyses allow me to distinguish internal variations within Kaymakçı's cattle population, which in turn provide data that indicate demographic sex classes as well as the possibility of castration. All these elements allow for a nuanced analysis of the scale and scope of human-cattle relationships at Kaymakçı, as described in the previous chapters.

4.1 Kaymakçı: Taxonomic Diversity and Relative Abundance

Kaymakçı was a welcoming place to many animal species, largely due to its surroundings with a very temperate inland Mediterranean climate, and location amongst a variety of environmental niches such as wetlands, rivers, and lakes as well as gentle slopes and steep mountains. Of the animal remains thus far recovered from excavations at Kaymakçı 66% have been identified to at least the species level (seldom to the genus). Of these 82% can be identified as “domestic food animals” (Table 4.1). These include cattle (*Bos taurus*), sheep (*Ovis aries*), goat (*Capra hircus*), and pig (*Sus domesticus*). The relatively high abundance of these animals supports the idea that Kaymakçı relied heavily on animal husbandry and exploitation – in fact, the data suggest that within this population there would have been a particularly protein-rich diet of meat and by extension

the use of dairy.¹⁸² The rare non-food domesticates are represented by dog, cat, horse, and donkey. New research by Price, Meier and Arbuckle points to the evidence that dogs may be regarded as food sources in the Bronze Age Near East¹⁸³, and this point is discussed further in Chapter 5; at this time firm evidence of dog consumption at Kaymakçı has yet to be confirmed. The wild taxa at Kaymakçı are diverse, as shown in the current list of identified species illustrated in Appendix 1. At least half of the large game animals are deer species: fallow deer (*Dama dama*), red deer (*Cervus elaphus*), and roe deer (*Capreolus capreolus*), respectively; fallow deer outnumber the others by 42%. There is also an evidence for tortoise (*Testudo* sp.) and European hare (*Lepus capensis*).¹⁸⁴ Large, exotic species such as several brown bear (*Ursus arctos*), one large felid (*Felidae* sp. - *Lynx lynx*?), and a very large mammal (possible hippopotamus/elephant/whale) are also included Kaymakçı's assemblage.

Animal Category	Number of identified specimens	% of total identified specimens
Domestic food animals	7181	82%
Domestic non-food animals	156	2%
Wild animals	649	7%
Fish	628	7%
Bird	81	1%
Mollusk	111	1%
Total	8806	100%

Table 4.1: Number of Identified Specimens (NISP) and relative abundance for the main animal categories of Kaymakçı.

Given the close proximity of Lake Marmara, it is no surprise that the assemblage from Kaymakçı yields deer, fish and other wetland species. Silurids and cyprinids (respectively catfish and carp families) make up most of the identified fish remains. Several of those fish bones are very large. Within the 111 remains of mollusks, there is evidence of both freshwater shells (*Unio* sp.) and marine shell species, including *Conus mediterraneus*, *Cerastoderma* sp., *Neverita* sp., *Monodonta* sp., and *Pinna* sp. Overall, and interestingly birds are relatively rare in the assemblage.¹⁸⁵

¹⁸² Marston *et al.*, 2021.

¹⁸³ Max Price, Jacqueline Meier and Benjamin Arbuckle "Canine Economies of the Ancient Near East and Eastern Mediterranean" *Journal of Field Archaeology*, 46.2. (2020): 81-92.

¹⁸⁴ Tortoise remains were found close to the topsoil, perhaps more indicative of later activities (although no other material evidence suggests later cultural activity). In contrast, there is much more precise stratigraphy for hare.

¹⁸⁵ After a full analysis of the heavy fraction is complete, this image might shift.

Turning now to the main domesticates of cattle, sheep, goat, and pig, I offer additional details (Table 4.2). Absolute and relative abundance were calculated through NISP and DZ (Figure 4.1). Pigs are the most prominent taxon with 44%; a sheep/goat category follows with 23% of DZ. Unfortunately, even with rigorous analysis, the sheep and goat bones are difficult to differentiate, a common challenge in zooarchaeological work and made more challenging by the heavy encrustation on many of the Kaymakçı bones (See Chapter 3). From the ongoing analyses, sheep appear more abundant than goat with a respective ratio of 2:1. After pig and sheep/goat, cattle is the most prominent taxon with approximately 13% of the assemblage.

Main Domesticates	Number of Identified Specimens	% of total Identified Specimens	Number of Diagnostic Zones	% of total Diagnostic Zones
Cattle (<i>Bos taurus</i>)	822	11%	312	13%
Sheep (<i>Ovis aries</i>)	602	8%	315	13%
Goat (<i>Capra hircus</i>)	291	4%	147	6%
Sheep or goat (<i>Ovis/Capra</i>)	1799	25%	543	23%
Pig (<i>Sus domesticus</i>)	3667	51%	1040	44%

Table 4.2: Absolute and relative numbers of the total of specimens and diagnostic zones of the four main domesticates in Kaymakçı.

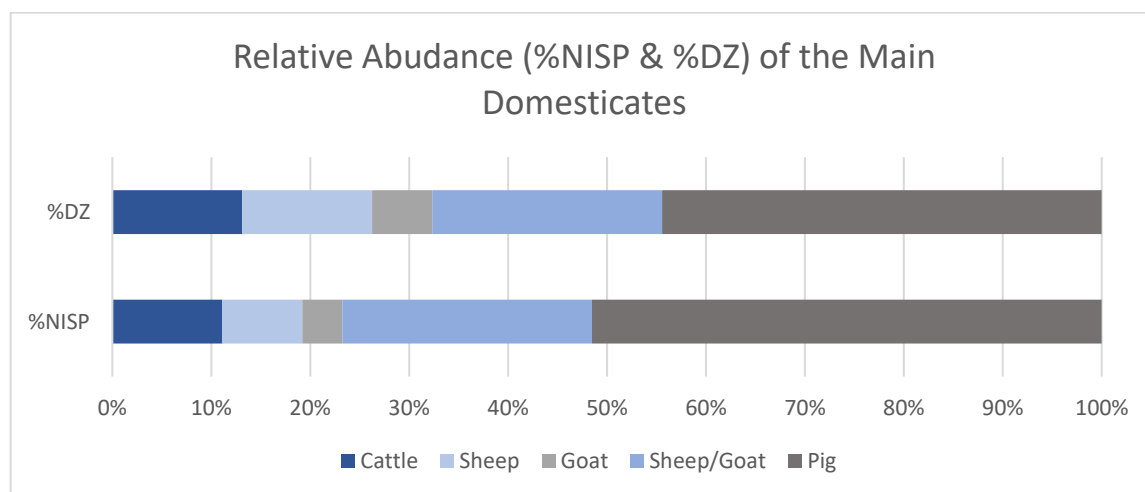


Figure 4.1: The relative abundance of the main domesticates for Kaymakçı, based on the Number of Identified Specimens and Diagnostic Zones.

4.1.1 Sheep Equivalent Factor

The analysis of Sheep Equivalent Factor aims to illustrate meat yield proportions of domesticates of Kaymakçı in order to understand better their contributions in the human diet. The data shows that cattle, with 78% of meat yield, in fact the major meat contributor at Kaymakçı (Figure 4.2). Relative abundance data show that the pigs were the most exploited taxa at Kaymakçı, but as shown here their meat yield is 12%. Sheep and goat category covers the 5% meat yield and individual sheep, and goat categories cover 3% and 1% respectively in the assemblage.

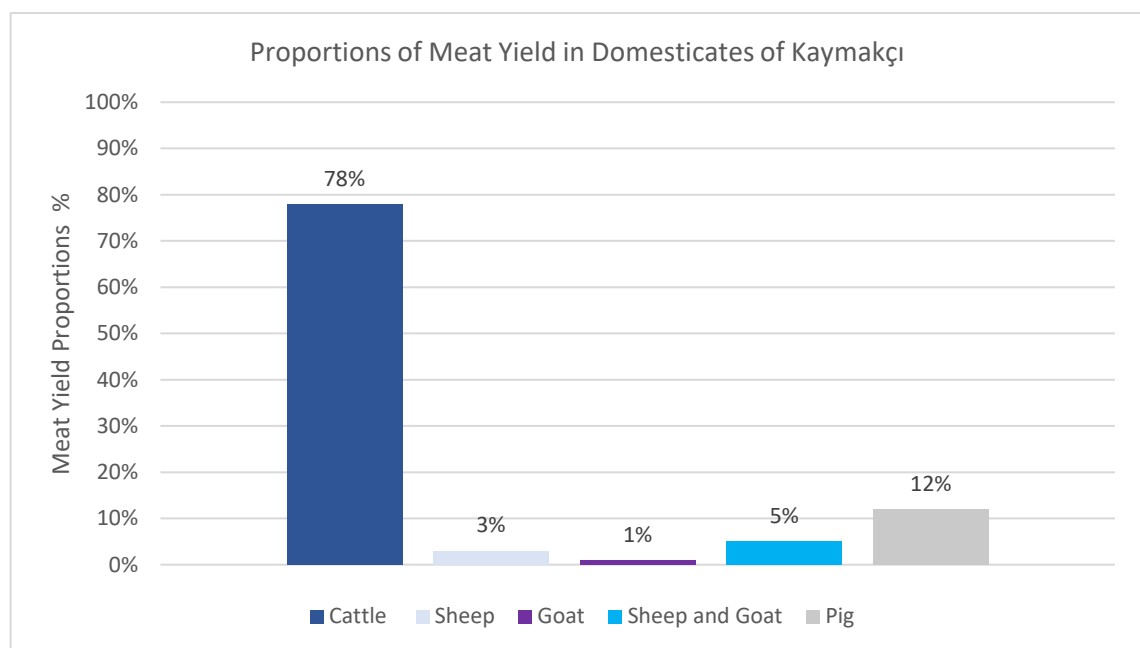


Figure 4.2: Proportions of estimated meat yield from domesticates at Kaymakçı using “sheep-equivalent factor” (Clason, 1973; Russel et al., 2013; Kamjan et al. 2021)

4.2 Comparative Cultural Zones

This analysis aims to compare Kaymakçı and other western and central Anatolian sites in terms of their general faunal and cattle assemblages. Figure 4.3 illustrates the comparisons among published assemblages of domesticates from sites in western Anatolia (on the left panel) and central Anatolia (on the right panel) – sites discussed also in Chapter 2. The baseline dataset draws from the Number of Identified Specimens (NISP) values of domesticates. The data illustrated here is used as a proxy for political and cultural influence among those settlements, consequently of those cultures as well as

to detect differences. Figure 4.4 illustrates only cattle and how it situated among other domesticates. To derive this dataset, cattle populations were compared to a complete assemblage of sheep, goat, and pigs. This approach allows me to explore the importance of cattle vis-à-vis entire assemblage of domesticates.

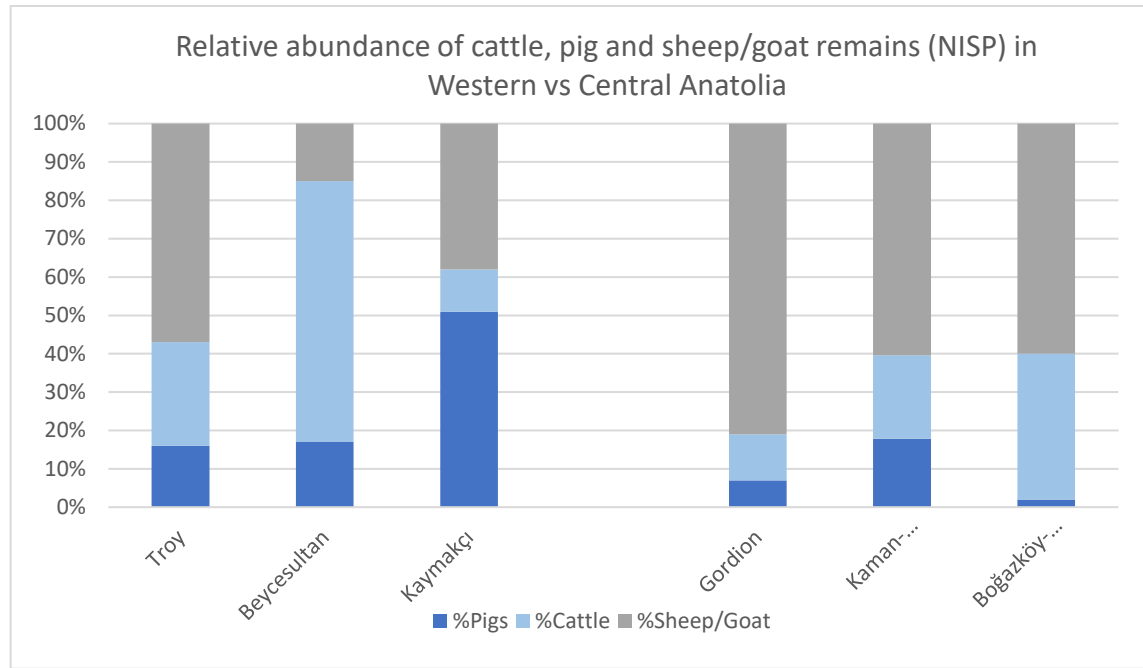


Figure 4.3: The relative abundance of cattle, pigs, and sheep/goat in LBA assemblages from different sites, based on Number of Identified Specimens (NISP). The three columns on the left of the graph illustrates western Anatolian sites, and the other three on the right of the graph illustrates central Anatolian sites.

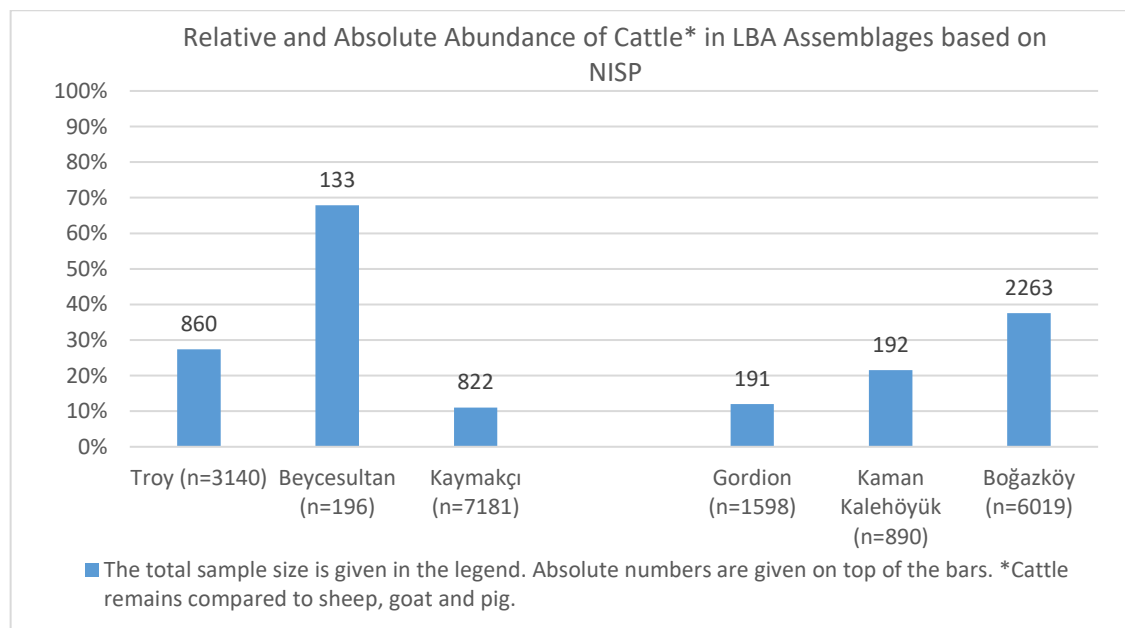


Figure 4.4: The relative and absolute abundance of cattle compared to sheep, goat and pig in LBA assemblages from different sites, based on Number of Identified Specimens (NISP). The three columns on the left of the graph illustrates western Anatolian sites, and

the other three on the right of the graph illustrates central Anatolian sites. The data are taken from Roosevelt et al., 2018 (Fig. 26).

The most significant domesticate of Kaymakçı in term of abundance was pigs.¹⁸⁶ Although other LBA sites incorporated pigs into their daily lives, based on current dataset, pigs were never the main domesticate, save the assemblage from Kaymakçı. Here pigs were the most exploited taxa: at least 51% of the domesticates are those of pigs.

Regarding the sheep and goat, the central Anatolian LBA sites display that their main protein source was sheep and goats. In western Anatolia sheep and goats were majorly employed by Troy with 57%. It may appear that coastal sites in western Anatolia (Troy) exploited sheep and goat, while it declined in inland sites (Beycesultan and Kaymakçı). It appears that the larger mixed herds of sheep and goat were managed in a similar way in central Anatolia.¹⁸⁷

Cattle, as opposed to the pigs, sheep and goats, are much larger animals (see sheep-equivalent analysis in Chapter 4.1 and Figure 4.2). Cattle, both in western and central Anatolian sites, generally were adopted as the second most prominent taxon, though it is significant in Boğazköy with the 38%. Moreover, Beycesultan's assemblage presents cattle as the most abundant taxa with 68%. The further discussion is in Chapter 5.

Exploring these broad datasets from the perspective of outside influences, notably Hittites, we must also consider the relative topographic and environmental conditions of the respective region – and size and population. To this end, it would have been expected that Kaymakçı's data would be closer to those datasets from Troy and Beycesultan. Given the harsher winters and dry summers of the high Anatolia plateau, we would expect similarities among the assemblages from Gordion, Kaman-Kalehöyük and Boğazköy-Hattusa.

Solely, Gordion, Kaman-Kalehöyük and Boğazköy-Hattusa present pig as their least exploited taxa respectively with 7%, 18% and 2% respectively. All three sites relied on caprines which made up more than 50% of the total assemblage. Among those three

¹⁸⁶ For further research on Kaymakçı pigs within the LBA context please see: Slim *et al.*, 2020; Francesca G. Slim. "Living with Pigs: Sharing space with scavengers in Late Bronze Age Kaymakçı, Western Anatolia". (*MSc Thesis, University of Groningen*, 2018).

¹⁸⁷ Slim *et al.*, 2020: 320.

sites, cattle were most abundant in Boğazköy-Hattusa with 38%. Notably, Boğazköy-Hattusa was the capital of the Hittite kingdom.

Site	NISP (total)	%Pigs	%Cattle	%Sheep/Goat
Troy	3140	16%	27%	57%
Beycesultan	196	17%	68%	15%
Gordion	1598	7%	12%	81%
Kaman Kalehöyük	890	18%	22%	61%
Boğazköy-Hattusa	6019	2%	38%	60%
Kaymakçı	7181	51%	11%	38%

Table 4.3: The Number of Identified Specimens (NISP) total values and the relative abundance of domesticates of LBA sites. The data is provided by Francesca Slim and Canan Çakırlar. The data is taken from Ducos 1965, Miller et al., 2009, Hongo 1996, von den Driesch and Pöllath. 2004.

4.3 Body Part Distribution

I now turn from a broad geographic analysis of cattle in LBA Anatolia to that of the local community at Kaymakçı. Here I analyze the local contexts of excavations to reveal patterns of cattle remains in context.

Body part representation and distribution of cattle to explore patterns of exploitation through spatial analysis is an important tool (Fig. 4.5). The deviation presented in the Figure 4.5 illustrates the deviation from the expected value in each excavation zones (inner citadel, southern terrace, and fortification system), which I calculated through MAU and MNE values. Traditionally, the high utility parts of body, such as proximal portions of limbs that yielded meat, marrow, and bone grease, would have been coveted by the community. Even so the lower utility portions, such as feet, which were likely less favored for protein, yet may have been used as tools for production and processing, such as in tanning, fur and hide production as well as gaming.¹⁸⁸

¹⁸⁸ Binford, 1981.; Roosevelt et al., 2018: 674.

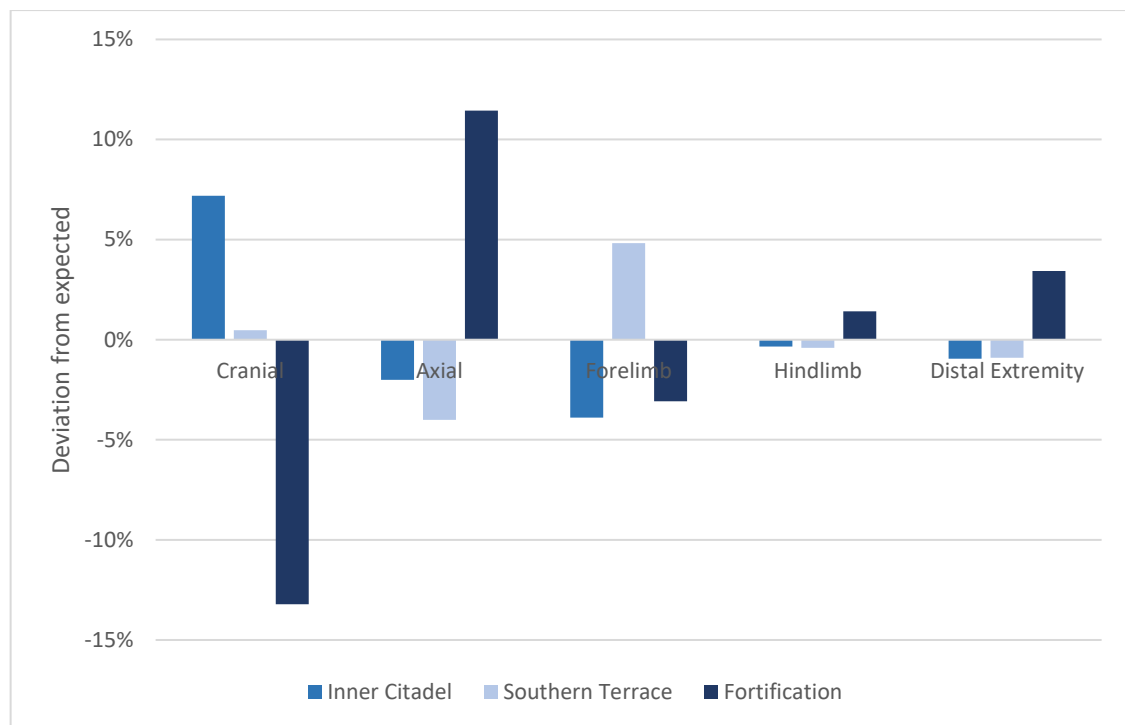


Figure 4.5: Deviations from the expected frequencies of skeletal elements in a complete ungulate skeleton for cattle ($n=248$) from Kaymakçı. Standards used for this graph are based on the MAU(MNE) values of cattle in the three excavation zones of Kaymakçı. The five anatomical units are followed by the definition of B. S. Arbuckle (2009).

For the sake of data presentation, the analysis presented here considers the 10% deviation as threshold. The pattern of skeletal distribution of cattle in the fortification system shows considerable negative deviation for cranial elements while the axial elements are notably overrepresented. Forelimbs, too, are slightly underrepresented with 5%. Hindlimbs and distal extremities show normal distribution.

One of the major questions of animal husbandry is where communities kept their animals. The skeletal distribution analysis offers a proxy to address this question. Starting with the cranial elements and the distal extremities, the data represents a pattern where almost all the cranial elements and distal extremities are underrepresented throughout the site, save the inner citadel for cranial elements and the fortification wall for the distal extremities. In these two locations both are overrepresented, respectively. Indeed, this pattern of distal extremities supports Çakırlar and Slim's suggestion¹⁸⁹ for off-site

¹⁸⁹ Roosevelt *et al.*, 2018.

butchering of the carcass, yet the cranial elements within the most guarded area of the citadel points to an exceptional pattern and suggests more specific behaviors.

The inner citadel area shows that the cranial elements are marginally better represented than any other body parts, yet it is still under the 10% threshold. Remains of cattle in southern terrace show almost 5% deviation between forelimbs and axial elements, respectively. Cranial elements, hindlimbs and distal extremities show normal distribution. The pattern of skeletal distribution illustrates minor deviation among different excavation zones, except from the fortification system. The only considerable extent of the deviation is in the fortification system with underrepresentation of cranial elements and overrepresentation of axial elements. The almost-normal deviation around the site with less than 5% could have been an indicator of social and economic structure as well as cattle provisioning across the site.

4.4 Mortality Profiles

Kill-off patterns and survivorship analysis show that the cattle from Kaymakçı were exploited for various reasons. Tooth wear on cattle mandibula reveals a trend of culling later in life, especially after they reached adulthood (see Figure 4.6 and 4.7), and this general longevity observed for the Kaymakçı cattle population indicates exploitation of cattle during their active lives for their secondary products. The evidence for epiphyseal fusion (see Figure 4.8) concurs with mandibular data and displays that almost 100% of the early fusing bones; 80% of the middle fusing bones; and almost 70% of the late fusing bones were fused. Epiphyseal fusion data indicates that the individuals were able to grow, thus their bones were fused.

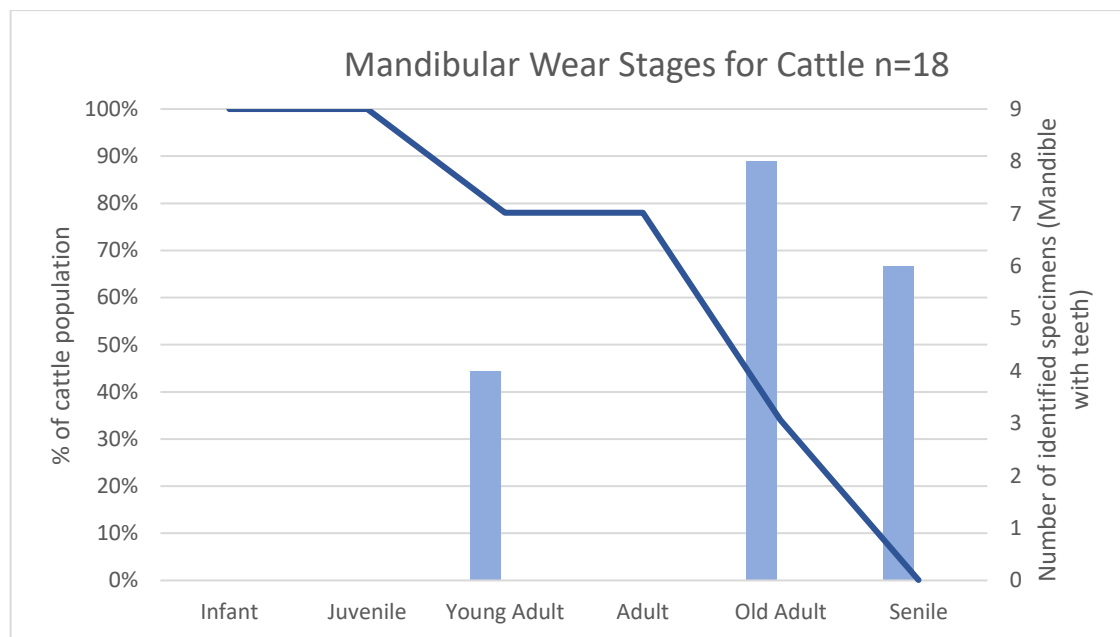


Figure 4.6: Mortality data for cattle mandibles with teeth (n=18) based on MWS (Mandible Wear Stages). The left axis and the line graph correspond to the percentage of the population alive following the kill-off curve. The right axis and columns show the number of individuals per age class.

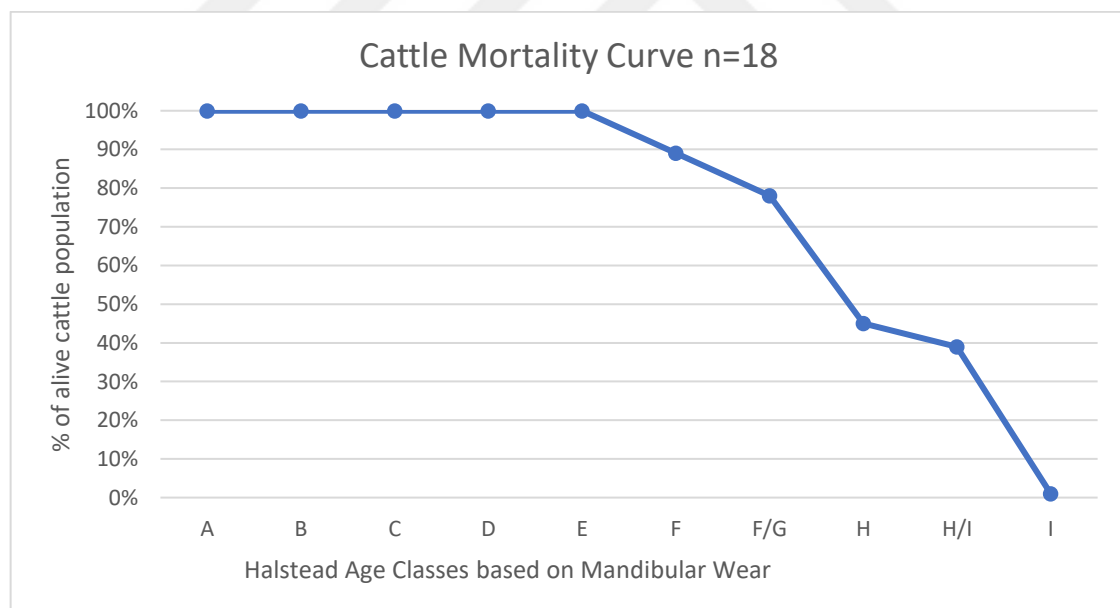


Figure 4.7: Decimation of the cattle population based on estimated age at death based on Halstead. 80% of the cattle population reached adulthood (stage G), nearly 45% reached old age (stage H).

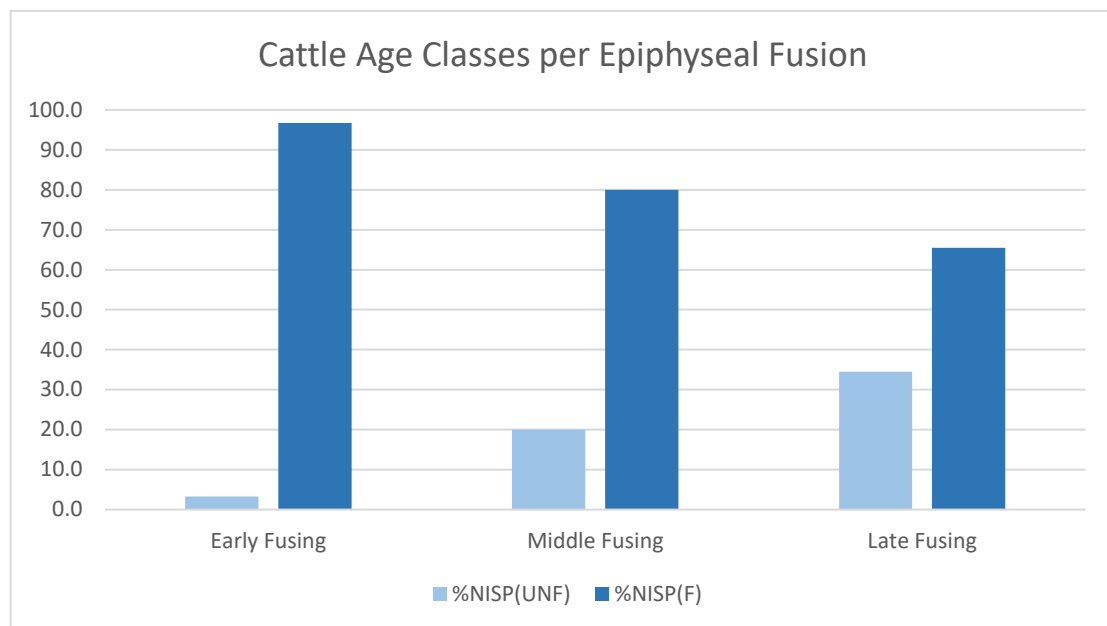


Figure 4.8: Mortality profiles based on cattle epiphyseal fusion data based on Reitz and Wing (2008).

From this dataset, we may confidently assess that the people of Kaymakçı preferred a system of husbandry where they could exploit cattle for a considerable period of time; in fact, on average cattle appear to have lived for at least 36 months before they may have been killed. Although our subject pool is relatively small, the pattern of survivorship corroborates an interpretation for a very distinct pattern for cattle exploitation. Moreover, it yields a new perspective for socioeconomic organization and ritual meanings.

4.5 Biometry – Logarithmic Size Index

Body size distribution analysis offers an understanding of size classes in a given assemblage. The cattle population of Kaymakçı is characterized by culling profiles focused on adults (3-years-old and later). Figure 4.9 presents adult and subadult specimens, noting that some subadult cattle have fused epiphyses at two-and-a-half years of age.¹⁹⁰ The standard reference values for Logarithmic Size Index (LSI) estimation were based on an adult female auroch.¹⁹¹ LSI indicates the size of specimens relative to that of

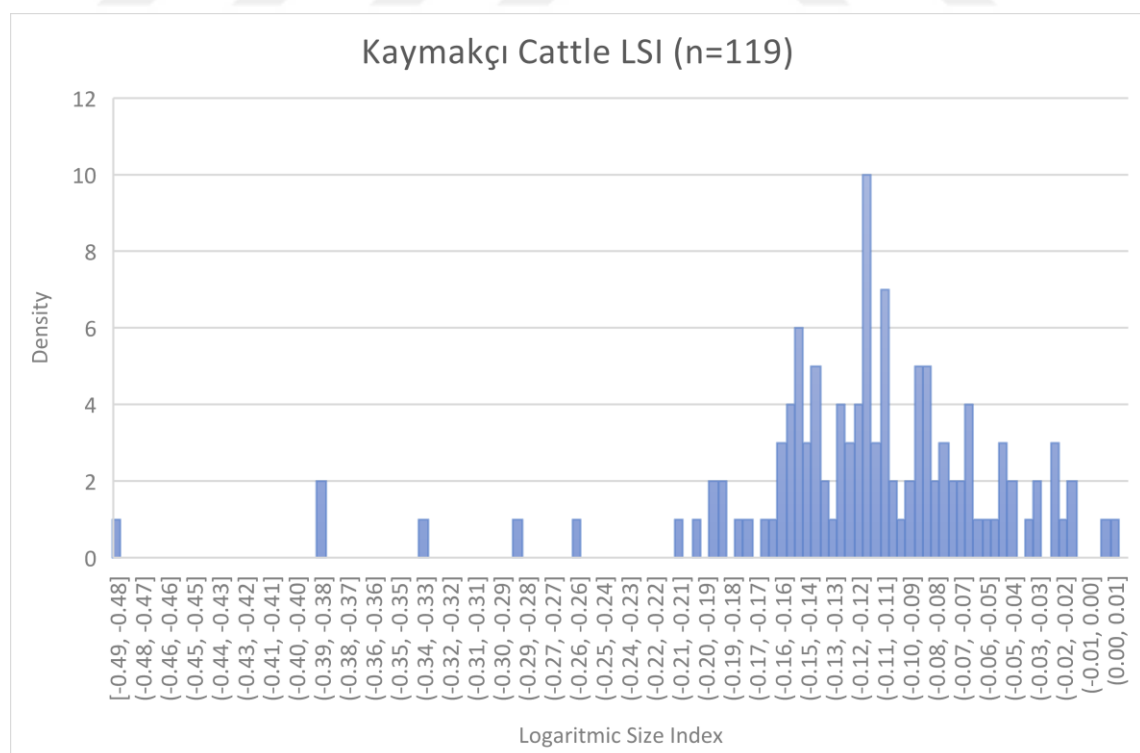
¹⁹⁰Miki Bopp-Ito *et al.*, "Size diversity in Swiss Bronze Age cattle." *International journal of osteoarchaeology* 28, no. 3 (2018): 294-304.

¹⁹¹ Degerbøl, 1970.

standardized measurements; if a specimen is larger than the reference specimen (LSI=0) it has a positive value; if a specimen is smaller than the reference specimen it has a negative value.¹⁹² All Kaymakçı specimens were recorded as cattle, both male and female. The expected pattern was to have a distribution range which would be majorly negative. Only two specimens have positive LSI value. These two specimens might be aurochs, big male cattle, or castrated males; however, at this point it is impossible to determine this. The other specimens fall within an expected distribution range.

To differentiate male and female specimens, mean and median values were used. Both the mean and median values are approximately 0.11. In this manner, the data show that male and female populations of cattle at Kaymakçı are similar, although there might be a slight surplus of males may exist if we disregard outliers (from the subadult category).

Furthermore, this size pattern would indicate systematic selective cattle breeding. The range displayed in Fig. 4.10 shows a narrow box which may indicate a one variety of species. As opposed to mixed sheep and goat herds, and two separate herds of pigs¹⁹³, cattle here display a singular, uniform system of management, and even an adaptation of a single breed.



¹⁹² Meadow, 1999.

¹⁹³ Slim *et al.*, 2020.

Figure 4.9: LSI distribution of Kaymakçı cattle. Only postcranial bones of adult specimens included.

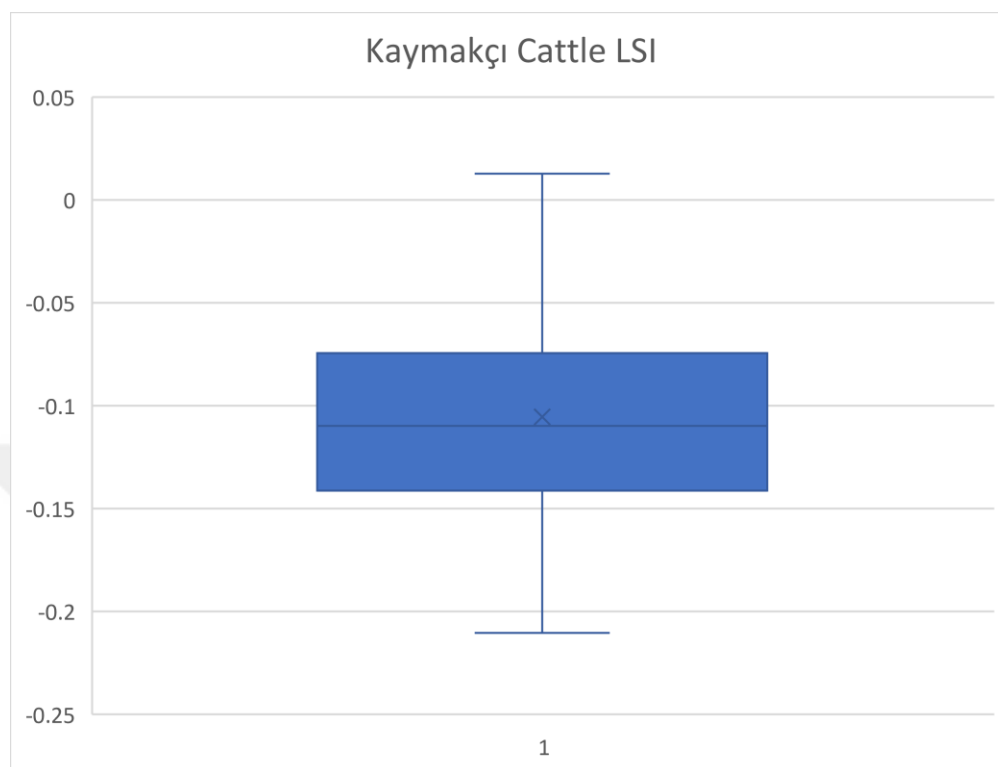


Figure 4.10: LSI distribution of Kaymakçı cattle displayed in box and whiskers graph. Only postcranial fused bone specimens are included.

The overall results of the abovementioned analyses complement each other. These results shed new light on the husbandry systems, exploitation models, and diversity of Kaymakçı cattle during LBA. General understanding of local systems of husbandry in western Anatolia that employ the most rational choices of behavior, were applied at Kaymakçı as well. While Kaymakçı relied most on pigs and caprids; age and size data of cattle illuminate how they managed as well. The possibility of provisioning cattle is shown with the mortality data and is supported by the size classes. Although the data for ritual-related practices are occasional, we see a more nuanced behavior towards elite presence and social hierarchy, as it will be explored in the next chapter

Chapter 5:

DISCUSSION

In this discussion, the research questions introduced in Chapter 1 are carefully elaborated on to establish patterns of exploitation and to understand the use of cattle at Kaymakçı during the Late Bronze Age. Although there are limitations in all archaeological datasets (i.e., taphonomic, anthropogenic, and analytical), I have indicated the measures taken to minimize biases as much as possible and to be explicit about the methods of research. This chapter returns to the research questions, explains why the methods and results of this thesis are acceptable, provides answers to research questions, describes their findings and limitations, introduces patterns and correlations, and finally demonstrates how this thesis contributes to the literature on the LBA in western Anatolia specifically.

The research questions focus on the general picture of animal management at Kaymakçı, and then probe the same specific to cattle management. Subsequently, the role of cattle with regards to social relations are analyzed to explore patterns of hierarchy in LBA Kaymakçı.

5.1 *Kaymakçı: Member of a Bigger World*

Late Bronze Age communities in Anatolia have been characterized by dependence on domestic livestock with respect to animal economies.¹⁹⁴ In central Anatolia, we observe the predominance of sheep and goats, the expansion over time and certainly into the LBA period of animal exploitation regarding both primary and secondary products, and controlled provisioning of these animals.¹⁹⁵ In western Anatolia, the data suggest more local characteristics with strategies adapted to the specific wetland environments and corresponding husbandry possibilities. Based on the contemporary Hittite and local western Anatolian cultures, my expectation for Kaymakçı was that there

¹⁹⁴ Slim *et al.*, 2020; Remi Berthon. "Herding for the Kingdom, Herding for the Empire. The Contribution of Zooarchaeology to the Knowledge of Hittite Economy." *Byzas* 23. (2017): 175–184.

¹⁹⁵ Susan D. DeFrance. "Zooarchaeology in complex societies: political economy, status, and ideology." *Journal of archaeological research* 17, no. 2 (2009): 105-168.; Arbuckle *et al.*, 2009; Melinda A. Zeder. "Understanding Urban Process Through the Study of Specialized Subsistence Economy in the Near East." *Journal of Anthropological Archaeology* 7.1 (1988): 1-55.; Melinda A. Zeder. *Feeding Cities: Specialized Animal Economy in the Ancient Near East*. (Washington: Smithsonian University Press. 1991).

would be similar patterns, such as significant dependence on domestic food supplies that mainly consisted of sheep and goat, centralized distribution and provisioning of the food supplies, specialized groups of animals for animal husbandry, and consistent butchery practices.¹⁹⁶

The research on the comparison of the faunal assemblage of Kaymakçı to other sites that were introduced in Chapter 2 and analyzed in Chapter 4 allows me to emphasize the possible relationships and networks between central and western Anatolian cultures and focus on Kaymakçı in terms of agriculture and livestock management systems as well as local autonomy and patterns of herding.

Comparison of Kaymakçı with Troy, Beycesultan, Gordion, Kaman-Kalehöyük, and Boğazköy-Hattusa is specifically important because all were large centers in the LBA in terms of both sheer size and other indicators of general cultural and political prosperity (small finds, ceramics, etc.).¹⁹⁷ Geographical setting (western vs. central Anatolia) influenced preferences and choices for domesticates. In general, according to the NISP dataset, the sites in central Anatolia exploited sheep and goats with cattle as their second most exploited taxon. Currently, data points to a minimal representation of pigs.

The difference in pig exploitation between central and western Anatolia is likely tied to relative climates and local landscapes. The high plains of central Anatolia are semi-arid and cold, which are not nearly as favorable as wetland Mediterranean climates preferred by pigs.¹⁹⁸ Although pigs would eat anything and everything, their environmental preference is wetlands.¹⁹⁹ The wetland environments in western Anatolia hold better conditions for pig husbandry. Importantly, this pattern may also be a result of cultural choice: Hittite texts inform about the bad reputation of pigs in the Hittite world, where pigs were linked to bad omens, death, and disease, and for these reasons, they were largely avoided for consumption.²⁰⁰

The clear focus on sheep and goats at the larger sites is a pattern we know from texts about the organization of Hittite animal economies.²⁰¹ Furthermore, the overall pattern of more drought resilient species including sheep and goats in central Anatolia

¹⁹⁶ Arbuckle, 2006; Zeder and Arter, 1994; Çakırlar and Atıcı, 2017; Kolb, 2004.; Mielke, 2011.

¹⁹⁷ Mielke, 2011.; Claudia Glatz. "Empire as network: Spheres of material interaction in Late Bronze Age Anatolia." *Journal of Anthropological Archaeology* 28, no. 2 (2009): 127-141.

¹⁹⁸ Slim *et al.*, 2020; Marston *et al.*, 2021: 10; Shin *et al.*, 2021: 13.

¹⁹⁹ Slim *et al.*, 2020; Slim, 2018.

²⁰⁰ Slim *et al.*, 2020.

²⁰¹ Singer, 2002; Bryce, 2018.

should also be considered in view of the relatively drier central Anatolian environment.²⁰² The high exploitation of sheep and goats in central Anatolia would have affected the perception towards cattle cultures which have been overlooked. Cattle appears in most of the Hittite textual evidence²⁰³ and as shown here, in faunal assemblages.

As expected, the central Anatolian highlands, the homeland of Gordion, Kaman-Kalehöyük and Boğazköy-Hattusa feature a similar pattern: a nuanced behavior towards cattle including reliance on its primary and secondary resources, and cattle as a prestigious asset (see Chapter 2); a high reliance on sheep and goat with less preference for pigs; high reliance on cereals, and possible usage of dung as fuel.²⁰⁴

Among central Anatolian sites cattle was the most exploited animal in Boğazköy-Hattusa -the capital of Hittite Kingdom. Such reliance on cattle not only presents welfare, but also serves as a proxy where cattle were not merely animals that provided protein (meat) and traction/energy; but were also, symbols of political power, used in rituals and thus a sophisticated commodity.

Kaymakçı, offering second biggest assemblage available, has the nominal cattle utilization. Yet, with the given background on cattle's role in LBA communities, the environmental aspects, and neighboring settlements datasets, as well as the further analyses on cattle about meat yield proportions, Kaymakçı displays a nuanced behavior. Before discussing cattle in more detail, here I would like to discuss other domesticates first. The sheep and goat, as seen from the other datasets as well, were a popular commodity throughout the LBA in Anatolia. They were relatively accessible to acquire and require far less sustainment. For a community with social hierarchy, the sheep and goat husbandry were crucial to sustain everyday life. Pigs are the most exploited taxon at Kaymakçı; however, the meat yield analysis shows that pigs would cover approximately the one tenth of the diet in terms of meat yield proportions. Respectively, sheep and goats cover one tenth of the assemblage as well. People's rational choices on pig and sheep/goat maintain the balance of everyday life, while cattle comply with its social, economic, and symbolic role. Neighboring cultures, as well, employed such rational choices to their livestock management systems; they contemplated what was best for their environment

²⁰² Arbuckle, 2014

²⁰³ Zeder and Arter, 1994; Arbuckle, 2006.

²⁰⁴ Roosevelt *et al.*, 2018.

and survival, while favoring cattle's further symbolization. Of course, the intensity of such symbolization and utilization varies between cultures.

Animal economies of Kaymakçı do not necessarily follow central or western Anatolian patterns. While species diversity was mainly similar to other western (and even central) Anatolian pattern, taxonomic abundance is different, and also, we see differences in animal management models followed by the community of Kaymakçı. Here I argue that the Kaymakçı dataset affirms local traditions that respond to both social and political dynamics that reflect outside influences as well as interaction with neighboring and more distant communities, such as Hittite spheres. My argument will also demonstrate the importance of the surrounding environment, vegetation and seasonality, and the presence of Lake Marmara and its wetlands. It is the entire scale and scope of this systems that afforded people the opportunity to make their own choices and gives Kaymakçı its own place among the LBA cultures of Anatolia.

Taxonomic spectrum data show that consumption animals (cattle, sheep, goat, and pig) cover 80% of the total animal assemblage. The remaining one fifth of the assemblage comes from a variety of wild resources at Kaymakçı. Wild ungulates such as boars, wild caprids, deer species; small game animals including hares and rabbits; large and medium carnivores including brown bear, wolves, foxes, and dogs as well as fish, bird, and mollusks suggest a variety of activities affecting human-animal relationships. At Kaymakçı, human-animal relationships went beyond domestic livestock husbandry or small game trapping. Our dataset reveals that people interacted with animals in many ways. Abundance of deer species (fallow, red, roe, respectively) suggest that hunting was a common practice. Fallow deer were abundant than red and roe deer species, which may be an indicator of the environmental preference of the animals; fallow deer are drawn to by marshlands and meadows, which in turn allow them to avoid seasonality and concentrate year round on grazing.²⁰⁵ Red deer, on the other hand, are intensive browsers and prefer to follow seasonal fluctuations in shrub vegetation.²⁰⁶ Such preferences align with Kaymakçı's surrounding habitat of marshlands and oak woodlands; while fallow deer were attracted by the year-round habitat, red deer may have been a more seasonal appearance. Other game animals such as hare, rabbit, wolf, and fox indicate that

²⁰⁵ F. Braza, and F. Alvarez. "Habitat use by red deer and fallow deer in Doñana National Park," *Miscel·lània Zoològica* (1987): 363-367.

²⁰⁶ Braza and Alvarez, 1987.

surrounding environment were habitable for a variety of species and those species may have been included in the diet. The abundance of fish and mollusks (both freshwater and marine mollusks) suggest that fish was an important part of the diet. Catfish and carp are the main identified species and were probably procured from the Lake Marmara. The latest study on dogs in Anatolia²⁰⁷ discusses them as consumption animals. Two percent of the Kaymakçı assemblage consisted of dog remains. We have not recorded any pathologies or butchering marks on the specimens due to the thick encrustations on the surface of the bones. Considering the high skeletal distribution of the dog assemblage however, -no articulated or *in situ* skeleton of dog has yet been recovered-, the possibility of the consumption of dogs at Kaymakçı would be a promising further study.

Of note is that the distribution of wild animal remains concentrate with much higher density in the inner citadel compared to other excavation zones of Kaymakçı. This pattern may suggest a positive correlation between hunting and elite practices as observed at other Bronze Age sites.²⁰⁸ Notably, the presence of “exotic” specimens (brown bear, big cat and a specimen identified either as a whale, hippo, or elephant) supports this pattern. With more clarified chronological and contextual patterns, it will be possible to expand on the meaning of this correlation.

Coupled with botanical data²⁰⁹, the abundance of subsistence reveals that community in Kaymakçı benefited from a rich diet where there were sufficient, if not more, food and variety of options. The archaeobotanical research at Kaymakçı reveals that there are pulses, cereals, and fruit were included in diet along with proteins from the animals including beef, pork, and fish. To be sure, as introduced in Chapter 4, Kaymakçı portrays a different subsistence economy from its contemporaneous settlements. In that manner, along with animals, Kaymakçı employed cereals and pulses equally while benefiting also from fruits -namely grapes.²¹⁰ This type of rich diet confirms the environmental reconstruction of Kaymakçı in LBA. Indeed, Kaymakçı is characterized by its own subsistence model and traditions while influenced by the general trend of LBA cattle cultures. For that matter, it is considered that Kaymakçı is a settlement which was

²⁰⁷ Price *et al.*, 2020.

²⁰⁸ Çakırlar and Atıcı, 2017; Halstead, 1985; Alice Mouton. “Animal Sacrifice in Hittite Anatolia”, in *Animal sacrifice in the Ancient Greek World* eds. S. Hitch and I. (Rutherford Oxford University Press, 2017): 239–252.

²⁰⁹ Roosevelt *et al.*, 2018; Shin *et al.*, 2021.

²¹⁰ Shin *et al.*, 2021.

affected by the surrounding cultural zones of Hittite and Myceneans while employing its own modes of production, agriculture, and husbandry in accordance with its culture and environment.²¹¹

5.2 *Mighty Cattle: What Do We Know, Now?*

Late Bronze Age cattle cultures display various interactions between people and cattle which show that those interactions are dependent on the landscape and environment along with cultural affiliations and communities. Although cattle can be bred in various climatic and environmental conditions some habitats have detrimental influence on animals' health while others are far more suitable and productive.²¹² Modern studies on cattle breeding present many factors that affect the performance, productiveness, and health of the animals.²¹³ Many factors can affect the growth, lactation, mating, birth, and meat quality of cattle, as well. Those can be examined in two categories: (1) environmental factors, and (2) individual-based factors²¹⁴. Environmental factors can be examined in ambient temperature, food and water availability, rangeland, and general conditions of animal sheds or barns. Individual-based factors affect decision-making processes with regard to husbandry methods. Different practices of cattle husbandry result in morphological, physiological, and anatomical differences across cattle (see Appendix 9). The purpose of different practices of cattle husbandry is to benefit from cattle in many forms. Meat supply, dairy production, and traction power are the main paradigms of different practices. Eventually, different roles were designated for cattle, perhaps even individually, requiring specific foraging and environmental conditions.

Such an environmental model strongly correlates with the zooarchaeological results concerning cattle husbandry presented in Chapter 4.

The three residential zones of excavation at Kaymakçı to date were introduced in Chapter 2. One of the aims was to identify whether particular patterns help inform the

²¹¹ Marston *et al.*, 2021.

²¹² National Research Council. "Effect of environment on nutrient requirements of domestic animals." Washington (DC): National Academies Press (US); 1981.

²¹³ Luděk Barton *et al.*, "Effect of breed on growth performance and carcass composition of Aberdeen Angus, Charolais, Hereford and Simmental bulls." *Czech Journal of Animal Science* 51, no. 2. (2006): 47-53.; Uğur, Feyzi. "Sığır Yetiştiriciliği", *Çanakkale Onsekiz Mart Üniversitesi Yayınları*, 2014; Durhasan Mundan and O. Karabulut. "Sütçü Sığırlarda Damızlıkta Kullanma Süresi ve Uzun Ömürlülüğün Ekonomik Açıdan Önemi." *Yüzüncü Yıl Üniversitesi Veteriner Fakültesi Dergisi* 19, no. 1 (2008): 65-68.

²¹⁴ Uğur, 2014.

definition of those three zones and to evaluate if cattle were used in feasting or ritual activities, or perhaps other community-based activities. The skeletal distribution of the cattle, on the other hand, shows almost homogeneous distribution across the site. One explanation (and limitation as well) could be the lack of incorporation of phasing evidence in this analysis of the faunal assemblage; although Kaymakçı stretches through the 2nd millennium B.C.E, the faunal assemblage has not been assessed in this light. Nonetheless, three patterns are distinct in the data.

As explored elsewhere, our working understanding of space at Kaymakçı is that areas on the inner citadel area were elite zones.²¹⁵ The first pattern shows a slight overrepresentation on cranial elements in the inner citadel. Special valuation and even ritual treatment of animal heads – especially those of cattle – was common in Bronze Age Anatolia and neighboring regions, as attested also iconographically.²¹⁶ The overrepresentation of cattle crania in the inner citadel might be an indication of such ritualistic exercises. This hypothesis can be supported by the next pattern: underrepresentation of cranial elements along the fortification walls. The fortification wall is the boundary that disengages Kaymakçı from the rest of the world. If the heads of the cattle were sacred, high-status assets, people would have preferred to keep them in the most sacred space rather than the boundary. A detailed examination of the butchery evidence, taphonomic agents, and pathologies of cranial elements would be a valuable indication of such performance in the future. The third pattern shows an overrepresentation of axial elements along the fortification system. Axial elements have low bone density and considering that skeletal representation is highly correlated with bone density²¹⁷, this data is indeed surprising. It was hypothesized elsewhere that faunal remains found along Kaymakçı's fortification system reflect a behavior that was more

²¹⁵ Roosevelt *et al.*, 2018.

²¹⁶ David W. Anthony and Dorcas R. Brown. "The dogs of war: A Bronze Age initiation ritual in the Russian steppes." *Journal of Anthropological Archaeology* 48. (2017) 134-148.; Adelheid Otto. "Defining and Transgressing the Boundaries Between Ritual Commensality and Daily Commensal Practices: the Case of Late Bronze Age Tall Bazi." *Journal for Ancient Studies: Sonderband/Special Volume 2* (2012).; Alan Peatfield. "Rural Ritual in Bronze Age Crete: the Peak Sanctuary at Atsipadhes." *Cambridge Archaeological Journal* 2, no. 1 (1992): 59-87.; Jennifer M. Webb and David Frankel. "Social Strategies, Ritual and Cosmology in Early Bronze Age Cyprus: an Investigation of Burial Data from the North Coast." *Levant* 42, no. 2 (2010): 185-209.

²¹⁷ Yin M. Lam, Xingbin Chen, and Osbjorn M. Pearson. "Intertaxonomic variability in patterns of bone density and the differential representation of bovid, cervid, and equid elements in the archaeological record." *American Antiquity* (1999): 343-362.; Nimrod Marom *et al.*, "Backbone of society: evidence for social and economic status of the Iron Age population of Tel Rehov, Beth Shean Valley, Israel." *Bulletin of the American Schools of Oriental Research* 354, no. 1 (2009): 55-75.

nuanced than simple discard or refuse.²¹⁸ Although this may be related to extensive provisioning of food or taphonomy, the data requires further analysis on bone surface modifications.

The analyses reveal that the site of Kaymakçı shows diversity of practices of carcass processing across the site, and thus perhaps also differences in initial choices in animal exploitation and provisioning. Broadly, these variations can be investigated through taphonomic processes, butchering, transportation, provisioning, food preparation and disposal habits. The evidence for cattle remains from Kaymakçı were likely to have been redistributed post-butchering across the site and further disturbances occurred via post-mortem decisions by human-agency in site condition. Of course, considering the big size of cattle, it requires more organized distribution and also be able to feed more people. It is precisely the characteristics in distribution patterns that point to the considerable interest in this animal, both in life and death.

Provisioning of cattle, notably high-protein and high-status animals, appears to endorse further this hypothesis about cattle being ritual elements. Elites would have had access and control over not only the inner citadel, but also materials used within it. Looking more closely at the distribution of crania in the inner citadel, we may see evidence of more ritually informed patterns of behavior in the future.

The mortality profile for cattle shows extreme longevity, an indication that people preferred cattle primarily for their secondary products along with keeping cattle for consumption. Sheep, goat, and pig mortality profiles from Kaymakçı generally show a first intense culling before they reached adulthood.²¹⁹ Such culling patterns of domestic livestock suggest that cattle may have been the main milk provider. Therefore, the production of milk and thus cheese and yogurt (among other products) would have been one of the major reasons to keep cattle alive. What is more, we may also consider particularly robust cattle for labor, especially in agricultural fields as well as beasts of burden for site-level necessities. In that manner, the archaeobotanical data from Kaymakçı reflect a nutrition-rich diet which intensified in pulses, cereals, and fruits.²²⁰

²¹⁸ Şengül Fındıklar and Ebru Kaner “Fortification or a Dumpster: A Collaborative Study on Animal Remains at the Fortification Walls of Kaymakçı”, *Annual Meetings of the American Schools of Oriental Research (ASOR)*, November 2020.

²¹⁹ Slim, 2018; Slim *et al.*, 2020; Marston *et al.*, 2021.

²²⁰ Roosevelt *et al.*, 2018; Nami Shin. “Archaeobotanical and Geospatial Analyses of Bronze Age Plant Remains from Kaymakçı, Western Turkey” *MA Thesis, Koç University*, 2019; Shin *et al.*, 2021.; Marston *et al.*, 2021.

Archaeobotanical research from Kaymakçı suggests that people adopted a risk-management system in agriculture and cultivation, there is evidence that less stress-tolerant crops were preferred, such as bitter vetch.²²¹ Eventually, such practices suggest that there was an effort for growing preferable crops. Herein, the role of cattle in agricultural practices rises. In such an intensified and varied agricultural system, cattle' labor power should be essential. I expect a further study on cattle metapodia and phalanges would show concentrated pathologies related to draught practices.

The mortality profile of cattle also suggests an intensive provisioning of cattle. As explained in Chapter 4, even if people preferred to exploit cattle for secondary products, culling them only after adulthood, a small portion of youngsters, at least, must have died from natural causes. Moreover, this pattern opens a new window on socioeconomic organization which might be related to the important position of Kaymakçı in the Seha River Land in the second millennium B.C.E. The intensive cattle provisioning at Kaymakçı may have suggest that of Kaymakçı as the urban center of the Seha River Land where other "rural" centers provisioned food and perhaps other supplies too. It is a known practice in Anatolia and the Levant in the Bronze Ages and stretching to later periods that the urban centers would offer protection against invaders and more efficient trading opportunities to rural areas, while the rural areas would provide food resources and labor to the urban centers.²²² The evidence from Kaymakçı cattle, along with sociocultural data, supports this possibility.

Ethnographic studies about cattle husbandry emphasize that depending on the age, sex, and the condition of the herd, cattle are assigned to specific roles (see Appendix 9).²²³ While some female cattle would be used for milk production, others would be kept for breeding; some male cattle would be trained to plough, others would be used only for breeding. Those roles were assigned upon birth or shortly thereafter. The body size analysis of Kaymakçı cattle reflects an almost equal distribution of males and females, with a slightly higher frequency of males. Cattle display relatively limited sexual dimorphism, however. Considering the longevity of cattle, the equal distribution of sex

²²¹ Shin, 2019.; Shin *et al.*, 2021.; Marston *et al.*, 2021.

²²² John M. Marston. "Agricultural strategies and political economy in ancient Anatolia." *American Journal of Archaeology* 116, no. 3 (2012): 377-403.; Steven E. Falconer. "Rural responses to early urbanism: Bronze Age household and village economy at Tell el-Hayyat, Jordan." *Journal of Field Archaeology* 22, no. 4 (1995): 399-419.

²²³ Uğur, 2014.

would strongly suggest the presence of a homogeneous, healthy, and actively laboring herd of cattle in Kaymakçı. The slight abundance of males could suggest a focus need for intensified labor, hence, intensified agriculture. The limited sexual dimorphism would be an indicator of highly strategic and selective breeding of cattle, and further supports provisioning as well. Overall, the taxonomic abundance, skeletal part distribution, mortality profile, and demographic sex profile of cattle complement the climate and environmental conditions and archaeobotanical data of Kaymakçı. Such strong correlation not only helps to understand Kaymakçı's animal management systems, but also sheds light on ancient decision-making processes and how people employed the most beneficial and rational behavior towards animal husbandry and agriculture.

5.3 Cattle Cultures: An Intangible Asset

This research has focused so far on the tangible aspects of cattle cultures; however, the symbolic meaning and utilization of cattle cannot be overlooked. With the rise of an elite class and emerging social hierarchies in Bronze Age Anatolia social, political, economic, military, and symbolic practices shifted,²²⁴ and such societies across BA Anatolia were connected by a network of trade and communication systems.²²⁵ Societies were able to share culture and commodities which resulted in holistic approaches towards hierarchy, prestige, and competitiveness²²⁶. In this context, cattle were highly valued assets as sources of wealth, symbols of power, and reflections of prestige.²²⁷ The cultural importance of cattle was embedded deeply in these societies, as seen in the textual evidence and iconographic depictions associated with welfare and aristocracy.²²⁸

The role of cattle could be derived particularly from the Late Bronze Age Hittites' textual and material evidence, which suggests that the concept of the "rise of elite class" had its peak in this period.²²⁹ Arbuckle argues that the dominance of sheep

²²⁴ Arbuckle, 2014.

²²⁵ Vasıf Şahoğlu. "The Anatolian trade network and the Izmir region during the Early Bronze Age." *Oxford Journal of Archaeology* 24, no. 4 (2005): 339-361.; Gojko Barjamovic. "A historical geography of Anatolia in the Old Assyrian colony period." (Vol. 38.) (*Museum Tusculanum Press*, 2011); Korfmann, 1998.

²²⁶ Sagona and Zimansky, 2015.; Arbuckle, 2014.

²²⁷ Arbuckle, 2014.

²²⁸ Arbuckle, 2014.

²²⁹ Arbuckle, 2014.

and goat across Anatolia (especially in Hittite settlements) does not undermine the importance of cattle, in fact, he claims that: "...much larger body size, higher meat weights, and strength and trainability cattle represent the single most important source of animal products and animal labor in Bronze Age Anatolian economies."²³⁰ In addition to high amount of meat, fat, grease, organs, leather, and bones, cattle were not merely a food source, in fact, the labor power for agriculture, and the dairy production potential, indeed, advance cattle as the *single most important animal*. Eventually, cattle became a symbol of power among those hierarchical societies.

The symbolic and iconographic value of cattle was introduced in Chapter 2. The great size and the broad spectrum of products that cattle provided have perceived as a symbol of power and wealth. To this extent, this perception has led by a further symbolic concept which is more religion and ritual predisposed. At Kaymakçı we see nuanced behaviors in cattle management as well as rational choices towards cattle husbandry. The data from the inner citadel area suggest that elites at Kaymakçı valued cattle more than its meat by keeping cattle crania along with parts of other exotic animals. With this in mind, I strongly believe that future excavations and research in the cemetery of Kaymakçı will further yield strong correlations between cattle cult and mortuary practices of Kaymakçı community in the LBA.

The role of cattle in Late Bronze Age Anatolia and the Aegean appears to be tied to ideological spheres and perceptions of power and prestige. Along with the monumental palpable benefits of cattle, human-cattle relationships in those peripheral zones were linked to an intangible network.²³¹ Despite the limited research on cattle in western Anatolian LBA sites, the research on Kaymakçı offers a holistic understanding towards the role of cattle on a regional basis. Although the people of Kaymakçı employed a local mode of husbandry; the elite class distinction and possible ritual-related preferences can be seen in Kaymakçı's cattle. The provisioning of cattle at Kaymakçı would further endorse the symbolic meaning of wealth and power that associated with cattle. Being the powerful urban center with an elite residence, rich agricultural resources, and provisioning cattle from the neighboring rural settlements, which in turn possibly provide

²³⁰ Arbuckle, 2014: 282.

²³¹ Arbuckle, 2014.; Mary K. Dabney, Paul Halstead, and Patrick Thomas. "Mycenaean feasting on Tsoungiza at ancient Nemea." *Hesperia* (2004): 197-215.

protection to them, it is possible to observe the symbolic role of cattle in hierarchy, economy, and political affairs related to power and wealth at Kaymakçı.



Chapter 6:

CONCLUSION

Animal economies of Kaymakçı in the Late Bronze Age were studied in detail with a given focus on cattle. This study aimed to understand the animal management strategies adopted by people at Kaymakçı, how Kaymakçı was situated in LBA Anatolia, and the importance of cattle by means of subsistence and symbology. The results of this study establish a baseline for further research in western Anatolian LBA animal management systems and provide a decent comparison of LBA cattle cultures between western and central Anatolia. By means of animal economies, Kaymakçı is characterized as a local western Anatolian community that adopted strategic behavior towards animals, especially cattle, in accordance with its culture, environment, and sociopolitical interests.

The role of cattle in Bronze Age communities, and even more widespread regions and periods, has been characterized as more than subsistence. As seen from the datasets from western and central Anatolian settlements, cattle were highly regarded, let alone the textual evidence from Hittite texts. Ideologically, cattle were not only considered big, meat yielding, milk providing and powerful animals, but they were also considered as symbols of power, wealth, wellbeing, and religious characters. At Kaymakçı, the detailed examination of cattle, illustrates certain elements that were inter-culturally shared, like representing an important symbol for perhaps wealth and power, but also the evidence suggests that there were complex strategies adopted for cattle husbandry at Kaymakçı.

Kaymakçı's cattle data is characterized by the absence of young individuals. It points to the possibility of provisioning of cattle from somewhere else, possibly neighboring citadels. There might be several reasons for this type of management strategy -the political position of Kaymakçı among Arzawa Lands, ecosystem sustainability, selective breeding, etc. Furthermore, the dietary contribution of cattle at Kaymakçı is distinguished. It appears that people not only included beef in their everyday life, but perhaps cattle was a common food for communal feasts among the LBA Kaymakçı community. Cattle data from Kaymakçı forms an important departure point for future research into LBA cattle cultures. Cattle bones so far recovered from Kaymakçı establishes a solid dataset, waiting for more in-depth analyses, and more bones to be excavated. For future studies, cattle in Kaymakçı may therefore offer a crucial dataset for environmental, social, political, and cognitive research questions.

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Appendices

Appendix 1: Number of Identified Specimens per taxon and excavation area (After Marston *et al.*, 2021).

Category	Taxa	Area 81.551	Area 93.545	Area 95.555	Area 97.541	Area 98.531	Area 99.526	Area 108.522	Area 109.523	Total
Domestic Animals -food oriented	<i>Bos taurus</i> (cattle)	89	150	75	121	18	143	92	134	822
	<i>Ovis aries</i> (sheep)	33	113	31	162	5	112	22	124	602
	<i>Capra hircus</i> (goat)	14	77	27	64	1	63	4	41	291
	Ovicaprid (sheep/goat)	133	311	164	293	47	398	138	315	1799
	<i>Sus domesticu s</i> (pig)	194	711	288	929	58	566	269	652	3667
Total of category		463	1362	585	1569	129	1282	525	1266	7181
Domestic Animals -nonfood oriented	<i>Canis familiaris</i> (dog)	9	30	21	12	1	20	4	30	127
	<i>Catus domesticus</i> (cat)			1						1
	<i>Equus caballus</i> (horse)	1								1
	<i>Equus asinus</i> (donkey)	1		2				1		4
	<i>Equus sp.</i>	2	2	6	8		2	2	1	23
Total of category		13	32	30	20	1	22	7	31	156
Wild Animals -ungulates	<i>Bos primagenius</i> (aurochs)		1		1					2
	<i>Bos taurus/primagenius</i> (cattle or aurochs)		2		4					6
	<i>Bos taurus/Cervus elaphus</i> (cattle or red deer)		2		3		3	1	3	12
	Wild ovicaprid		1	2						3
	<i>Capra aegagrus</i> (wild goat)			1			1			2
	<i>Capreolus capreolus</i> (roe deer)	1	3	4	1				3	12
	<i>Cervus elaphus</i> (red deer)		10		7		4		2	23
	<i>Dama dama</i> (fallow deer)	5	20	3	31	2	6	11	6	84
	Deer (<i>Dama</i> , <i>Cervus</i> , <i>Capreolus</i>)	30	58	36	90	8	24	14	23	283
	<i>Sus domesticus/Sus scrofa</i> (pig or boar)	18	41	2	24	2	4	2	17	110
Total of category		54	138	48	161	12	42	28	54	537
Wild Animals -other	<i>Anas sp.</i> (wild or domestic duck)			1					1	2
	<i>Lepus capansis</i> (European hare)		3	1	2		13		5	24
	<i>Oryctolagus cuniculus</i> (rabbit)		2		1				1	4
	Rodentia indet.		3				3		4	10
	Muridae		1				1			2
	<i>Testudo sp.</i> (Turtle)			5			2		14	21
Total of category		0	9	7	3	0	19	0	25	63
Large carnivores	<i>Ursus arctos</i> (Brown bear)		1							1
	Large felid		1							1
	Large carnivore							1		1
Total of category		0	2	0	0	0	0	1	0	3
Medium carnivores	<i>Canis familiaris/Canis lupus</i> (dog or wolf)	1	4		6		13		1	25
	<i>Canis familiaris/Vulpes vulpes</i> (dog or red fox)		1		2		3		1	7
	<i>Meles meles</i> (European badger)	1								1
	<i>Vulpes vulpes</i> (red fox)	1							5	6
	Medium carnivore		1		2	1	2	1		7
Total of category		3	6	0	10	1	18	1	7	46
Ichthyofauna	Cyprinidae		6		16		123		6	151
	<i>Cyprinus carpio</i> (common carp)				1		8			9
	<i>Silurus glanis</i> (catfish)		25	12	19		39	2	19	116
	Pisces indet.	10	27	21	38	7	173	12	64	352
Total of category		10	58	33	74	7	343	14	89	628
Avifauna	Aves indet.	5	7	13	8		28	2	18	81
Total of category		5	7	13	8	0	28	2	18	81
Shells	Bivalve			1		8	7	1	5	22
	<i>Conus mediterraneus</i>			1	4		1		2	8
	Land snail	3	2	1	1	4	3	1	6	21
	Marine shell	1	4	2	4		1		2	14
	Unio sp.		5		8	3	12	2	16	46
Total of category		4	11	5	17	15	24	4	31	111
Total of above categories		552	1625	721	1862	165	1778	582	1521	8806
Unid. Mammals in size category	Unid. Large mammal (red deer, cattle, horse)	24	89	33	64	13	94	21	76	414
	Unid. Medium to large mammal (wild pig to donkey)	46	64	22	52	12	79	31	68	374
	Unid. Medium mammal (sheep to pig)	88	204	89	170	28	487	70	347	1483
	Unid. Small to medium mammal (hare to dog)	18	26	11	27	10	91	23	54	260
	Unid. Small mammal (rat to rabbit)	2	10	1	6	2	11	1	11	44
Total of category		178	393	156	319	65	762	146	556	2575
Unid. Mammals	Unidentified mammal	78	402	157	322	46	590	121	226	1942
Total of category		78	402	157	322	46	590	121	226	1942

Appendix 2: Diagnostic Zones for the Main Domestic Species

Element	Portion	155/18			95/95			96/96			97/97			98/98			99/99			100/100			Grand Total		
		Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis	Bos	Ovis	Capri/Ovis			
1st phalanx	Complete	1	1	2	1	6	4	1	4	3	15	3	2	1	4	5	15	4	4	1	2	16	27		
	Almost Complete	1	1	1	3	3	1	1	3	9	5	2	2	9	3	2	1	4	5	15	3	2	1		
	Proximal	1	1	2	3	2	1	3	1	1	5	1	2	1	1	5	1	1	1	5	1	1	1		
	Distal	0	1	2	2	5	1	1	3	4	1	1	2	1	1	1	1	1	1	2	1	1	1		
2nd phalanx	Complete	2	1	2	5	1	1	3	6	11	2	2	1	7	10	4	1	1	3	4	13	1	1		
	Almost Complete	1	2	1	1	2	1	2	2	1	2	2	2	1	2	1	6	1	2	1	6	8	0		
	Proximal	1	1	2	1	1	2	3	1	1	1	1	1	1	1	1	1	1	1	1	2	2	0		
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
3rd phalanx	Complete	3	1	2	6	2	1	3	3	3	1	1	5	5	3	1	4	13	0	0	0	0	0		
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Astragalus	Complete	1	3	3	1	8	3	3	1	4	5	16	1	2	2	1	6	6	1	1	12	19	1		
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Atlas	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Axis	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Calcaneum	Complete	3	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	1	1	3	2	2	6	3	1	4	1	2	5	8	1	1	1	1	1	1	1	1			
	Proximal	1	1	2	1	2	4	1	7	1	1	1	1	1	2	1	1	1	1	1	1	1			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Femur	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	3	3	6	4	1	1	2	1	1	1	3	2	9	5	16	1	1	1	1	1	1			
	Distal	1	1	2	2	1	11	14	1	1	1	1	1	2	3	6	1	1	1	1	1	1			
Humerus	Complete	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	2	2	1	5	1	3	1	5	1	1	2	1	1	2	3	1	1	1	1	1	1			
	Proximal	1	1	4	3	1	1	3	1	1	1	2	1	1	2	3	10	3	1	3	10	3			
	Distal	1	1	1	4	10	4	8	2	7	18	39	1	5	5	13	24	8	1	7	23	38			
P4 (mandible and loose)	Complete	2	3	3	2	10	1	12	2	6	14	35	3	2	3	8	2	6	4	2	10	24			
	Almost Complete	1	3	1	5	1	2	2	5	1	2	2	5	1	1	8	11	1	1	1	8	11			
	Proximal	1	3	1	5	1	2	2	5	1	2	2	5	1	1	8	11	1	1	1	8	11			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Dedious P4 (mandible)	Complete	1	2	1	4	5	5	10	30	2	1	1	6	10	5	4	3	17	29	2	2	1			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Metapodials	Complete	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	5	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
	Proximal	1	3	1	5	2	5	8	15	3	2	2	3	10	2	1	3	5	11	1	1	1			
	Distal	1	1	1	3	4	1	3	3	11	2	2	4	7	4	2	13	1	2	2	5	3			
Pelvis	Complete	2	2	2	4	1	3	1	4	1	1	1	3	3	1	1	1	1	1	1	1	1			
	Almost Complete	2	2	1	2	2	6	3	3	3	1	1	6	1	9	0	3	2	5	1	1	1			
	Proximal	1	1	1	4	1	1	5	3	2	5	0	4	4	4	0	4	1	5	3	2	5			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Radius	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	1	3	4	4	3	2	7	16	1	1	4	5	11	3	1	17	21	0	0	0	0			
	Distal	2	1	2	5	1	1	1	4	3	10	1	2	3	3	1	3	2	7	0	0	0			
Radius and Ulna	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Scapula	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	3	3	6	2	5	11	18	1	3	3	7	1	1	4	5	11	1	1	3	11	18			
	Proximal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Tibia	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	2	1	3	1	4	6	11	4	9	15	33	2	4	1	5	1	1	1	9	13	13			
	Distal	2	2	3	4	11	4	9	15	33	2	4	1	5	1	5	17	35	1	1	1	1			
Ulna	Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Almost Complete	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Proximal	1	4	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
	Distal	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
Absolute count of Diagnostic Zones per species per element		26	14	10	50	46	146	53	44	38	99	191	425	34	23	16	52	72	197	42	71	73	237	444	
Relative count of Diagnostic Zones per species per element		18%	10%	7%	34%	32%	100%	12%	10%	9%	23%	45%	100%	17%	12%	8%	26%	37%	100%	9%	16%	5%	16%	53%	100%
Relative count of Diagnostic Zones per species per element		18%	10%	7%	34%	32%	100%	12%	10%	9%	23%	45%	100%	17%	12%	8%	26%	37%	100%	9%	16%	5%	16%	53%	100%
Relative count of Diagnostic Zones per species per element		18%	10%	7%	34%	32%	100%	12%	10%	9%	23%	45%	100%	17%	12%	8%	26%	37%	100%	9%	16%	5%	16%	53%	100%

Appendix 3: Raw Data (NISP) for Epiphyseal Fusion.

	Unfused	Fused
Early Fusing		
Humerus, distal	1	5
Scapula, distal		3
Radius, proximal		7
Metapodium, proximal		11
Phalanx 1, proximal		47
Phalanx 2, proximal	2	15
Middle Fusing		
Tibia, distal	3	10
Calcaneus, proximal	2	4
Metapodium, distal	4	22
Late Fusing		
Humerus, proximal	3	2
Radius, distal	1	4
Ulna, proximal	3	4
Ulna, distal		
Femur, proximal	1	4
Femur, distal	2	2
Tibia, proximal		3

Appendix 4: %NISP data for Epiphyseal Fusion.

	NISP (UNF)	%NISP(UNF)	NISP (F)	%NISP(F)	NISP (Total)
Early Fusing	3	3.3	88	96.7	91
Middle Fusing	9	20	36	80	45
Late Fusing	10	34.5	19	65.5	29

Appendix 5: Tooth wear stages of KAP cattle; Jones & Sadler (2012), Halstead (1985), and Legge (1992) is calculated according to Grant's wear stages (1982). Published in Marston et al., 2021 (Fig. 6).

Taxon	Common name	LD4	LP4	LM1	LM2	LM3	Jones&Sadler	Halstead	Legge
Bos taurus	Cattle		Grant Stage g	Grant Stage g	Grant Stage g		gkk	H	8
Bos taurus	Cattle		Grant Stage g	Grant Stage m	Grant Stage k	Grant Stage k	glkk	I	9
Bos taurus	Cattle				Grant Stage o	Grant Stage m	mm	I	9
Bos taurus	Cattle			Grant Stage l	Grant Stage k	Grant Stage j	lkj	H	9
Bos taurus	Cattle		Grant Stage g			Grant Stage m	gm	I	9
Bos taurus	Cattle					Grant Stage j		H	8,9
Bos taurus	Cattle				Grant Stage k	Grant Stage k	kk	I	8,9
Bos taurus	Cattle					Grant Stage j/k		H	8,9
Bos taurus	Cattle			Grant Stage o	Grant Stage k	Grant Stage j	lkj	H	9
Bos taurus	Cattle					Grant Stage l		H/I	
Bos taurus	Cattle		Grant Stage f	Grant Stage g	Grant Stage f	Grant Stage f	c-jf/fjgg	F/G	7
Bos taurus	Cattle		Grant Stage f	Grant Stage k	Grant Stage k	Grant Stage f	c-jf/fjgg	F/G	7
Bos taurus	Cattle					Grant Stage k		I	8,9
Bos taurus	Cattle					Grant Stage k		I	8,9
Bos taurus	Cattle					Grant Stage e/f		F	7,8
Bos taurus	Cattle					Grant Stage e/f		F	7,8
Bos taurus	Cattle				Grant Stage k	Grant Stage j		H	8,9
Bos taurus	Cattle			Grant Stage o/p	Grant Stage o/p		oo	I	10

Appendix 6: Definition of Halstead's (1985) Age Classes based on Grant (1982).

Halstead Age Class	Suggested Age (months)	Definition
A	0-1	p4 unworn
B	1-8	p4 in wear, M1 unworn
C	8-18	M1 in wear, M2 unworn
D	18-30	M2 in wear, M3 unworn
E	30-36	M3 in wear, posterior cusp unworn
F	young adult	M3 post cusp in wear, M3 wear stage <g*
G	adult	M3 wear at stage g*
H	old adult	M3 wear at stage h or j*
I	senile	M3 wear > stage j*
		*Wear stages as defined in Grant 1982

Appendix 7: Standard measurements in millimeters of female aurochs (Degerbøl, 1970) used for log size index calculations.

Scapula	LG: 70	BG: 60	SLC: 69		
Humerus	GL: 359	GLC: 309	SD: 46	Bd: 97	BT: 89
Radius	GL: 320	Bp: 100	BFp: 90	SF: 56.5	Bd: 92
Metacarpal	GL: 246	Bp: 74	SD: 40	Bd: 73	
Phalanx 1 A	GLpe: 69	Bp: 39	SD: 33	Bd: 34	
Phalanx 2 A	GL: 50	Bp: 36	SD: 28	Bd: 31	
Femur	GL: 445	Bp: 145	DC: 57	SD: 54	Bd: 116
Tibia	GL: 420	Bp: 126	SD: 52	Bd: 78	
Calcaneum	GL: 165				
Astragalus	GLl: 83	Bd: 52			
Os centrotarsale	GB: 67				
Metatarsal	GL: 280	Bp: 62	SD: 35.5	Bd: 68	
Phalanx 1 P	GLpe: 72	Bp: 35.5	SD: 29	Bd: 35	
Phalanx 2 P	GL: 47	Bp: 34	SD: 27	Bd: 29	

Appendix 8: Age in months when epiphyseal fusion of different skeletal elements may be completed in cattle (Reitz and Wing, 2008: 72).

Early Fusing	Age in months for Cattle
Humerus, distal	12-18
Scapula, distal	7-10
Radius, proximal	12-18
Metapodium, proximal	fused before birth
Phalanx 1, proximal	18-24
Phalanx 2, proximal	18-24
Acetabulum	6-10
Middle Fusing	Age in months for Cattle
Tibia, distal	24-30
Calcaneus, proximal	36-42
Metapodium, distal	24-36
Late Fusing	Age in months for Cattle
Humerus, proximal	42-48
Radius, distal	42-48
Ulna, proximal	42-48
Ulna, distal	42-48
Femur, proximal	42
Femur, distal	42-48
Tibia, proximal	42-48
Vertebral centrum	84-108

Appendix 9: Cattle Terminology, definitions are from the Webster Dictionary.

Cow	Adult female cattle
Bull	Uncastrated adult male cattle
Calf	Young cattle, either sex
Heifer	Young cow, that has not given birth yet
Steer	Male cattle castrated before maturity
Ox	Castrated adult male kept for draft
Springer	Cow or heifer ready to calf
Freemartin	Sexually imperfect usually sterile female calf twinborn with a male
Maverick	Unbranded calf
Neat	Horned oxen
Polled	Unhorned cattle
Beef Cattle	Raised and kept for human consumption
Dairy Cattle	Cattle bred selectively raised for milk production