THE LATE BRONZE AGE ANIMAL MOBILITY AND HERDING STRATEGIES: A GEOMETRIC MORPHOMETRIC STUDY OF *OVIS ARIES* AND *CAPRA HIRCUS* REMAINS FROM HITTITE PERIOD ŠAPINUWA (ORTAKÖY/TURKEY)

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ABSTRACT

THE LATE BRONZE AGE ANIMAL MOBILITY AND HERDING STRATEGIES: A GEOMETRIC MORPHOMETRIC STUDY OF *OVIS ARIES* AND *CAPRA HIRCUS* REMAINS FROM HITTITE PERIOD ŠAPINUWA (ORTAKÖY/TURKEY)

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Throughout the Late Bronze Age period, pastoralism remained crucial for the social and economic system of the Hittite states (Beckman, 1988; Schachner, 2012; Yakar, 2000). The faunal analysis of different Hittite sites indicates a well-developed animal husbandry and a good knowledge of breeding practices which is also mentioned in Hittite archives. In tandem with this information, this thesis aims to explore the animal husbandry management, animal mobility and breeding practices during the Hittite Late Bronze Age period. This thesis will apply interdisciplinary research by taking the faunal remains of Šapinuwa (Ortaköy) as a case study. Šapinuwa, located in the North Central Anatolia, has long been assigned as the second capital of Hittite Empire in the 14th century BCE. In this thesis, two-dimensional geometric morphometric analysis is employed to investigate whether a specialized veterinary activity was practiced by the Hittite Empire and if so, how it affected socio-economic hierarchy during the Late Bronze Age period. In order to increase the effectiveness of examination beside geometric morphometric analysis, traditional measurements will be used as a comparative methodology. This research focuses on the analysis of *Ovis aries* and *Capra hircus* astragalus, metacarpal and metatarsal bones on the basis of a multidisciplinary approach. For the effectiveness of the technique, other than geometric morphometrics, traditional measurements will then be used as a comparison. This study employs standard and specialized zooarchaeological techniques to present two aspects of animal husbandry in Hittite; mobility of animals and selective breeding.

Keywords: Late Bronze Age, Central Anatolia, Šapinuwa, Geometric Morphometrics, Animal Mobility, Hittite Period

ÖZ

GEÇ TUNÇ ÇAĞI HAYVAN MOBİLİTESİ VE HAYVANCILIK STRATEJİLERİ: HİTİT DÖNEMİ ŠAPİNUWA (ORTAKÖY/TÜRKİYE) KENTİ KOYUN VE KEÇİ KALINTILARININ GEOMETRİK MORFOMETRİK ÇALIŞMASI

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Geç Tunç Çağı boyunca, pastoralizm Hitit devletlerinin sosyal ve ekonomik sistemi içinde oldukça önemli bir rol oynamıştır (Beckman, 1988; Schachner, 2012; Yakar, 2000). Hitit arşivlerini doğrulayacak bilgiler sunan farklı Hitit yerleşimlerine ait faunal analizler sonucunda gelişmiş bir hayvancılık ve yetiştirme uygulamasına işaret eden bir bilgi birikimine sahip olduğumuz söylenebilir. Bu bilgiler ışığında, bu tez çalışması, Hitit Geç Tunç Çağı döneminde Šapinuwa kenti, modern Ortaköy/Çorum kazısında bulunan hayvan kemiklerini vaka çalışması olarak ele alarak, hayvancılık, hayvan mobilitesi ve ıslah çalışmaları hakkında disiplinlerarası bir çalışma sunmayı amaçlamaktadır. Milattan önce 14. Yüzyılda Hitit İmparatorluğunun ikinci başkenti olduğu düşünülen Šapinuwa, Kuzey Orta Anadoluda yer almaktadır. Bu çalışma, Hitit dönemi hayvancılığında sürü yönetimi, hayvan mobilitesi ve ıslah çalışmaları hakkında geometrik morfometri ve oestrometri metodları kullanılarak dönemin hayvancılık ve ekonomik dinamikleri konusundunda araştırmaları ortaya koymayı amaçlamaktadır. Koyun ve keçi astragalus, metacarpal ve metatarsal kemiklerinin multidisipliner yaklaşım temelinde analizine odaklanmaktadır ve tekniğin etkinliği

için geometrik morfometrik dışında, geleneksel ölçümlerle (osteometri) yapılacak analizler bir karşılaştırma olarak kullanılacaktır.

Anahtar Kelimeler: Geç Tunç Çağı, Orta Anadolu, Šapinuwa, Geometrik Morfometriks, Hayvan Mobilitesi, Hayvan Islahı

To My Family

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
BCE	Before the Common Era
CVA	Canonical Variate Analysis
GMM	Geometric Morphometric Methods
MANOVA	Multivariate Analysis of Variance
PAST	Paleontological Statistics
PCA	Principle Component Analysis
SZB	Standard Zooarchaeological Biometry

CHAPTER 1

INTRODUCTION

Pastoralism has played a highly important role both in the economic and social system of Hittite states in the Late Bronze Age period (Beckman, 1988; Schachner, 2012; Yakar, 2000), but it is not certain what kind and how far specialized techniques were employed for animal exploitation so far. Animals were used for meat as well as for their secondary products such as wool and leather throughout the prehistoric ages to the present time in Anatolia. The development of animal management strategies such as animal mobility and good knowledge of breeding practices are mentioned in Hittite archives uncovered from different Hittite sites.

Animal mobility as a strategy related to animal management is thought to have existed in Anatolia since prehistoric times (Yakar, 2006: 46). Furthermore, the mobility of animals as taxes, booty, and offers for sacrifices between the states was also mentioned in Hittite archives. It is also mentioned that centralized animal management strategies as well as qualified/specialized staff just for animal husbandry existed in the Late Bronze Age Hittite states. Although we have some evidence that indicates mobile pastoralism in southern and northern Anatolia, central Anatolian mobile pastoralism has not yet been examined in a more detailed way. Additionally, the assumption of animal mobility and exchange of animals, both of which need interdisciplinary and scientific approaches to test within the framework of archaeology, have been presented recently (Balasse et al., 2002; Colominas et al., 2019; Howell-Meurs, 2001; Irvine & Erdal, 2020; C. A. Makarewicz, 2015; Cheryl A. Makarewicz et al., 2017; Ventresca Miller & Makarewicz, 2017).

As Willeke Wendrich and Hans Barnard mentioned that the archaeology in Old World is more related with sciences, languages and history, however, archaeologists, who have more affinity with social science (e.g. anthroology), in the New World should build bridges between different disciplines as well as different arcchaeological fileds of research (Barnard & Wendrich, 2008, p. 7). Picking relatively specific subjects from its temporal context and examine the results of a multidisciplinary research paved the way for discussing results as well as the methodologies in a way of broaden interpretative framework (Barnard & Wendrich, 2008, p. 7).

The aim of this thesis is to explore the animal husbandry, mobility and selective breeding of animals at Šapinuwa (Ortaköy) in the Late Bronze Age period through interdisciplinary research in combination with osteometry and geometric morphometric analyses. Since the excavation has taken place at two different areas of the Hittite city and there were different spatial divisions within these two main locations where those locations were used by people that are from different social classes (such as priests, artisans, administrative officiers and probably even rulers), I am able to select samples coming from Palatial (common space where administrative officiers and artisans used the place), Sacrificial, and Temple spaces. This means that the possibly different classes of people who used these areas may had consumed animals coming from flocks with different animal management strategies. In my thesis, I will conduct a research about the differences of animal bone morphology and the data will be analyzed from three areas of the Hittite city; Tepelerarası, Sacrificial and Ağılönü areas in order to compare the animal husbandry practices as well as detecting social hierarchical access to different breed managements.

Osteometry is a traditional measurement technique for evaluating size and shape by using calipers in the zooarchaeological research for many years. In 1976, standardization of measurement techniques were introduced by Von Den Driesch (1976). In the late 1980's and early 1990's, the development of measurement and the data analyses techniques brought out new ways for morphological studies (Adams et al., 2004). Capturing the morphological structure of geometry with landmarks were introduced and the new approach was called as geometric morphometrics. Geometric morphometric is a technique to explore shape variation (Adams et al., 2004; Bookstein, 1996; Rohlf & Marcus, 1993; Slice, 2005; Zelditch et al., 2004). The use of landmark-based geometric morphometrics has been practised in various disciplines such as biology, anthropology, medicine, palaeontology (Lawing & Polly, 2010) and the method has been applied by many zooarchaeologists for studying morphological differences between and within groups. The importance of geometric morphometrics compared to the traditional measurements is that the smallest changes in shape that can be missed by traditional measurements, could be detected by this method.

The thesis consists of 6 parts: the first chapter is introduction and the last chapter is conclusion. Brief information about Hittites, detailed discussion of the case study site Šapinuwa and animal husbandry of Hittite states are introduced in Chapter 2. Furthermore, theoretical and methodological framework of the Late Bronze Age animal husbandry in Hittite states in the past and present archaeological and zooarchaeological researches are summarized.

In Chapter 3, the methodological and theoretical overview of the thesis will be introduced. As geometric morphometrics and osteometrical analyses are used in the research, work flows of the two methodologies will be presented and explained at each steps in a detailed way. Beside these, zooarchaeological data collected for the thesis, statistical approaches and evaluation of zooarchaeological data in general framework will be discussed.

4th Chapter is organized in two main sections as the result of osteometry and geometric morphometrics analyses. The results of both analyses which were retrieved via computer aided statistical methods (PAST and MorphoJ) will be given based on graphs and ANOVA results will be present in this chapter.

The discussion, comparison and contrast of analyses' results and animal mobility based on morphological differences in Šapinuwa will be approached in Chapter 5. Additionally, the evidence provided from the Hittite archives will be compared with zooarchaeological results.

The last chapter includes the research conclusions and limitations of the research. Moreover, further overview of the research will be approached in Chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Archaeological background of Hittite

The socio-political and cultural uniformity in Anatolia was realized by Hittites (ca. 1650-1200 BCE) in the seventieth century BC (Schachner, 2010 ; Van den Hout, 2013). Although the presence of Indo-Europeans in Anatolia has chronological problems (Bryce, 2005, pp. 11–15; Collins, 2007, pp. 23–25; Ünal, 2002, pp. 11–29), the origin of Hittites considered to be Indio-European but it is still ambiguous where the Hittites exactly came from. The formation of this community was first seen around the Kızılırmak basin which was called ‘the land of Hatti’ but the geographical boundaries of the Hittite state, which had a feudal structure, had been varied in time. The core of the Hittite state was in Central Anatolia but the state boundary extended to Northern Syria and the west of Mesopotamia.

Linguistically, the presence of Indo-European speaking peoples in Anatolia has been attested during the second half of the third millennium BCE (Beckman, 2011, p. 522; Bryce, 2005, p. 11; Gorny, 1989, p. 82) but the archaeological evidence of Indo-European speaking groups in Central Anatolia was provided with the Old Assyrian texts written by merchants who were bringing tin and textile in Anatolia and taking metal resources to their lands. These were unearthed in Level II at Kültepe (Kaneš) and dated in ninetieth century BCE (Bryce, 2005, p. 16; Klengel, 2011, p. 31). The texts discovered from Kültepe, comprising of over 23,500 cuneiform tablets, (Kulakoğlu, 2011, p. 1028) are generally commercial including some other topics related with contracts and a few historical texts (Cecile Michel, 2003, pp. 135–141; Cécile Michel, 2011, p. 319). These tablets help us to understand the relationship between Assyrian and Anatolian rulers with the long-distance trades, history, political and administrative situations of Anatolian kingdoms as well as sheding light to the chronology.

There were several small city states around a few local centres that they were sometimes in alliance and sometimes had wars between them during the Karum II period in Anatolia. These wars and even peace were mentioned in some letters because those actions could affect the trade between Assyrians and Anatolia. However, the archives created by Assyrian merchants never mentioned local ruler names, except for Labarsa (Cécile Michel, 2011, p. 322) until Karum Ib period when Anatolians had started to document their history. However, some scholars argue that Labarsa is a regular Central Anatolian personel name and there is no relation between Labarsa and Labarna (Blasweiler, 2019, p. 6; Soysal, 2005, p. 203). The trade between Anatolians and Assyrians depended on the metallurgical resources. The economy of Anatolia was mainly based on animal husbandry and agriculture but metal resources, which is the main reason of the Assyrian attraction, were also richly present in Anatolia at that time. Assyrian merchants were bringing tin and textile products to Anatolia and taking silver (western Anatolia) and gold (west and southwest Anatolia) to their homeland (De Jesus, 1980; Cécile Michel, 2011, p. 325). The copper, which was another payment currency other than grain, was mainly found around Kızılırmak and/or near Ergani but tin was brought from northwest Iran and Uzbekistan by Assyrian merchants and Anatolian metalworkers combined the two metals and worked their own bronze to get tools, objects and weapons (Özgüç, 1986). Gorny (1989) proposes that the Assyrian presence in Anatolia could be the inspiration of developing a centralized economy by Hittites, furthermore, the already developing regional unification of Anatolia could have been affected by Old Assyrian traders in terms of providing a central focus and sense of common identity to the people living in Anatolia at that time (Gorny, 1989, pp. 82–85).

The chronology and terminology of Hittite is controversial. In earlier times, before the linguistically defined Middle Hittite script which was in use during the fifteenth and fourteenth centuries B.C.E. (Seeher, 2011), the division of the Hittite period was as Old Kingdom and New Kingdom or Empire period (Burney, 2004; Collins, 2007).

Nowadays, although the division is postulated as Old Kingdom, Middle Kingdom and Empire periods (MacQueen, 2015, p. 48; McMahon, 1989, p. 64), the two-stage scheme is still supported by some scholars.

In the Late Bronze Age, the Hittite Empire was one of the great powers among Egypt, Babylon, Assyrian and Mitanni in Near East and it was in a struggle with them for similar interests. Although having a more egalitarian policy for relationships with the other empires during the Empire period (Alp, 2001, p. 145; De Martino, 2006, p. 81; Gavaz Sir, 2008), the written sources mentioned the conflict between the people of Kaška (see page 10 for further discussion of Kaška relations), who were known as pastoral tribes in the northern Anatolia, and Hittite state from its establishment until its collapse (Glatz & Matthews, 2005; Matthews & Glatz, 2009; Yakar, 2008).

The geography and especially the topography of a place had affected the decisions of Hittites as to where to establish a settlement. These two influenced administrative and religious concepts and had affected the urban structure and specific urban elements as well. Besides giving importance to the landscape of the Hatti land, palaces, public squares and temples also reflected the importance of architectural structures.The location of some Hittite settlements such as Hattuša (Boğazkale), Šapinuwa (Ortaköy) and Sarissa (Kuşaklı höyük) was choosen in line with their political and religious needs (Bahar et al., 2018, p. 408). Moreover, some sanctuaries were purposely built outside of the settlement, sometimes near water resources, or on a mountain or even between rocky places. Especially, mountains played major role for the Hittite religion. In fact, it is thought that when gods are summoned, they first come to the mountain near the temple where they summoned and then entered the temple (Bryce, 2002, p. 154). According to Beckman (1989), mountains were also mentioned as treaty witnesses of some political treaties.

Figure 1: The relief of the Great King Tudhaliya IV in Chamber A at Yazılıkaya (image adapted from Zangger and Gautschy 2019, 20, Fig. 10).

The Hittite state had a theocratic and feudal structure, and a centralized management approach was adopted in administrative, economic and organizational aspects (Alp, 2001, p. 147; Ünal, 2005, pp. 100–101). The social structure included royals and/or elites, people who were responsible for religious activities (depended on temples), the common people and slaves. Gods had the ownership of the lands and organization and management of the lands were under the authority of the kings who were taking their power from gods themselves (De Martino, 2006, p. 77; Ünal, 2005, p. 144). In fact, kings were generally depicted as high priests wearing a skull cap and long, ankle-length robe (Fig. 1) which represents the king as gods' agent or 'shepherd of the god' (Bryce, 2002, p. 20). The king also was mentioned as commander and judge of the Hittite state (Bryce, 2002, p. 21). The queen also played important role in administrative, social and religious aspects. In fact, they had an important position in the Hittite Kingdom; Tawananna, the official title for the queen, was chosen from a woman member of the royal family and had own right in political and religious activities (Bin-Nun, 1975; Bryce, 2005, p. 92).

The Hittite kingdom's lands outside of the central state were governed with the centralist approach. High officials, son of the kings/princes, and even sometimes elite members who were close to the king were appointed to larger states, whilst local rulers were choosen to rule smaller states (Alp, 2001, p. 147; Yiğit, 2004, p. 220). The smaller units defined as houses are also mentioned in the Hittite archives and these smaller units generally were depended on larger houses (Bryce, 2002, p. 75; Karauğuz, 2019, pp. 119–122; Sevinç-Erbaşı, 2014). The people who were living in the smaller units contributed to production by working both in their fields and in the palace as well as temple fields. The surplus products collected by centralist authority were stored and distributed in a hierarchical order to the society (Reyhan, 2009).

2.2 Animal Husbandry of Hittite and Possibility of Breeding Practises

According to the previous researches, it is no doubted that pastoralism is a crucial component for Hittite economy but it is not certain what kind and how far specialized techniques were employed for animal exploitation in the Hittite Anatolia[1]. In the Hittite social structure, all fields/lands belonged to gods and people were actually serving the gods in a hierarchical order (Demirel, 2014, p. 2; MacQueen, 2015, p. 115). Land/field regulations, distribution of livestock-related field usage and even animals belonging to the soldiers were taken care by the state (Beal, 1992, pp. 135, 401). Additionally, it is mentioned in the Hittite archives that temples had their own large fields, herds (Beckman, 1988, p. 35; Reyhan, 2009, p. 161) as well as specialized official personnel who were responsible for especially these activities related with agriculture and husbandry. The rules that officials must obey and the fields specially provided for the temple were clearly stated in the Hittite instructions (Sir Gavaz, 2012; A. Süel, 1985).

Animal mobility is thought to have been practised in Anatolia since prehistoric times as a subsistence strategy (Schachner, 2012, p. 30; Yakar, 2006, p. 46). Although we have some evidence that indicate mobile pastoralism in the southern and northern

[1] For further discussion, see Gerçek's (2017: 257-278) chapter 12 "A *Capra hircus*herd Shall Not Enter!" Observations on Pastoralism and Mobility in Hittite Anatolia".

Anatolia, Central Anatolian mobile pastoralism has not yet been examined in more detailed way. The strong evidence comes from the treaties mentioned Kizzuwatna[2] and Tarhuntassa[3] indicating that mobile pastoralism was practiced in this region during the LBA (Gerçek, 2017, p. 269). In the Black Sea region, we have evidence about a group of people who were known as "Kaška men" and E. van Schuler first mentioned about them as a semi-nomadic pastoralist groups in the central Black Sea region (Von Schuler, 1965, pp. 75–78). As it is indicated in the written records in Hittite language, we know that Kaška people and Hittite were mostly fighting with each other and some of those fights ended with agreements about peace.[4] The evidence indicate that pastoralism is thought to have been practiced in conjuction with Kaška during the peaceful interaction between the Kaška and Hittite. Based on the written records of Hittite, one might suggested that Kaška men seem to have been employed by Hittites as herdsmen (Gerçek, 2017, p. 266).

"Because you are allies, the cattle [and sheep] of Ḫatti [and your cattle] and sheep are mixed together, and the cowherds and shepherds [pasture] together. But if an enemy attacks, we shall hold you alone responsible. […] you indeed drive (the animals) here. The cowherds and shepherds […] If they kill anyone, either one man, or one [ox, or one sheep], you shall replace them (i.e. the men) and [you shall replace the] cattle [and sheep] of Ḫatti as well. You shall give three men for one man, you shall also give [three oxen for one ox] and you shall give three [she]ep for one sheep." [5] *(Gerçek, 2017, pp. 266–267).*

Scholars indicate that Kaška people, as both pastoralist and to some extend agriculturalist, practiced vertical transhumance (seasonal) moving during the summer from their winter settlement to the campsite like summer settlement close to the highlands' pastures (Glatz & Matthews, 2005, p. 59; Yakar, 2000, pp. 283–302; Zimansky, 2007, p. 168). According to the ethnographic evidence, central Anatolia

[2] Padatiššu Treaty, paragraphs 5'-8', CTH 26.
[3] Ulmi-Teššup Treaty, KBo 4.10+, i 33'-35' translated by Beckman (1999: 114-124).
[4] See the Middle Hittite Kaška agreements, the corpus of letters from Maşat Höyük.
[5] See passage from agreement CTH 138.3.A (ii 21'-28'), KUB 26.19 ii 21'-28'.

also was only suitable for short distance mobile pastoralism of transhumance practice (Yakar, 2000, p. 220). Written records of Hittite also mentioned different kind of pastures and mostly it is common to see pasture for cattle (Ú.SAL (-LUM) was often used to refer this kind of pasture) located close to the rivers or canals (Rüster & Wilhelm, 2012, pp. 231–244). Moreover, in Rüster and Wilhelm's research, summer and winter pasturages for different species of animals (wešiya- "pasture" and wellu- "grassland, meadow")[6] are also mentioned and this might indicate that the Hittite Kingdom tried to enforce specialized animal management activities controlled by palaces and temples.

From Hittite sources we know that there are various names used for animals; "UDU=sheep", GU4=cattle", "MAŠ, UZ6=goat", ŠAH=pig", "ANŠE=donkey", "ANŠE.GiR.NUN.NA= mule", "ANŠE.KUR.RA=horse", "UR, UR.GI7=dog.[7] It is also known that the Hittite state interfered with animal husbandry and allocated animals to the palace, and to the temples. The preferential mentioning of animals for the "Gods" at Hittite texts (the biggest and best animals are the Gods' animals) also implies the same. The Hittite state, being theocratic, regulates and executes a large number of festivals to which the sacrifice of animals is central. These animals could be offers from the animals of the temples or the palace or/and might be offers from the people. At the same time, the Hittite state also receives large numbers of animals as taxes from various parts of the Empire and booty from wars.

"In one instance the god Telipinu of Kasha receives a delivery of 50 cattle and 100 sheep from the chief shepherd of the town of Ankuwa, and Queen Puduhepa issues 287 female sheep, 100 male sheep, and 11 goats from the property of the palace to the goddess Lelwani." (Beckman, 1988, p. 34). [8]

The most general booty animal of Hittite were sheep and cattle. As Goetze indicated that sheep was a general levy which certain people had to donate sheep regularly to

[6] Nr. 91 (KBo 5.7) rev. 1 and 10 in Rüster and Wilhelm 2012, 231–244.
[7] Ertem, H. 1965:5
[8] CTH 585

the Sun-goddess of Arina for Hatti land (Beckman, 1988, p. 34). These show that the state had strong interest in the animal husbandry and the strict regulation of it. It also indicates a very active movement of animals throughout the Empire either as taxes, booty or sacrifices for the Gods.

In addition to this, Beckman mentioned that herding in Hittite were seen as an activity of low status people based on a Hittite text (Beckman, 1988, p. 38), however, the text were taken is part of an administrative/royal document and indicated that the protection of the herds were provided by laws and restrictions.[9] It is clear that animal management was controled by the state and it indicates centralized control of animal husbandry.

Other than written text from the Hittite period, the zooarchaeological evidences also indicate the good knowledge of animal husbandry and breeding practices by the Hittite states (Dörfler et al., 2011, p. 115). However, many zooarcaheological researches on Hittite period sites in central Anatolia have been mostly descriptive such as this of von den Driesch and Boessneck (1981). The main aim of the researches have been mostly on the economic importance of animals and generally far away from the comparative analysis. There are few works that provided comparative data from the Hittite period sites. The general framework what we know about Hittite animal management is still mostly based on ancient written records and two main sites the Hattuşa and Kuşaklı-Šarrišša. Nevertheless, new researches are conducted recently with the help of new zooarchaeological techniques and methodologies based on different sites (Adcock, 2020; Dörfler et al., 2011; Hongo, 1996; Pişkin, 2019; Pişkin et al., 2020).

2.3 Archaeological Background and Animal Husbandry of Šapinuwa

Šapinuwa (^{URU}Sa-pi-id-du-wa)[10], which is thought as the second capital of Hittite Empire in the Middle Hittite Kingdom period, is located in North of Central Anatolian Steppe (Fig. 2). The name of the city has been confirmed from the tablets discovered

[9] See Adcock (2011), 26.

[10] Güterbock (1956), 125-126.

Figure 2: Modern location of Ortaköy/Šapinuwa (image adapted from google maps).

during the excavations. The site is also known as Ortaköy which is within the border of Çorum city and it is located 53 km southeast of Çorum city centre and 60 km northeast of Boğazköy. The city situated near the Kelkit valley which is kind of a gateway to Anatolia through the Caucasus. The settlement area is ca. 9 km square meter in size and consist of upper and lower part (Fig. 3). The site was found as a result of three years of surveys by Aygül and Mustafa Süel in 1987 and it has been excavated since 1990 (A. Süel & Süel, 2017, pp. 29–30). Šapinuwa as a Hittite city was known as a religious centre under the influence of Hurrians and it is mentioned in the Boğazköy texts that were translated at the beginning of the 20th century before the city was discovered. Furthermore, it is mentioned in these texts that the text of Hurrian mouth-washing rituals (*itkalzi*) had been written here and sent to the rest of the Hittite states (see page 18 for further information). [11]

[11] See the discussion de Martino and Süel 2015.

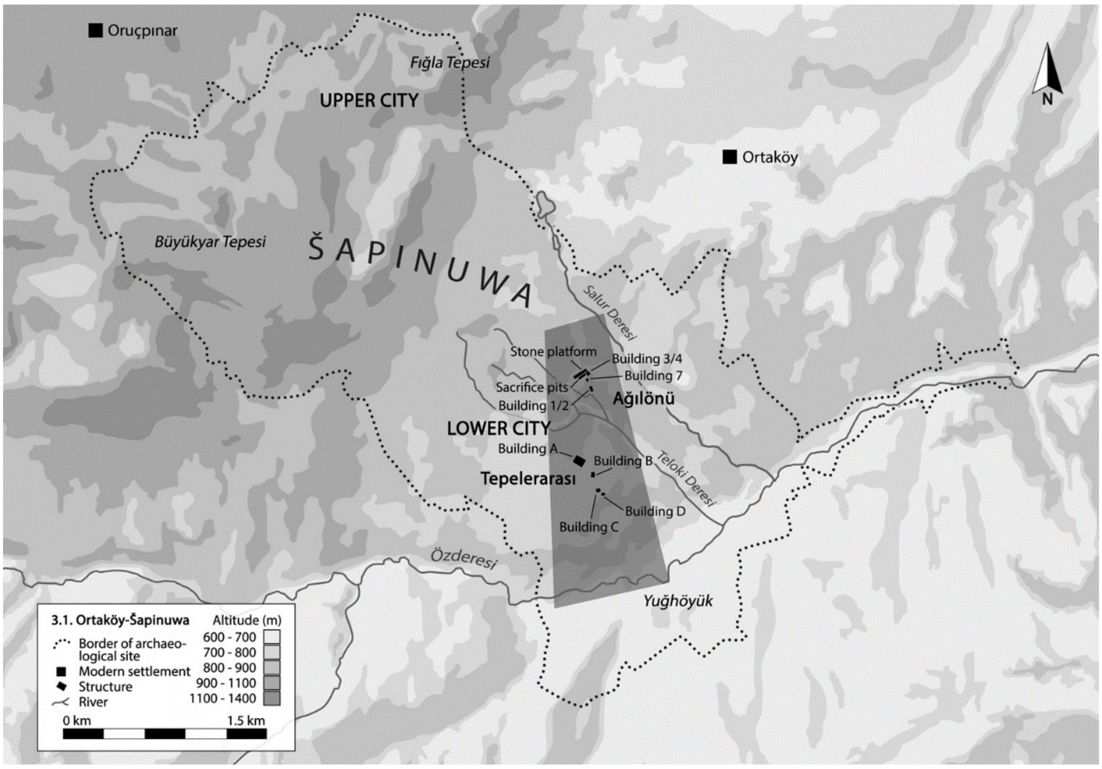


Figure 3: Ortaköy-Šapinuwa Hittite City Map (image adapted from Süel 2017, 66, Fig. 2).

According to the excavation team, the flat settlement was not existing before the Hittites arrived. Instead construction works, terracing and levelling, were done by people in the Hittite period (A. Süel & Süel, 2017, p. 29). Excavation of the site focus on two main areas; Ağılönü and Tepelerarası and the distance between the two areas is ca. 1 km (Figure 4). According to Hittite tablets that have been found during the excavations, scholars indicate that Šapinuwa was not only an administrative center of Hittite but it was also center of the state during the reign of the Great King (A. Süel, 1998, p. 37). The tablets found in the excavation are generally dated back to 14th century B.C. and illustrate important information about the socio-economic and political situation of the site (A. Süel, 1998, p. 37).

Figure 4: Ağılönü area on the left and Tepelerarası area on the right, Ortaköy-Šapinuwa Hittite City (image adapted from Süel 2017, 67, Fig. 3-4).

Considering the ecological and landscape settings, Šapinuwa does not seem to be a reasonable choice for building here a big center because of the limited water resources and agricultural spaces (A. Süel, 1998, p. 39). The area is defined by Alan Dağları on south and Karadağlar on north part and it is located on a plateau the elevation of which decreases from the western part to the eastern part of the site. However, the strategical position of the location is highly likely the reason for the settlement location. It might have served as a passageway between Göynücek- Amasya plain, Kelkit valley and Alaca-Sungurlu plain (which is close to the Boğazköy). The western part of the site where the steepest foothills are located should have been used for all kind of resources for the Hittite center. These foothills had extensive forest areas as well as water sources. It is known that when a Hittite settlement site were chosen, the people of Hittite gave great deal of importance to the geographical and topographical features of the area. These strategical choices are clearly seen in Hattuša (Boğazkale), Šapinuwa (Ortaköy) and Sarissa (Kuşaklı höyük). Some scholars indicate that some of the ritual spaces were located outside of the settlement, generally mountainous regions (Zimmer-Vorhaus, 2011, p. 196). Although it is not known that how those ritual spaces, which were located outside of the settlement, were chosen (Ökse, 2011, p. 222), it is thought that those ritual areas might have been located on mountainous regions which are closest to the settlement (Bahar et al., 2018, p. 408). Ağılönü is the highest area of the site, 1 km far away from the Tepelerarası, and also accepted as ritual space of the site (A. Süel, 2015a, pp. 101–106; M. Süel & Ayyıldız, 2010, p. 63).

Figure 5: Stone pavement in Ağılönü area (image adapted from Süel 2015, 110, Fig. 13).

The Ağılönü area, which is thirty thousand square meters in size, is located in the north of the city and the place is considered to be a sacred area of Šapinuwa. In Ağılönü, where the excavation started in 2000, an unusual and massive stone pavement, (lying north-south direction) which is 1500 square meters in size built with a special technique and thought to belong to a ritual area, was unearthed (Fig. 5). A few workshops, millstones and ovens were also discovered in this area and it is indicated that there were some locations used for daily life activities as well. Another important element of the area is the various sacrificial pits full of animal bones which were found in the south of the stone pavement (Fig. 6) (Pişkin, 2019). The animal sacrifice was a common tradition for the Hittite period and the sacrificial rituals are generally mentioned in the Hittite archives. The seals belonging to high officials, tablets and sacrificial pits full of animal bones as evidences indicate that the place is an important ritual area.

Figure 6: Two sacrificial pits found in Ağılönü area (image adepted from Süel 2015, 110-111, Fig. 18-21).

The Sacrifical area where sacrificial pits were unearthed is surrounded with poorly organized walls and pits were dug as single, double, triple and quadruple in various size (Fig. 7). Beside these feeble walls, various buildings are located close to the stone pavement and sacrificial pits. The animal bones were found in these pits sometimes as burnt, highly fragmented or even sometimes as a whole. According to Süel (2015), birds, sheep, goats (and mountain goats) were burnt together during the ceremonies in the Hittite period. Moreover, the animals were hit by a stone or/and a tool to make them dizzy before the sacrificial ceremonies according to the Hittite archives. According to the archaeological evidence, lightly trimmed or non-trimmed stones were discovered inside and outside of the pits in Ağılönü. After the sacrifice was carried out by a priest, the blood of the animal was poured into the pits and the body parts were eaten or destroyed, however, some part of elements of the animals (skull, rib, jaw, leg bone[12], tooth, vertebras) were also put into the pits and found in the Ortaköy pits as well. Although seals, spindle whorls and stones were found beside animal bones in the sacrificial pits, the bottom of them was generally empty (A. Süel, 2015a, p. 104). After the ritual performed, the top of the pits was covered with earth because it was thought that when a pit was used, it became dirty. [13]

[12] This element together with sacrum were rarely found inside the pits, see Süel, A. 2015:104.

[13] KBo 10.45 (III 26)

Figure 7: A view of Sacrificial Area (image adapted from Süel 2015, 111, Fig. 24).

Tepelerarası is located in the center of the city and surrounded by defensive fortifications within which monumental and administrative structures are located (Fig. 4). An excavation project started in this area and important buildings of the city have been exposed. The buildings A, B, C, D, G and area G have been studied until now in Tepelerarası. Area G is also defined as workshop area where metal moulds, large amount of pottery sherds, metal hammers, metal arrows, clay moulds were found. Building A which was constructed with an unusual symmetrical architecture have been thought as a monumental building where various royal seals had been discovered (A. Süel, 2015b, p. 102). The remains of the Building B which is identified as a depot where storage of the city was displayed was unearthed 150 meters east of the Building A and consist of a cyclopean foundation with mud-brick walls 1.5 meter in height. Both Building C and Building D are located on the southern terrace of the city. In building C, an axe and spear heads with a cuneiform inscription "Great King" were discovered. Additionally, it is thought that a purification ritual called "*Itkalzi*" which performed to clean the polluted energy of both a household and whole society, but especially for purify the royal family was taking place in Building D of the city (A.

Süel, 2015b, p. 102). At the entrance of the Building D, the God Teššub was depicted with his armours as welcoming the people who were entering the building (Fig. 10).[14]

Figure 8: Workshops in Tepelerarası (image adapted from Süel 2017, 68, Fig. 5)

[14] See Süel, A. 2015.

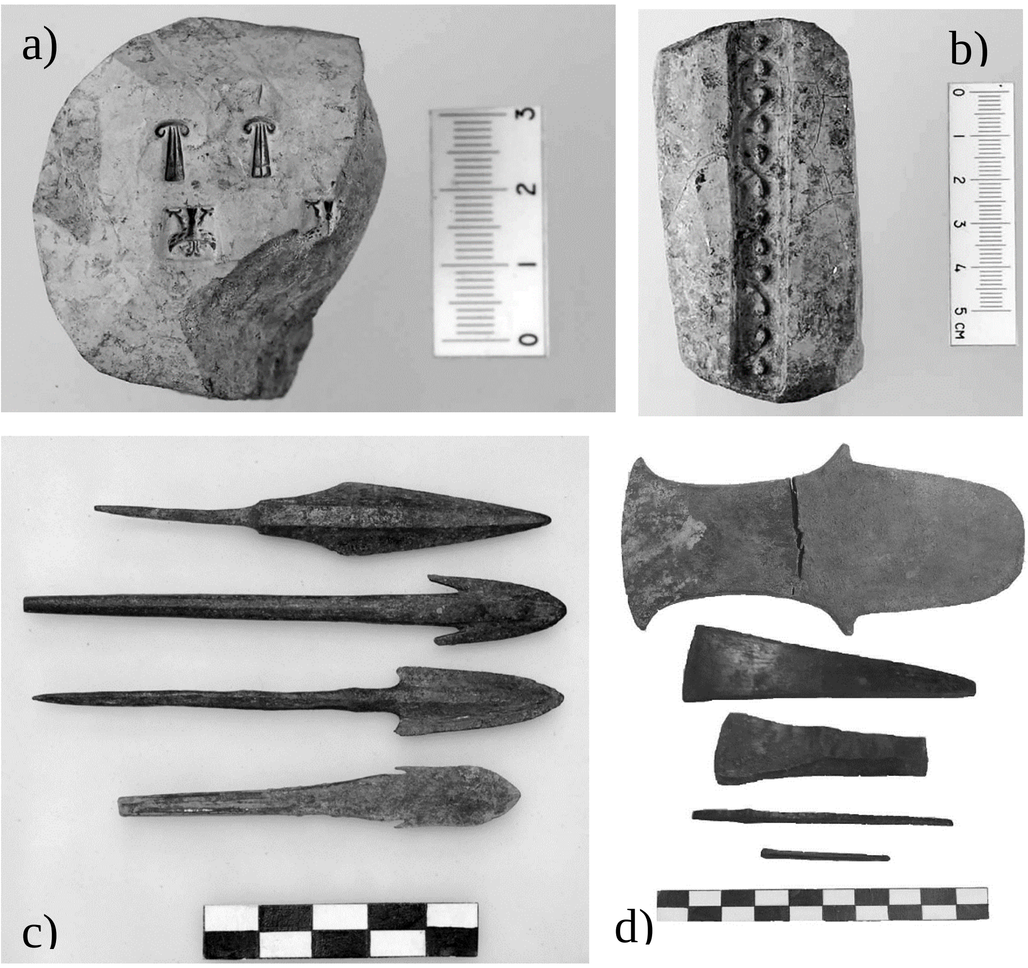


Figure 9: Clay moulds (a and b), bronze arrows (c), and metal materials (d) obrained from Workshops, Tepelerarası (images adapted from Süel 2017,70-73 , Fig. 8, 9, 18, 22.

Beside the archaeological evidences indicating the importance of the city both as administrative and religious centre, the relatively large archive in Hittite period with over 4000 tablets and tablet fragments found in the city could be shown as an evidence for the importance of the city (A. Süel & Süel, 2017, p. 30).[15] In fact, according to the excavation team, the tablets found in the site are important evidence about the sacredness of the city during the reign of the King Tudhaliya III and his wife Taduhepa (A. Süel, 2015a, p. 101).

[15] For further Sapinuwa text, see Süel, A.,1997; Süel, A.,1998; Süel, A.,1999.

Figure 10: Representation of an armed god at the entrance of Building D (image adapted from Süel & Süel 2017, 186, Fig. 12)

Since the excavation has taken place to different areas of the city, I am able to select samples coming from Palatial, Sacrificial and Temple spaces. For my thesis, I will conduct a research about the differences of animal morphology on bones and data will be analyzed from Tepelerarası, Sacrificial Area and Ağılönü areas in order to compare the animal husbandry practices as well as detecting social hierarchical access to different animals displaying different morphological features based on breeding and animal mobility. In this research two-dimensional geometric morphometric analysis is employed to investigate whether a specialized animal breeding activity was practiced by the Hittite Empire and if so, how this have in relation with socio-economic complexity during the Late Bronze Age period. This research focuses on the analysis of *Ovis aries* and *Capra hircus* astragalus, metacarpal and metatarsal bones on the basis of multidisciplinary approach. For the effectiveness of the technique, other than geometric morphometrics, traditional measurements will then be used as a comparison. This study employs standard and specialized zooarchaeological techniques to present two main aspects of animal husbandry in Hittite; animal mobility and selective breeding.

In this research I will try to answer two main questions:

a) Are there any evidence for selective breeding directed by the Hittite State?

b) Are the animals found in Šapinuwa possibly originated from different environments and if yes how this relates to the different social classes living in this city. In other words, I am asking whether these animals are coming from another geographical region as taxes, booty, or sacrificial offers. Also if there are any differences amongst animals that will indicate flocks belonging to Temple, Palace or Sacrificial Area and if these are different breeds? (Temple – Palace – Sacrificial Area may pasture and manage their animals differently or they may have access to different "breeds").

In general, I am focusing on accessing the animals that come from different areas of the city assunimg that these express animal use by people who were of different social status. For the comparison of the two techniques, geometric morphometris and traditional zooarchaeological biometry, there were applied to the elements astragalus, metacarpal and metatarsal of the species *Ovis aries* and *Capra hircus* to investigate if there is any phenotype differences of animals based on three different areas.

CHAPTER 3

GEOMETRIC MORPHOMETRICS AND ZOOARCHAEOLOGY BIOMETRICS METHODOLOGY

This research aim is to investigate phenotypic variation of *Ovis aries* and *Capra hircus* within and between two locations in Šapinuwa. Both Geometric morphometrics and traditional biometry were applied to investigate shape variations of *Ovis aries* and *Capra hircus,* and three inter-site locations; Ağılönü, Sacrificial Area and Tepelerarası in the Late Bronze Age Hittite Šapinuwa. Tepelerarası where administrative management and production were taken place, the palatial area. There are administrative buildings in which many Hittite archives were found and workshops where metal prodcution were processed by artisans. On the other hand, the spatial funtion of Ağılönü area is complex. In my research, I divided the Ağılönü, although excavation team named Ağılönü as one location, area into two different locations based on the spatial function of it because there is a distinction between a sacrificial place where sacrificial rituals were pereformed and rest of the Temple area where priest were living in and probably some ordinary life activities were also taken place (see Chapter 2 for the details of the function of the locations). The name of 'Sacrificial Area' is given to the specific location where sacrificial pits were unearthed and Ağılönü is given to the lower part of the same location where some common space, buildings and workshops belonging to the "Temple" were discovered. The reason I chose to work on both geometric morphometrics and traditional biometry in the research is evaluating both measurement techniques for detecting variation between groups as well as for facilitating the decision about the landmark locations.

Traditional biometrics are used for a long time in zooarchaeological research and have been proven a useful tool for investigating such questions (Onar & Belli, 2005; Peters et al., 2017; Pilaar Birch et al., 2019; Soykan, 2007). Geometric morphometrics on the other hand is a recent loan to zooarchaeology from the science of biology for investigating shape and shape variation that has been proven a very promising technique because it allows a more detailed picture of bone shape to be examined hence it can capture morphological variation in a population better.

3.1 Specimen Selection and Biological and Phylogeny and Ontogeny

Morphology is one of the important points for evaluating variations for identification of the bones, adaptation and speciation. It is formed as a result of a complex process that contains both inherited and developmental characteristics of an organism. The variation within a specimen related with both environmental and biological conditions. The inherited characteristics of biological beings, phylogeny, are determined by DNA. The hox genes drive the morphology of a specimen in a population and any valid morphological differences are the result of these genes (Burke et al., 1995).

One of the important notions for characterising the vertebrates is the locomotion behaviour. The modes of locomotion affect bone articulation and shapes of epiphyses and diaphysis. For example; one the one hand, ovicaprids are known for having long metapodia suited to their way of movement but on the other hand *Ovis orientalis* (wild sheep) use their shorter metacarpals not only for running, but also climbing (Haruda, 2014: 139). By evaluating the locomotion behaviour of ovicaprids, the metapodial bones are key bone for examining variation within a species.

Since domestication, human has control over the *Ovis aries* and *Capra hircus* by changing the inherited characteristics for maximizing the quality and quantity of products getting from the animals such as Merino sheep which has a good quality of wool and Karakul sheep which is fat-tailed (Mason, 1996). This kind of action called breeding, however, it is not biologically defined word. The closest biological term in the same manner is 'subspecies' which means a group of animals having specific characteristics mostly according to the geographical zones that the species are living in. Haruda (2014) defined the term as 'landrace' that is identifying the morphological characteristics which is changing according to region.

This morphological differences based on regions are well described by phenotypic characteristics of animals rather than ontogeny which includes all the developments of an organism within a lifespan. Astragalus which morphology of bone in the ankle joint are the key bones for identifying such morphological differences based on specific environments and geographical/topographical differences. The resilience of the ankle joints is interpreted by astragalus morphology by providing phenotypic characteristics of traits by ecozone. In this research, such phenotypic characteristics are analysed and evaluated rather than ontogenic features in order to detect the difference caused by geographical differences.

Astragali, metacarpals and metatarsals were selected from the archaeological site Šapinuwa. The best preserved specimens were chosen, however, because the context from where the bones were excavated were very close to the top soil, the preservation was not good because of being exposed to different evironmental condition (such as rain, heavy rains etc).

3.2 Introduction to Geometric Morphometrics

Geometric morphometrics is a technique to explore shape variation (Rohlf & Marcus 1993; Bookstein 1996; Adams et al. 2004; Zelditch et al. 2004, Slice 2005). The use of landmark-based geometric morphometrics has been practiced in various disciplines such as biology, anthropology, medicine, paleontology (Lawing & Polly 2010) and the method has been applied by many zooarchaeologists for studying morphological differences between and within groups.

Geometric Morphometrics as a term was first introduced in the late 1970s (Bookstein 1978) and the improvement of the technique has occurred in the last 30 years (Bookstein 2005, Boyko et al. 2010, Curran 2012, Goodall 1991, Kendall 1984, Klingenberg 1996, 1998, O'Higgins 1997, Rolf 1990, 1996, Richtsmeir et al. 1993, 2005, Singleton 2005, Taylor and Slice 2003, Volkman et al. 2003, von, Zelditch et al. 2012). The major advantage of geometric morphometrics is the ability to catch the morphological differences that are missed in traditional zooarchaeological measurement methods (Curran 2012, Zelditch et al. 2012).

3.3 Data Acquisitions

Geometric morphometrics focus upon two or three dimensional Cartesian coordinates of relevant landmark points. Landmarks carried shape data retrieved from edges, anatomical features and other unique characteristics. "The information about shape is contained in the entire constellation of landmarks and semilandmarks, i.e. the configuration of points." (Zelditch et al. 2004: 23). Unlike traditional zooarchaeological biometrics, for GMM, each measurement taken from the specimen is not evaluated individually because they are hardly meaningful one their own. Instead they are combined together to give the geometric shape of the object under study.

Recording of geometric shape data with landmarks can be carried out by using various techniques such as taking photographs, which is a 2D technique, and 3D laser scanning. I used two dimensional technique and digital images taken with a digital camera. Landmarks are located in these data and converted to coordinate system. To minimize the error stemming from equipment used such as digital camera lens' distortion, some conditions must be satisfied. First of all, objects must be located on a flat surface and distance of objects from the surface to the lens must always be the same. Additionally, the light must be also taken into account because under a very bright or dark light, the digital image may be perceived mistakenly by the researcher.

3.4 Landmarks

Landmarks are the easiest way to collect shape data in geometric morphometrics. The set of landmarks are determined according to shape of the object and research questions. There are commonly three types of landmarks (Bookstein 1991);

Type I: The landmarks are located on intersection of tissues, bone fissures and/or muscle attachments and foramen. These landmarks must be homologous that is located in the same position across all specimens.

Type II: The landmarks define the minima or maxima of curved structures and homology of the points are not based on histological location but geometric or shape indication such as the point of a tooth.

Type III: The landmarks are much related with the points defined for traditional measurements because they define the object axes. The landmarks are located at the end of the objects and included external points that give the maximum length and/or breadth of the object.

Semi landmarks which are used to collect information between landmark points are also used in geometric morphometrics. These are “extra” points used to describe in more detail difficult shapes, especially curves. Whilst landmarks are located at the most important positions that clearly define the basic shape of an object (As defined in I, II and III), semi landmarks are located between two landmarks to describe in more detail the shape of the space between these two landmarks. They are much more numerous and distanced equally between them. Their number depends on the decision of the researcher as to how many semi landmarks he/she thinks are needed to describe the shape correctly.

3.5 Digitization and Measurement errors

Measurement error is inevitable in all morphometric analyses. There are various reasons for such measurement errors that they can be related to data, investigators and tools/equipment.

One of the most common errors occur during the digitisation process. When photographs of objects are taken, digital camera lenses can affect the capture of objects because parts of objects or specimens that are at the edge of the frame can be distorted (Haruda 2014: 134). This kind of error can be handled by providing a careful recording process by using a tripod and taking photographs from the same distance (not too closed and not too far away from the objects in order to fit the object in a balanced frame) or it is better to use scanners as a digitising method for three-dimensional objects. Especially when homologous landmarks are located on large amounts of data, those measurement errors can be detected. This type of errors can be controlled by applying Procrustes ANOVA. When digitising error is not higher than minimum level of biological variation, it means that the error is not significant otherwise measurement or digitising process should be repeated until reducing the error (Klingenberg et al. 2002).

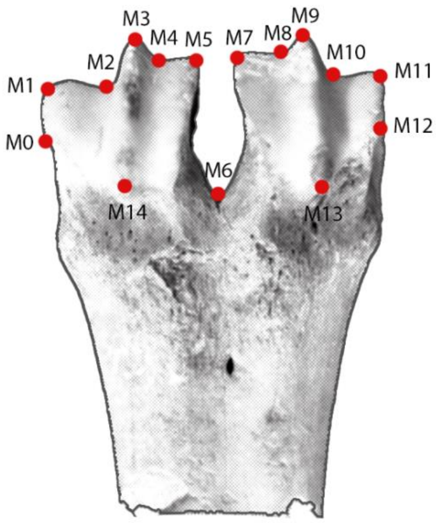
The non-shape variations must be removed to extract differences only related to the shape rather than position, scale and rotation (Kendall 1977, Rohlf and Slice 1990, Zelditch et al. 2012). The most common method for configuration and uniformity of the landmarks in geometric morphometrics is Generalized Procrustes Analysis (GPA) that is also known as Procustes superimposition (Viscosi & Cardini, 2011, Zeltditch et. al. 2004). Procrustes methods provide evaluation of all landmarks as a datum in landmark configuration rather than as individual data points. In other words, the variation is no longer between individual landmarks but between configurations.

A covariance matrix which displays the relationship between landmarks was generated after the GPA analysis. In order to find more variance in Principal Component analysis (PCA), covariance matrices which show all the relationship between landmakrs are also advantageous because running PCA on a correlation matrix gives chance to find more variation between landmarks (Zelditch et al., 2004)

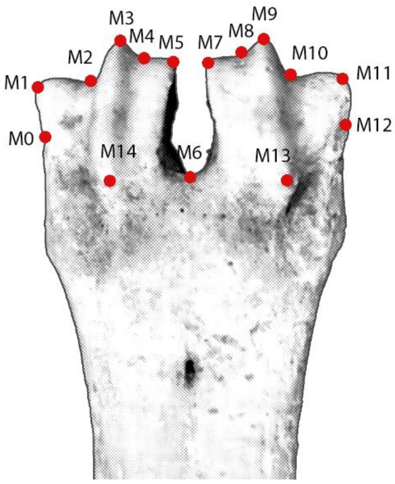
For investigating shape differences within and between my groups I run both Principle Component analysis (PCA) and Canonical Variate Analysis (CVA). PCA is useful for investigating the overall variation and shape differences, however, it displays the most explicit groups without taking into account any classifiers which are identified groups of data. Some significant information in the data such as the places where the bones came from and species such as *Ovis aries* and *Capra hircus* can be classified as separate groups in the analysis as classifiers. On the other hand, CVA is better suited for evaluating defined classifiers especially if the amount of sample is small by maximizing variation within groups (Klingenberg & Monterio 2005). Although maximizing variation by defined classifiers, for example *Ovis aries* and *Capra hircus*, may not be always the best choice because identification of *Ovis aries* and *Capra hircus* from an archaeological context is challenging and are not reliable 100%. In this case, applying first PCA and then CVA, and comparing the results can be the best choice.

3.6 Data Digitalisation for GMM

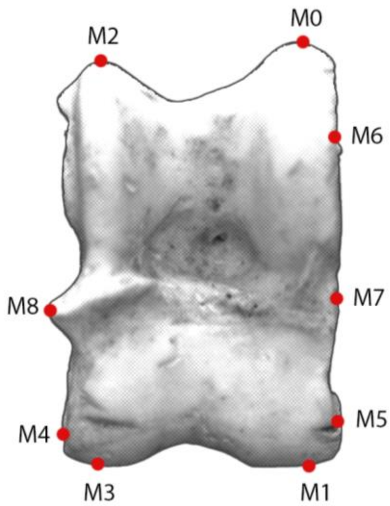
Specimens were digitized by Nikon D90 digital camera (with a Nikon macro lens 50mm) which was fixed on a tripod within a certain distance from the bones. The bones were laid on a flat surface. Then the camera was set on the tripod and was kept parallel to the flat surface. To ensure that both the flat surface and the camera were parallel, these were levelled with a two spirit levels, one attached to the top of the camera and the other on the flat surface. I prepared labels for each specimen and located them with a scale bar under each bone during the digitization process. After taking photographs of bones, I built a Tps format file for placing the landmarks that were determined in advance. I used TpsUtil (http://www.sbmorphometrics.org/) for this purpose (Rohlf, 2012). For placing landmarks on the digital images, I plotted landmarks on TpsDig2 (http://www.sbmorphometrics.org/soft-dataacq.html) which is one of the many examples of software programs available for this analysis (Rohlf, 2010). Nine (9) landmarks are selected for astragalus following Haruda (2014) and fifteen (15) landmarks are selected both for metacarpal and metatarsal bones following Fhionnghaile et al. (2015) (Fig. 11a, 11b, 11c). There are various methods for analyzing the data set and one of the software package is MorphoJ used both for two and three-dimensional landmark data set (Klingenberg 2011, https://morphometrics.uk/MorphoJ_page.html). Right after plotting the landmarks, the data was superimposed by a generalized Procrustes analysis to scale a landmark configuration. Scale, rotation and orientation of the landmarks were configured with the computation of a centroid size as the same and then the analysis was run to find outliers, if there were any. Outliers were detected by comparing the variation of each landmark in configurations because the software program provides average configuration for each of them and it is possible to exclude and/or relocate landmarks or data for analysis.



a) Landmarks on metacarpal



b) Lanmarks on metatarsal



c) Landmarks on astragalus

Figure 11: Landmarks on the elements used for this research.

3.7 Traditional Biometry

Animal bones were not brushed or washed before during the excavation seasons and these were kept in plastic bags with tags which had information about the area, date, trench and sometimes elevations roughly. After animal bones were washed and/or brushed, the elements astragalus, metacarpal and metatarsal that I used for this research were chosen by comparing with the bone manuals by Schmid (1972), articles for the separation of *Ovis aries* and *Capra hircus* (Zeder and Lapham, 2010), the animal bone reference collection at the Environmental Archaeology Research Unit at METU and according to some criteria suitable for the research questions. The criteria are;

1- Distal epiphysis should not be damaged or broken because this part is important for the measurements and landmarks, however, the distal part of the shaft of the bone is not included in this criterion.

2- All animal bones in this research have their epiphyses complete and fused thus originate from adult animals whilst young animals with unfused epihyses were excluded (Reitz and Wing 2008).

3- There are burnt context (such as sacrificial pits) in the excavation site and burnt animal bones from these contexts were excluded because burning changes the shape of the bones, however, other animal bones from this area were kept in the database.

4- If there is any anomaly on the bones, related to pathologies and diseases, these bones were excluded from the research database.

5- All the bones on which measurements were taken, were choosen from amongst the bones which geometric morphometric analysis were done.

After the elimination of data, bones were recorded in an Access database management system. Each row contains an identified element basically with the information of area in the site, date, context, species, element, sides and measurements. While recoding the bones, each bone was measured based on Driesch (1976) with digital calipers and selection of the measurements were given in Table 1. Both right and left specimens had been selected for the three elements mentioned above and identified with the criteria given by Schmid (1972).

Table 1: Traditional measurement points according to Von den Driesch (1976).

Astragalus Traditional Biometry Points	Description
M1 (GL1)	Greatest length of the lateral half
M2 (GLm)	Greatest length of the medial half
M5 (Bd)	Greatest breadth of the distal end
Metacarpal Traditional Boimetry Points	Description
M4	Greatest breadth of the distal end
M5	Greatest depth of the distal end
MS1	Depth of the medial trochlear condyle
MS2	Depth of the medial verticillus
MS3	Width of the medial condyle
MB1	Depth of the lateral trochlear condyle
MB2	Depth of the lateral verticillus
MB3	Width of the lateral condyle
M1	Greatest breadth of proximal end
M2	Greatest depth of the proximal end
M8	Greatest length

After taking measurements and recording data for traditional biometry, PAST software was used for statistics. Principle component analysis which is a technique for reducing the dimensionality and retaining the most variation in the dataset while keeping minimum loss of the data was run (Jolliffe et al., 2016). Principle component analysis allows us to see whether there are groups in the dataset by reducing the variables to fewer rather than using complex values of many variables and data. These could be also plotted on a graph which also helps us to see differences and/or similarities between samples.

CHAPTER 4

GEOMETRIC MORPHOMETRICS AND ZOOARCHAEOLOGICAL BIOMETRICS RESULTS

4.1 Geometric Mophometric Results

Ovis aries and *Capra hircus* specimens were analyzed separately both with geometric morphometric methods and zooarchaeological biometric methods to detect morphological differences within and between the classifiers (excavation locations). Both the left and right sides of the astragalus element, metacarpal, and metatarsal were used to create the datasets (Table 2).

As it is mentioned in Chapter 3, the principal component analysis (PCA) is descriptive, and classifiers, which are based on the three excavation locations of animals in this research, are not predetermined. It provides variation among uncorrelated principal components and does not conduct under a hypothesis. As a result, the statistical significance is not a concern in this research as much as canonical variate analysis (CVA), which operates under a hypothesis such as the relation of the groups and each group member. Unlike PCA, the data is measured based on variation by Mahalanobis distance in CVA, showing as much variation between the groups' means in a small space. In this research, CVA is conducted with a permutation test (1000 permutations) according to the Mahalanobis distances between classifiers/groups. In this framework, the statistical numbers (p-value) of CVA will be given for comparing the groups.

In order to make the best comparison between the results of both methods, that is geometric morphometric and traditional biometry, principle component and MANOVA/CVA analyses were applied to data, and the datasets for these analyses were created with traditional zooarchaeological measurements (See Appendix A).

However, because some bones were recovered damaged, physical measurements could not be taken in all cases, and the specimens in the dataset for which there were missing measurements were excluded from the datasets created for zooarchaeological biometric methods. All the specimens in these datasets were also tested with GMM, but some of the data in the datasets created for GMM could not be tested in zooarchaeological biometric analyses. Missing of some measurements of many specimens of *Ovis aries* metacarpal and *Capra hircus* metatarsal datasets caused them not to be analyzed in MANOVA/ (CVA) because more than one specimen must be entered in a data set to run analysis.

Table 2: The number of data used in Geometric Morphometrics Analyses.

Elements	Number of Data from Tepelerarası		Number of Data from Ağılönü		Number of Data from Sacrificial Area		Number of Landmarks
Species	*Ovis aries*	*Capra hircus*	*Ovis aries*	*Capra hircus*	*Ovis aries*	*Capra hircus*	
Astragalus	13	5	5	2	6	8	9
Metacarpal	28	8	6	4	1	3	15
Metatarsal	35	8	9	6	4	2	15
Total	76	21	20	12	11	13	

4.1.1 Astragalus Analysis Results

For astragalus, a total of twenty-one Ağılönü (fourteen of it from Sacrificial Area) and eighteen Tepelerarası bones were analyzed. In total, the two datasets consisted of twenty-four *Ovis aries* and fiftheen *Capra hircus* created as TPS files. Both left and right bones were included in the analysis as mentioned above. Nine homologous landmarks were placed on specific locations based on Haruda's (2012) research. The specimens were analyzed in Morpho J software and plotted along with the Principle component and Canonical variate analyses to detect shape changes both within and between the groups.

A. Ovis aries

Twenty-four specimens were analyzed with the process described in Chapter 3. The data include thirteen from Tepelerarası, five from Ağılönü, and six from Sacrificial Area. Firstly, principal component analyses were conducted, and the first two Eigenvalues give 57% related to shape variation. It is observed that there are morphologically different groups of animals that tend to cluster as Sacrificial Area on the left and Tepelerarası on the right of the principal component 1 axis (Fig. 12). While the data from Ağılönü and Sacrificial Area do not cluster as a group, in fact, the data edited as Ağılönü classifier spread over the different parts of the graph except for AGIL533, which it clusters together with TEP483, TEP897, TEP544, and TEP546. It means that specimens from Ağılönü display more variation than the other two groups. As a result of the analysis, although specimens from Tepelerarası, Sacrificial Area, and Ağılönü do not entirely form three tight and distinct clusters, TEP496, TEP 550, AGIL561, and AGIL 563 seem to be of different morphology compared to other data.

Canonical variate analysis was conducted for *Ovis arie*s astragalus from Tepelerarası, Sacrificial Area, and Ağılönü (Fig. 13). The clear separation of the specimens from the three areas with canonical variate 1 and 2 is seen in Figure 13, and it was a predictable result based on the PCA results above. Confidence ellipses were drawn based on equal frequency ellipses with 0.9 probability and classifiers; Ağılönü, Tepelerarası and Sacrificial area were set up as a criterion for grouping observations. P-value from permutation test (1000 permutation rounds) for Mahalanobis distance among Sacrificial Area, Ağılönü, and Tepelerarası is $p<.0001$, displaying that there are significant differences between *Ovis aries* from these three areas (see Appendix for the results). According to the CVA, the specimens which are from Tepelerarası do not form a tight cluster within the group; in fact, TEP491 displays similar morphological variation with the specimens from Ağılönü. Moreover, the specimens from Ağılönü also could not clustered as much as the data from Sacrificial Area and AGIL531 has close morphological variation with Tepelerarası data. As it is seen from the CVA graph (Fig. 13), Tepelerarası and Ağılönü ellipses intersect each other, which means that some of the specimens from these areas show similar morphological variation. For Sacrificial Area, SAC294 and SAC296 specimens are morphologically different from those within this group. After CVA, discriminant analysis is run for cross-validation, in other words, misclassification and/or true allocated data results with 1000 permutation rounds. As it only compared two classifiers with each other, the result of the misclassification table shows that the most exact classification was provided with the comparison of Sacrificial Area (63%) and Tepelerarası (54%) (Table3).

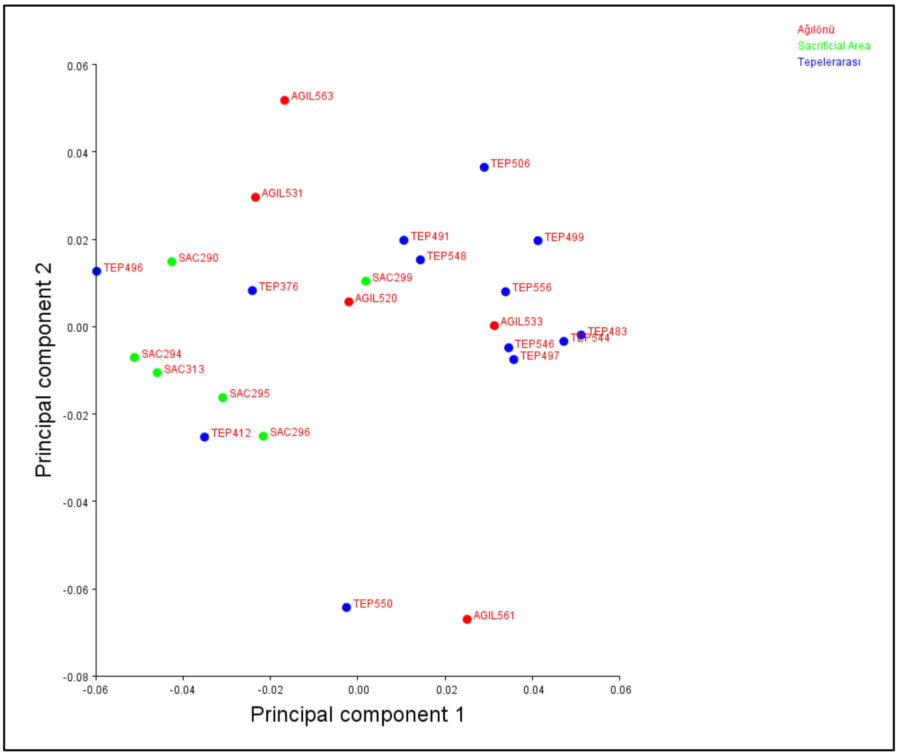


Figure 12: Princpal Component Scores plotted for *Ovis aries* astragalus from all areas.

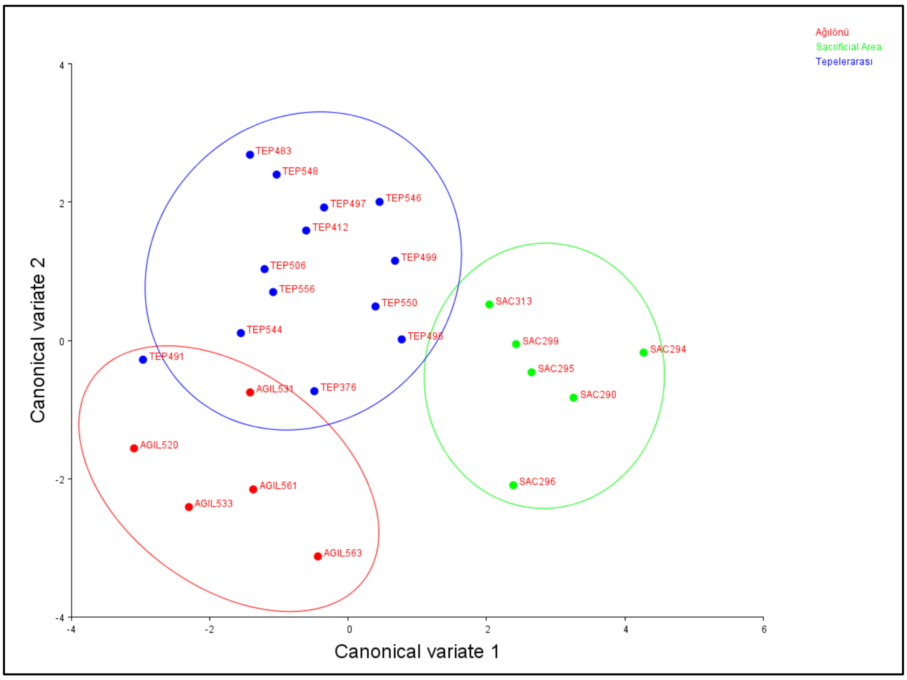


Figure 13: Canonical Variate Scores plotted for *Ovis aries* astragalus from all areas

Table 3: The classification/misclassification table of *Ovis aries* astragalus

Classification/misclassification tables			
Group 1: Sacrificial Area			
Group 2: Tepelerarasi			
From discriminant function:			
True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	6	0	6
Group 2	0	13	13
From cross-validation:			
True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	4	2	6
Group 2	6	7	13

B. Capra hircus

Fifteen *Capra hircu*s specimens were analyzed, five of these from Tepelerarası, two from Ağılönü, and eight from Sacrificial Area. Principle component analysis was carried out, and the first five Eigenvalues give 65.2% related to shape variation. The data were spread all over the graph and not clustered except for SAC293 and SAC300, which clustered together with AGIL512 (Fig. 14). While the specimens from Sacrificial Area can be interpreted as being more similar to each other, the specimens from Tepelerarası are morphologically different from each other. The specimens TEP507, TEP554 and TEP567 were found from the same area, 'Building E'. TEP334 and TEP413, for which the variation is obvious from the graph below (Fig. 14), were discovered from the workshop area, and these specimens were morphologically different. Unfortunately, there are only two data from Ağılönü. These are AGIL 523 and AGIL512 are plotted close to each other.

Canonical variate analysis was conducted for *Capra hircus* astragalus from Tepelerarası, Sacrificial Area, and Ağılönü. The separation based on the area is given in Figure 15. Confidence ellipses were drawn based on equal frequency ellipses with 0.9 probability and classifiers; Ağılönü, Tepelerarası and Sacrificial Area were set up as a criterion for grouping observations. P-values from permutation test (1000 permutation rounds) for Mahalanobis distance among three areas are $p< 0.0110$, displaying morphological differences within *Capra hircus* specimens from these two areas. While AGIIL512 and AGIL523 are set apart and indicate variation within the group, the data from Tepelerarası and Sacrificial Area cluster within their groups. However, the SAC300 falls within the intersection of the ellipses of Sacrificial Area and Tepelerarası, and SAC298 follows the same pattern with this data. The results from Ağılönü might have been related to the lack of data from this area. After CVA, discriminant analysis is run for cross-validation, in other words, misclassification and/or true allocated data results with 1000 permutation rounds. According to the misclassification table, the most exact classification was provided with the comparison of Ağılönü (100%) and Tepelerarası (80%) (Table 4).

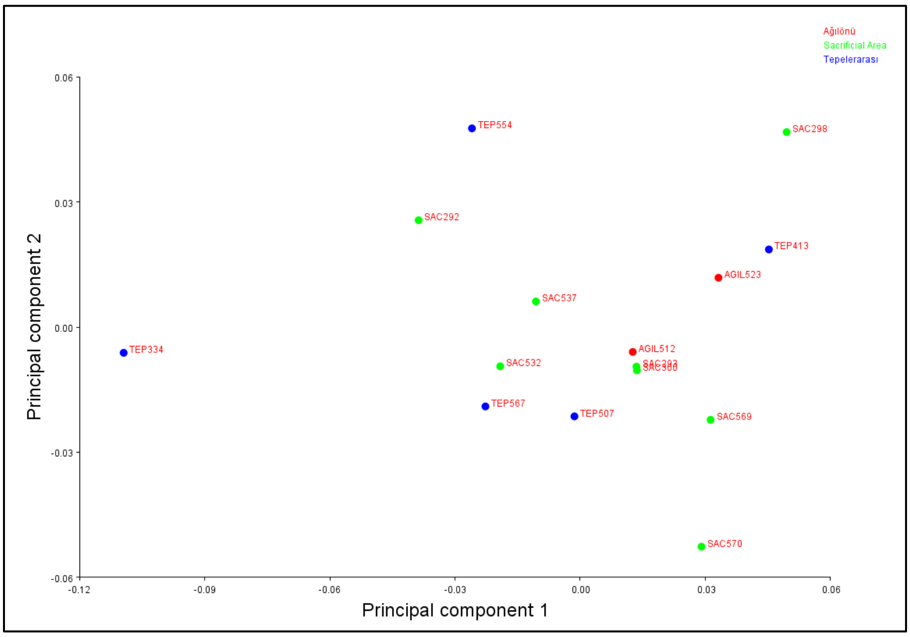


Figure 14: Princpal Component Scores plotted for *Capra hircus* astragalus from all sites.

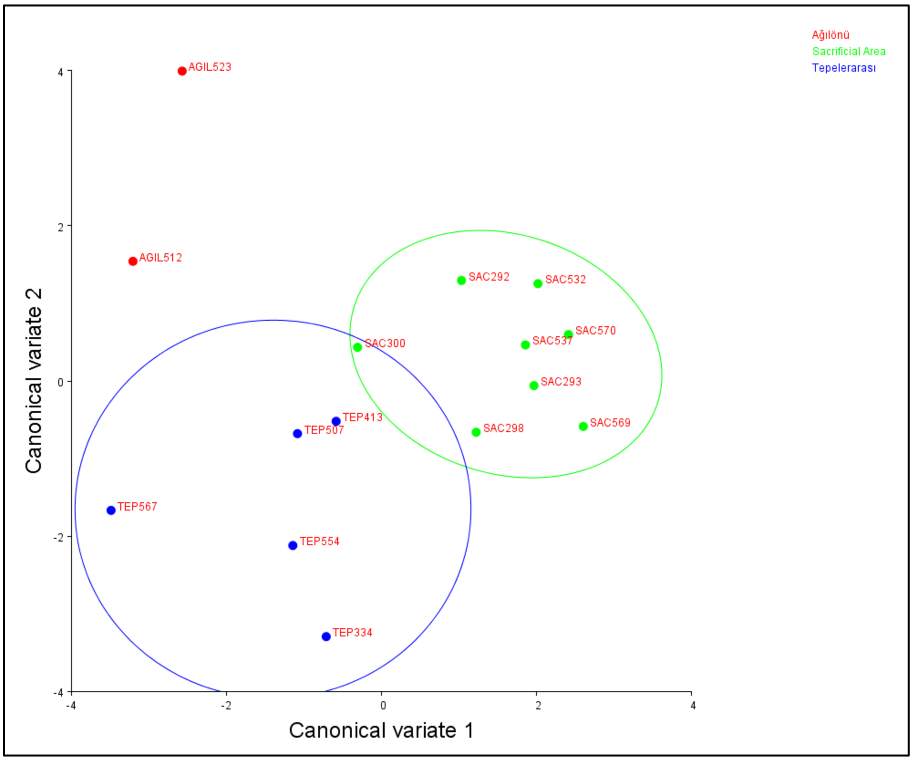


Figure 15: Canonical Variate Scores plotted for *Capra hircus* astragalus from all areas.

Table 4: The classification/misclassification table of *Capra hircus* astragalus

Classification/misclassification tables			
Group 1: Ağıllönü			
Group 2: Tepelerarası			
From discriminant function:			
True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	1	4	5
From cross-validation:			
True	Allocated to		
Group	Group 1	Group 2	Total
Group 1	1	1	2
Group 2	2	3	5

4.1.2 Metacarpal Anaylsis Results

A total of fourteen Ağılönü (four of these from Sacrificial Area) and thirty-six Tepelerarası specimens were analyzed. The two datasets consisted of thirty-five *Ovis aries* and fifteen *Capra hircus* metacarapal pictures created as TPS files, and both left and right bones were included analysis. Fifteen homologous landmarks had been placed on specific locations based on Fhionnghaile et al.'s (2015) research. The specimens analyzed in Morpho J software were plotted along with the Principle component and Canonical variate analyses to detect shape changes both within and between the groups.

A. Ovis aries

Thirty-five specimens were analyzed from Tepelerarası, Ağılönü, and Sacrificial Area. The dataset consisted of twenty-eight Tepelerarası, six Ağılönü, and one Sacrificial Area specimens. Firstly, principal component analysis weas conducted, and the first two Eigenvalues give 55.2% related to shape variation. The data are spread all over the graph (Fig. 16) indicating that there is variation within groups rather than clustering based on the areas. However, it is observed that the data from Ağılönü tend to cluster on the right and Tepelerarası, which has the most variance within its group, plots on the left of the principal component 1 axis (Fig. 16). While SAC759, TEP350, TEP352, and TEP766 clustered, AGIL763, AGIL515, AGIL757, AGIL 516, and TEP431 enclose this group. Interestingly, TEP350 and TEP 351 were found from precisely the same trench (trench no: 4), and TEP766 and TEP431 were also found in the west of Building E, located near the workshop area. Although AGIL515 and AGIL516 were discovered from the same trench (where the oven was located), AGIL757 was found in different location of Ağılönü. The small group on the lower left of the graph consists of TEP772, TEP471, and TEP769, also found in the same area, northeast of Building D.

Canonical variate analysis was conducted for *Ovis aries* metacarpal from Tepelerarası, Sacrificial Area, and Ağılönü. The result of CVA based on the area could be seen in Figure 17. Confidence ellipses were drawn based on equal frequency ellipses with 0.9 probability and classifiers; Ağılönü, Tepelerarası and Sacrificial area were set up as a criterion for grouping observations. P-values from permutation test (1000 permutation rounds) for Mahalanobis distance among three areas is $p< 0.0324$ (for the variation between Tepelerarası and Ağılönü $p<.0001$), displaying that there are morphological differences within *Ovis aries* specimens from these three areas. As it is seen in Figure 17, the specimens from the three areas are morphologically different animals from each other according to the statistical results as well. The only outlieer within the dataset is TEP501 which showed the same results in PCA too. Discriminant analysis is run to check for cross-validation, in other words, misclassification and/or true allocated data results with 1000 permutation rounds after CVA. Although each comparison of the sites indicates substantial allocation of the groups, the most exact classification was provided with the comparison of Ağılönü (84%) and Sacrificial Area (100%), the lack of data from Sacrificial Area might have affected the results (Table 5). Nevertheless, according to the comparison of Tepelerarası and Ağılönü, 72% of the animals in Tepelerarası shows distinct variation with this group, while the percentage is lower in Ağılönü at only 67%.

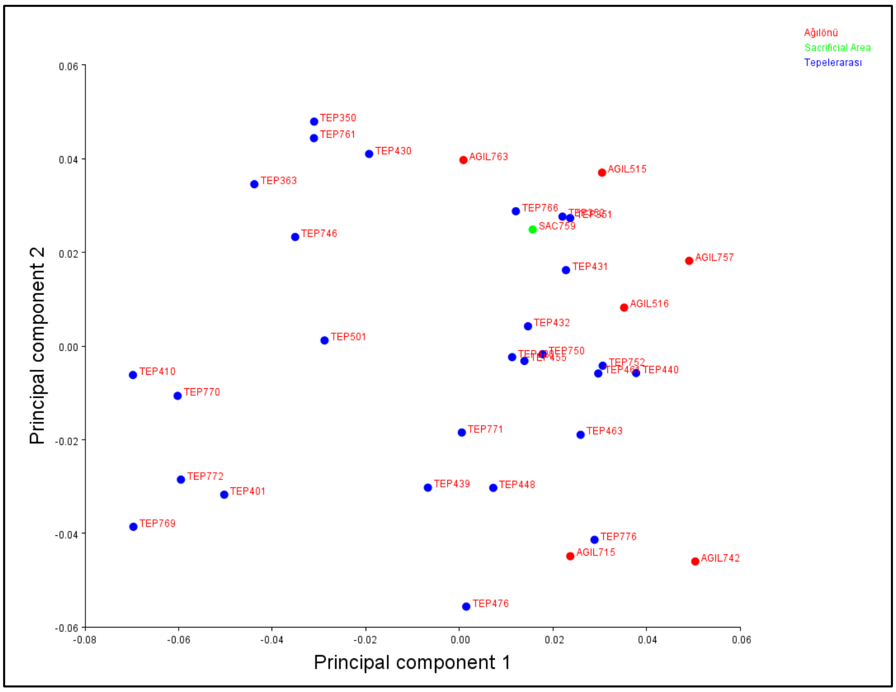


Figure 16: Princpal Component Scores plotted for *Ovis aries* metacarpal from all sites.

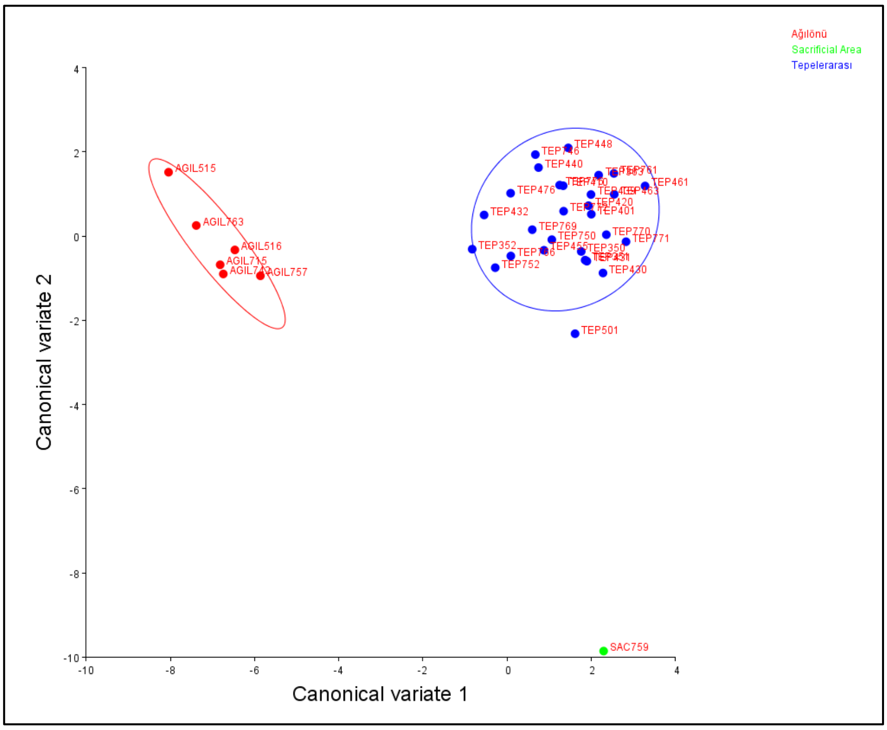


Figure 17: Canonical Variate Scores plotted for *Ovis aries* metacarpal from all areas.

Table 5: The classification/misclassification table of *Ovis aries* metacarpal.

Classification/misclassification tables

Group 1: Agilonu

Group 2: Sacrificial Area

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	4	2	6
Group 2	0	1	1

From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	3	3	6
Group 2	0	1	1

B. Capra hircus

Fifteen specimens were analyzed from Tepelerarası, Ağılönü, and Sacrificial Area. The dataset includes eight Tepelerarası, four Ağılönü, and three Sacrificial Area specimens. Firstly, principal component analysis was conducted, and the first five Eigenvalues give 56.6% related to shape variation. Although there are not clusters based on areas, some data tend to form small clusters, such as TEP360 and TEP484 lower right edge of principal component 1 (Fig. 18). TEP774, TEP400, and SAC749 were also plotted near these areas; interestingly, TEP360, TEP484, and TEP400 specimens were found from the same area (northeast of Building D). Additionally, TEP435 and TEP460 were clustered together with AGIL 762; the specimens from Tepelerarası in this group were also discovered from the northeast of Building D. As it is seen in Figure 18, the data from Ağılönü and Sacrificial Area are plotted all over the graph. It means that these specimens show significant variation; in other words, morphological differences are seen for these specimens.

Canonical variate analysis was conducted for *Capra hircus* metacarpal from Tepelerarası, Sacrificial Area, and Ağılönü. The result of CVA based on the area could be seen in Figure 19. P-value from permutation test (1000 permutation rounds) for Mahalanobis distance among three areas is $p < 0.008$, displaying morphological differences within *Capra hircus* specimens among these three areas. Even though the specimens did not form tight clusters according to the areas where they were found, it can be mentioned that there is some slight disposition of the data based on the areas. Accordingly, the data from Tepelerarası clustered into two different spaces of the CVA graph (Fig. 19). The specimens were separated in two, indicating morphological differences within the group based on the variation between the areas. On the top left of the graph, the specimens from Ağılönü were plotted all over these areas while the data from Sacrificial Area were located on the top right of the graph. SAC749 and SAC773 were discovered from the same Trench (South of the stone pavement), but SAC748 was found inside Building 7. Discriminant analysis with cross-validation is run to see misclassification and/or accurate allocated data results with 1000 permutation rounds after CVA. Although each comparison of the sites indicates robust allocation of the groups, the most exact classification was provided with the comparison of Ağılönü (75%) and Tepelerarası (75%), the lack of data from Sacrificial Area might have affected the results (Table 6).

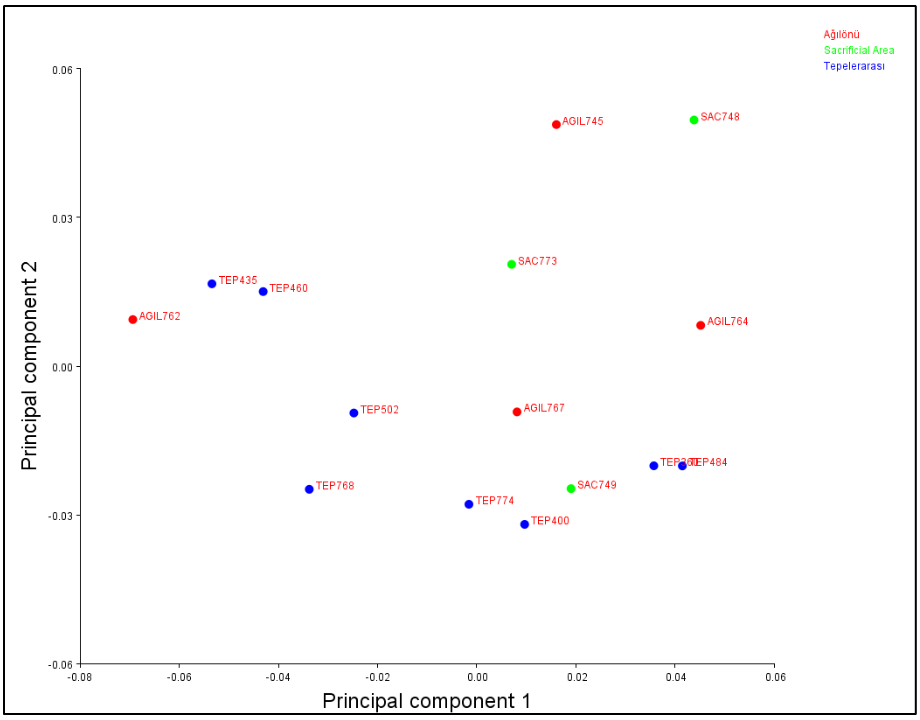


Figure 18: Princpal Component Scores plotted for *Capra hircus* metacarpal from all sites.

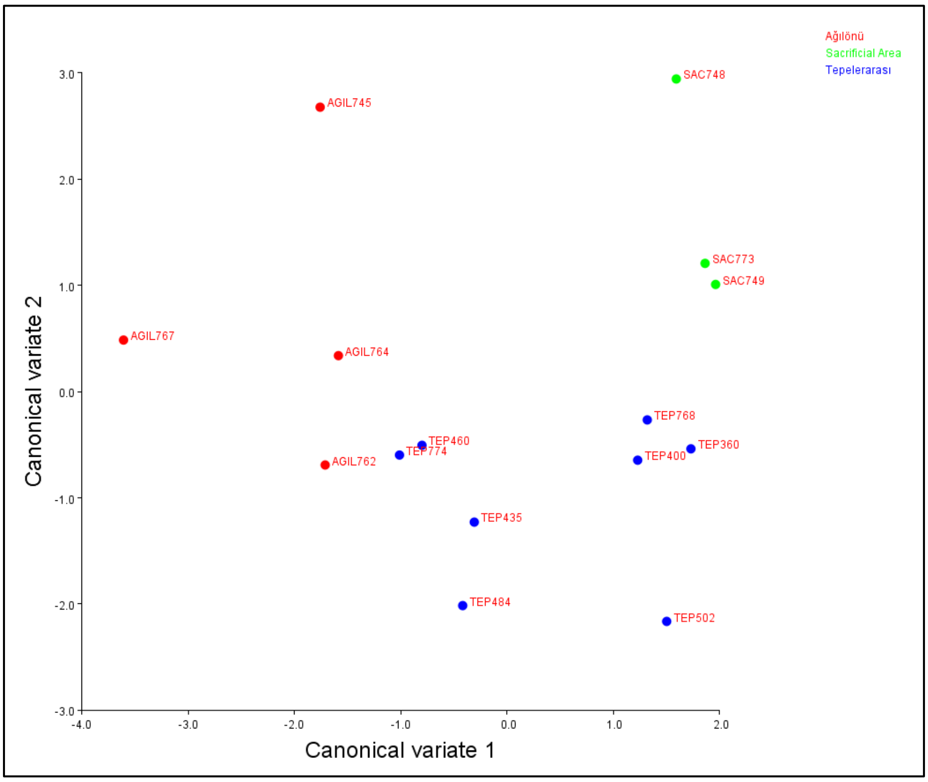


Figure 19: Canonical Variate Scores plotted for *Capra hircus* metacarpal from all areas.

Table 6: The classification/misclassification table of *Capra hircus* metacarpal.

Classification/misclassification tables			
Group 1: Agilonu			
Group 2: Tepelerarasi			
From discriminant function:			
True	Allocated to		
Group	Group 1	Group 2	
Total			
Group 1	3	1	4
Group 2	1	7	8
From cross-validation:			
True	Allocated to		
Group	Group 1	Group 2	
Total			
Group 1	2	2	4
Group 2	3	5	8

4.1.3 Metatarsal Analysis Results

A total of twenty-one Ağılönü (four of these from Sacrificial Area) and fourty-three Tepelerarası specimens were analyzed. The two datasets consisted of fourty-eight *Ovis aries* and sixtheen *Capra hircus* created as TPS files, and both left and right bones were included analysis. Fifteen homologous landmarks had been placed on specific locations based on Fhionnghaile et al.'s (2015) research. The specimens analyzed in Morpho J software plotted along with the Principle component and Canonical variate analyses to detect shape changes both within and between the groups.

A. Ovis aries

Fourty-eight specimens were analyzed from Tepelerarası, Ağılönü, and Sacrificial Area. The dataset includes thirty-five Tepelerarası, nine Ağılönü, and four Sacrificial Area specimens. Firstly, principal component analyses were conducted, and the first five Eigenvalues give 48.6% related to shape variation. For *Ovis aries* metatarsal, there are not clusters based on the area; however, AGIL696, TEP378, and TEP404 display larger variation within their dataset (Fig. 20). In other words, these specimens indicate stronger morphological differences than other specimens.

Canonical variate analysis was conducted for *Ovis aries* metatarsal from Tepelerarası, Sacrificial Area, and Ağılönü. The result of CVA based on the area is given in Figure 21. The comparison of Ağılönü-Sacrificial area with Sacrificial Area-Tepelerarası, p-value is $p>0.05$ from the permutation test (1000 permutation rounds) for Mahalanobis distance among three areas, meaning that there is not significant variation based on groups. The comparison of Ağılönü and Tepelerarası resulted in a $p<0.0003$ which indicates the variation among groups is statisticaly significant. However, the specimens from Ağılönü are plotted slightly on the right, and Tepelerarası specimens are plotted on the left of the graph while the specimens from Sacrificial Area is spread all over the graph area. It could be said that, although there are minor morphological differences between the animals discovered from Ağılönü and Tepelerarası, the animals from Sacrificial Area do not fit any group. In fact, the animals from Sacrificial Area do not cluster within its group, indicating that these animals are also displaying morphological differences among each other. Although each comparison of the sites does not indicate substantial allocation of the groups, the most exact classification was provided with the comparison of Ağılönü (45%) and Tepelerarası (66%) (Table 7).

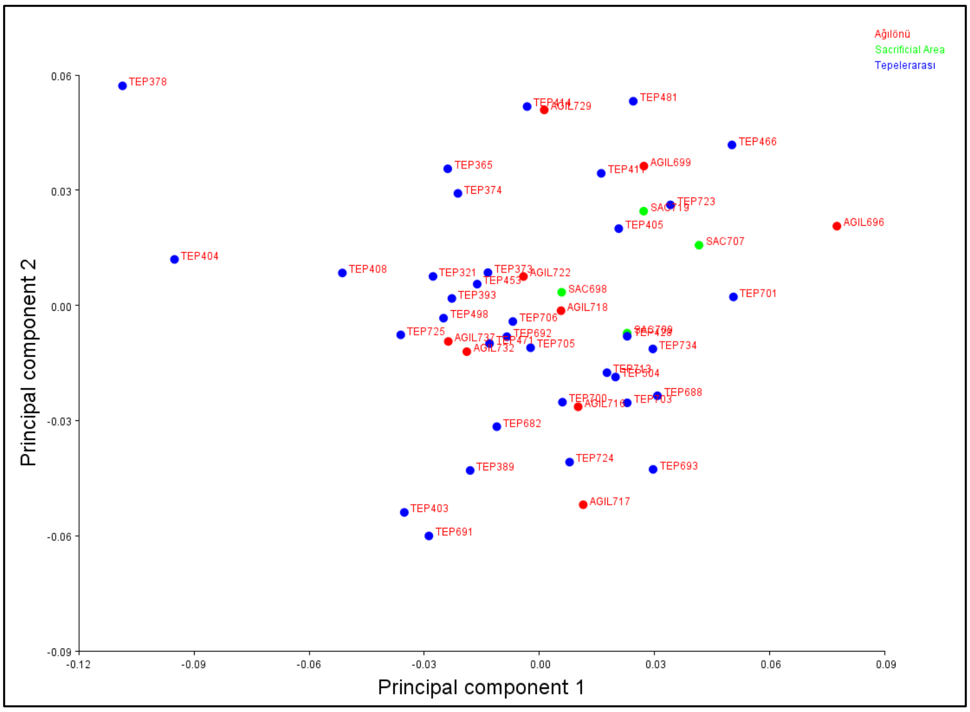


Figure 20: Princpal Component Scores plotted for *Ovis aries* metatarsal from all sites.

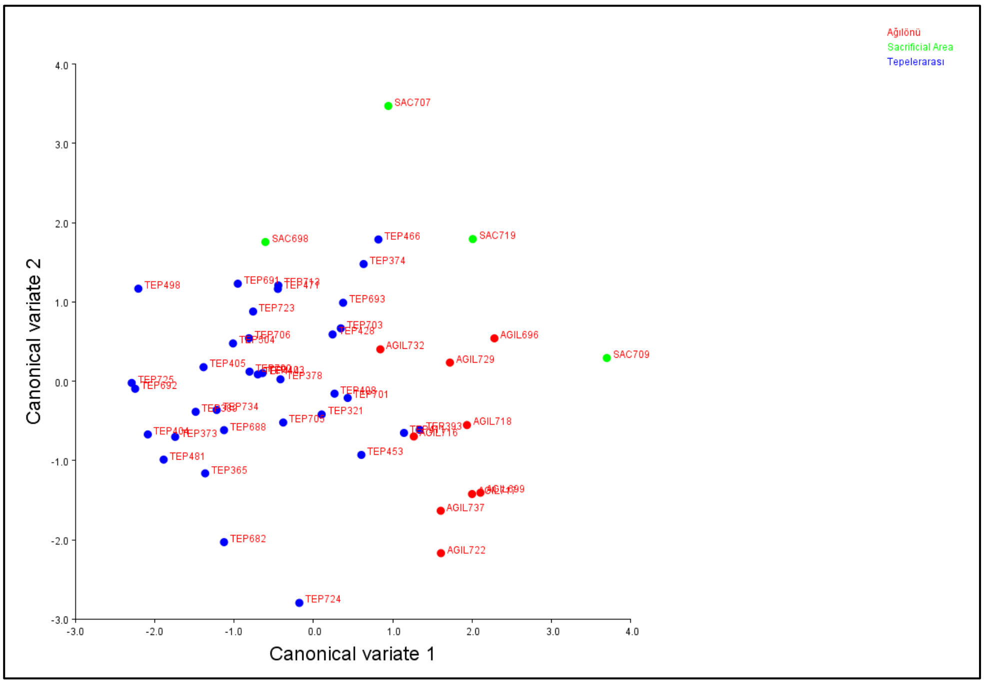


Figure 21: Canonical Variate Scores plotted for *Ovis aries* metatarsal from all areas.

Table 7: The classification/misclassification table of *Ovis aries* metatarsal.

Classification/misclassification tables
Group 1: Agilonu
Group 2: Tepelerarasi

From discriminant function:

True Group	Allocated to Group 1	Group 2	Total
Group 1	9	0	9
Group 2	3	32	35

From cross-validation:

True Group	Allocated to Group 1	Group 2	Total
Group 1	4	5	9
Group 2	15	20	35

B. Capra hircus

Sixteen specimens were analyzed from Tepelerarası, Ağılönü, and Sacrificial Area. The dataset consisted of eight Tepelerarası, six Ağılönü, and two Sacrificial Area specimens. Firstly, principal component analysis was conducted, and the first five Eigenvalues gives 53% related to shape variation. In Figure 22, the variation of the data according to the PCA results is given. While the animals from Sacrificial Area are scattered along all the different space in the graphs, the animals from Tepelerarası tend to cluster away from principle component 1 axis, and the animals from Ağılönü tend to cluster close to the principal component 1 axis. As a result of this, animals from Tepelerarası and Ağılönü have indicated differences in small scale morphologically; however, the same could not be claimed for the animals from Sacrificial Area.

Canonical variate analysis was conducted for *Capra hircus* metatarsal from Tepelerarası, Sacrificial Area, and Ağılönü. The result of CVA based on the excavation area can be seen in Figure 23. Confidence ellipses were drawn based on equal frequency ellipses with 0.9 probability and classifiers; Ağılönü, Tepelerarası and Sacrificial area were set up as a criterion for grouping observations. Based on statistical results, while there is morphological differences of animal between Ağılönü and Sacrificial Area ($p<0.0097$) and between Ağılönü and Tepelerarası ($p<0.0141$). However, the csomparison of Sacrificial Area and Tepelerarası has a p value which is greater than 0.05 ($p=0.8823$). This might have been related to the small number of data from Sacrificial Area. However, it could be claimed that there are morphological differences within *Capra hircus* specimens from these three areas. Although each comparison of the sites does not indicate substantial allocation of the groups, the most exact classification was provided with the comparison of Ağılönü (83%) and Sacrificial Area (100%) (Table 8).

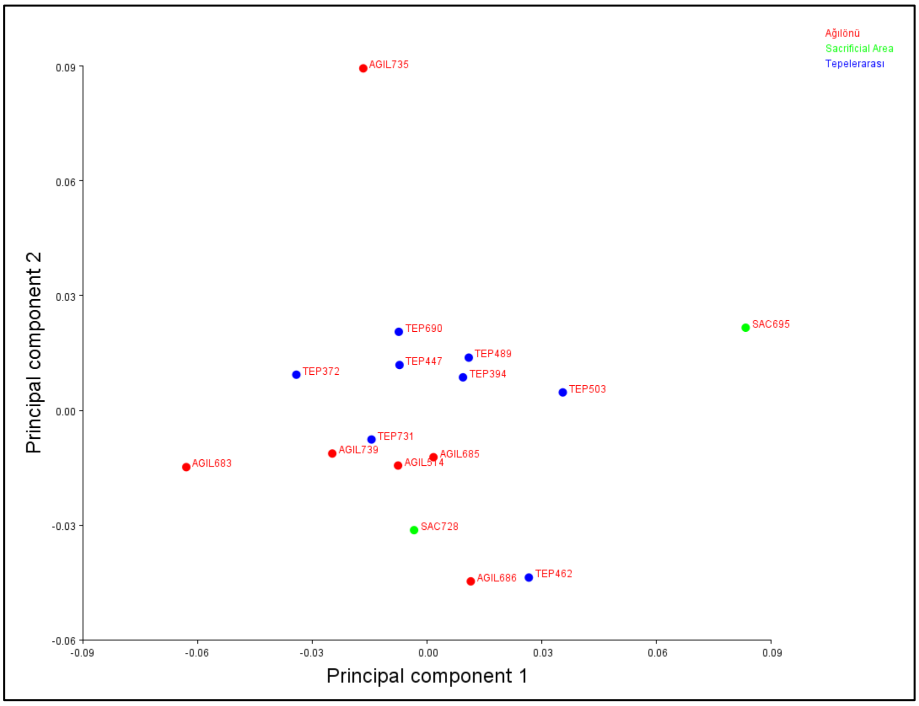


Figure 22: Princpal Component Scores plotted for *Capra hircus* metatarsal from all sites.

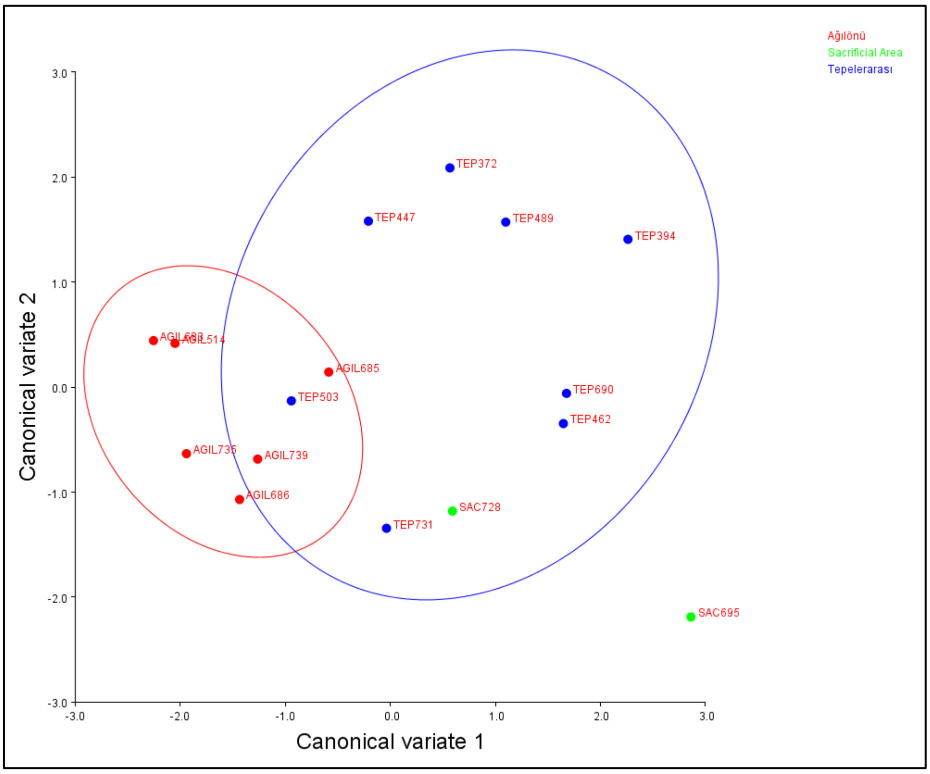


Figure 23: Canonical Variate Scores plotted for *Capra hircus* metatarsal from all areas.

Table 8: The classification/misclassification table of *Capra hircus* metatarsal.

Classification/misclassification tables			
Group 1: Agilonu			
Group 2: Sacrificial Area			
From discriminant function:			
True	Allocated to		
Group	Group 1	Group 2	
Total			
Group 1	5	1	6
Group 2	1	1	2
From cross-validation:			
True	Allocated to		

Group	Group 1	Group 2	Total
Group 1	4	2	6
Group 2	1	1	2

4.2 Zooarchaeological Biometrics Results

For zooarchaeological biometry analysis, both principal components and MANOVA canonical variate analysis in PAST software were conducted to compare the results obtained by GMM. As the principal component is used for detecting possible variance in the multivariate data, MANOVA/CVA is used to test two or more groups' variance based on the predetermined classifiers. However, unlike GMM, there should be more than one data for each classifier/group. Because there was only one specimen in the dataset of *Ovis aries* metacarpal and *Capra hircus* metatarsal, these datasets were excluded from these analyses. All measurements taken on the specimens are given in Chapter 3 (Table 1), and the numerical dataset is given in the Appendix part of this research. The number of data based on element and area is given in Table 9 below.

Table 9: The number of data used in Zooarchaeological Biometric Analyses

Elements	Number of Data from Tepelerarası		Number of Data from Ağılönü		Number of Data from Sacrificial Area	
Species	*Ovis aries*	*Capra hircus*	*Ovis aries*	*Capra hircus*	*Ovis aries*	*Capra hircus*
Astragalus	13	5	5	2	6	7
Metacarpal	16	6	3	3	1	2
Metatarsal	29	5	6	1	4	1

4.2.1 Astragalus Analysis

Thirty-eight astragalus, a total of twenty from Ağılönü (thirteen of these are from Sacrificial Area) and eighteen from Tepelerarası, both from *Ovis aries* and *Capra* *hircus* were separately tested by in principle component analysis and MANOVA/CVA by using PAST software computer program. Twenty-four *Ovis aries* and fourteen *Capra hircus* prepared as two separated datasets to detect morphological changes based on the classifiers.

A. Ovis aries

Twenty-four *Ovis aries,* including five Ağılönü, six Sacrificial Area and thirteen Tepelerarası specimens, were analyzed in principle component analysis to see the variation between specimens without predetermined classifiers. Three different measurements were set up for astragalus (Table1), and these measurements were taken from each specimen (See Appendix for the measurements). In Figure 24, all the data were scattered widely over the graph. There is no cluster based on the area; instead, it is clear that some specimens display more variation than other specimens. The specimens which are TEP550, SAC313, TEP412, SAC296, TEP544, TEP483, and AGIL533 indicate different morphological features more than the other specimens. In geometric morphometric methods' PCA results on the *Ovis aries* astragalus (Fig. 12), TEP412, TEP506, and TEP550 specimens are also indicating similar patterns with this result. Moreover, the specimens from Ağılönü were dispersed all over the graph space in both analysis graphs.

Based on Figure 25, morphological difference is seen for some specimens compared with the rest of the data, but no clusters are observed depending on the variation of excavation area. In Figure 25, the MANOVA/CVA results do not display any cluster in the graph; in fact, there are not many differences between PCA and MANOVA/CVA graphs on *Ovis aries* astragalus analysis. Similar to the PCA, the specimens TEP544, TEP412, TEP550, and TEP483 are seen as indicating larger morphological differences than other data. However, numerical statistical results also agree with the observation that no clusters of similar morphologically specimens are present since the possibility found is only $p>0.05$.

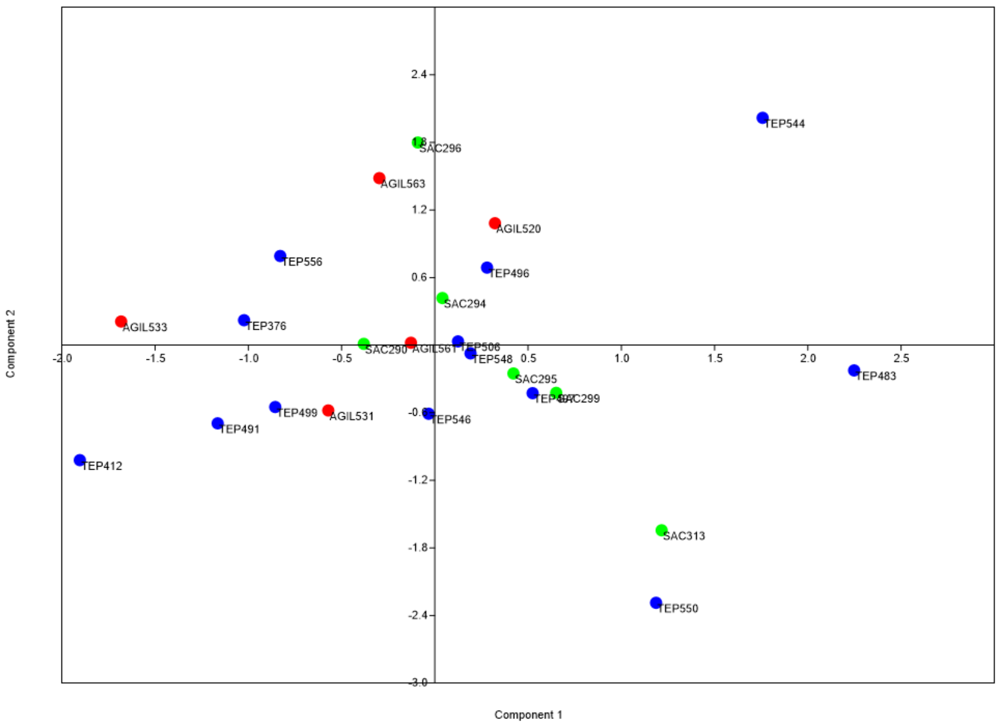


Figure 24: Principal Component Scores plotted for Ovis aries astragalus from all areas

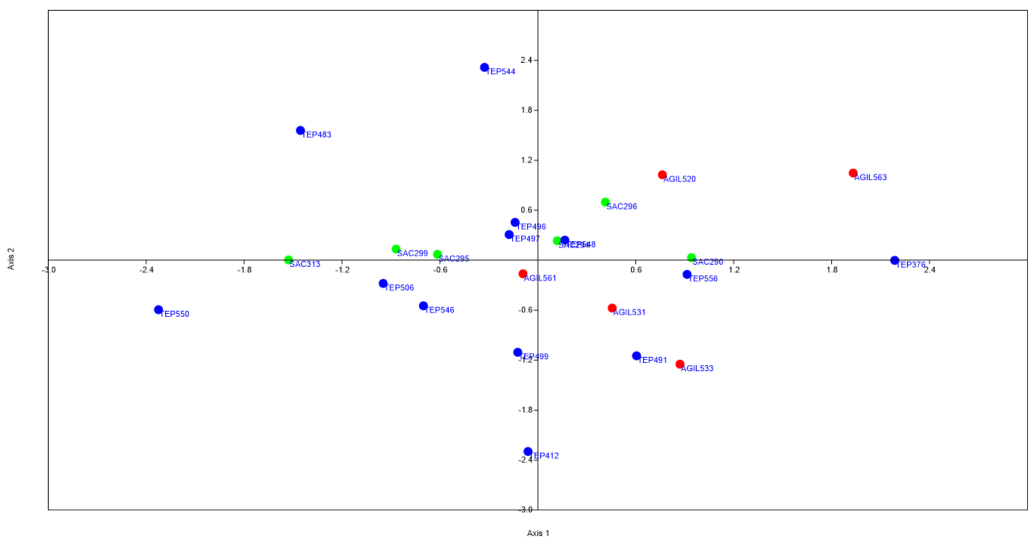


Figure 25: MANOVA/CVA Scores plotted for *Ovis aries* astragalus from all areas.

B. Capra hircus

Fourteen *Capra hircus*, which includes two Ağılönü, seven Sacrificial Area and five Tepelerarası specimens were analyzed with principle component analysis. Three different measurements were set up for astragalus (Table 1), and these measurements were taken from each specimen (See Appendix A for the measurements). In Figure 26, almost all specimens from Sacrificial Area are seen on the left of the graph except SAC300 and SAC537, while most specimens from Tepelerarası (TEP334, TEP413, and TEP567) clustered on the upper right quadrant of the graph except for TEP507 and TEP554. The specimens found in Ağılönü display different morphological features within its group. Based on the results, although the clusters based on the area are not tight, the specimens have a tendency to cluster according to the area.

In Figure 27, the graphic plotted as a result of MANOVA/CVA indicates slight separation based on two areas that are Tepelerarası and Sacrificial Area. The two Ağılönü specimens, AGIL512 and AGIL523 are close to the specimens from Tepelerarası. As it is seen in the graph, most of the specimens from Tepelerarası, that are TEP334, TEP567, and TEP554, clustered on the positive side of the axis one except TEP413 and TEP507 while almost all the specimens from Sacrificial Area that are SAC298, SAC669, SAC293, and SAC292 are plotted on the negative side of the axis one except for SAC537 and SAC300. As morphological differences between groups were also seen in the result of GMM, the differences between the specimens from Ağılönü and Tepelerarası were also seen in the *Capra hircus* astragalus GMM graph as well (Fig. 15).

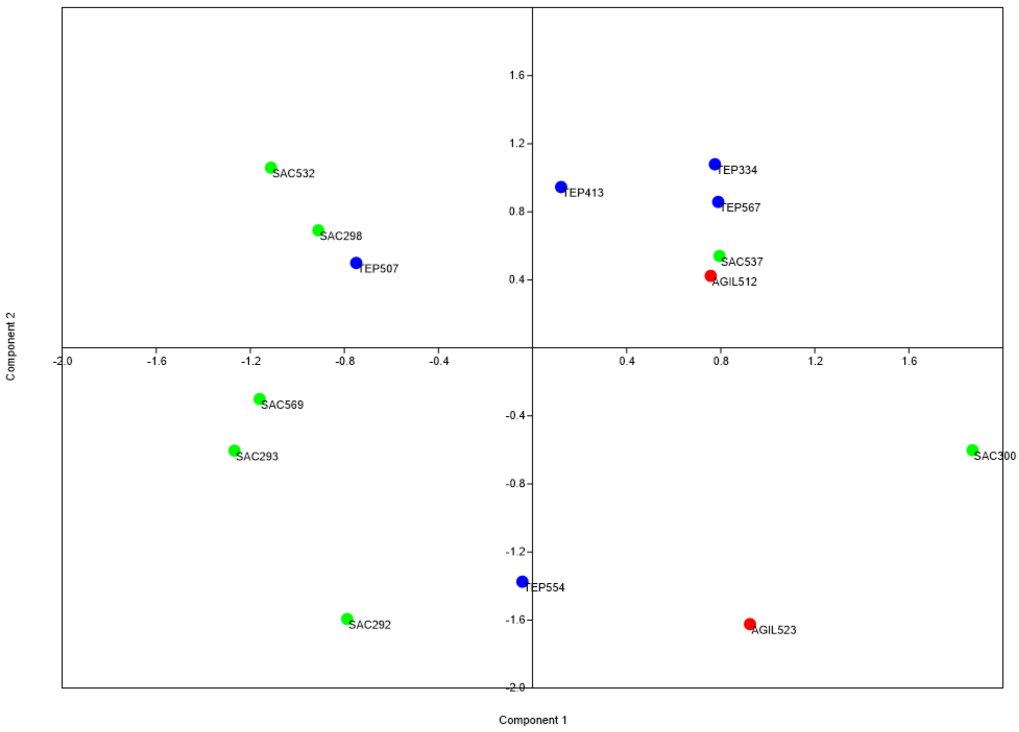


Figure 26: Princpal Component Scores plotted for *Capra hircus* astragalus from all areas.

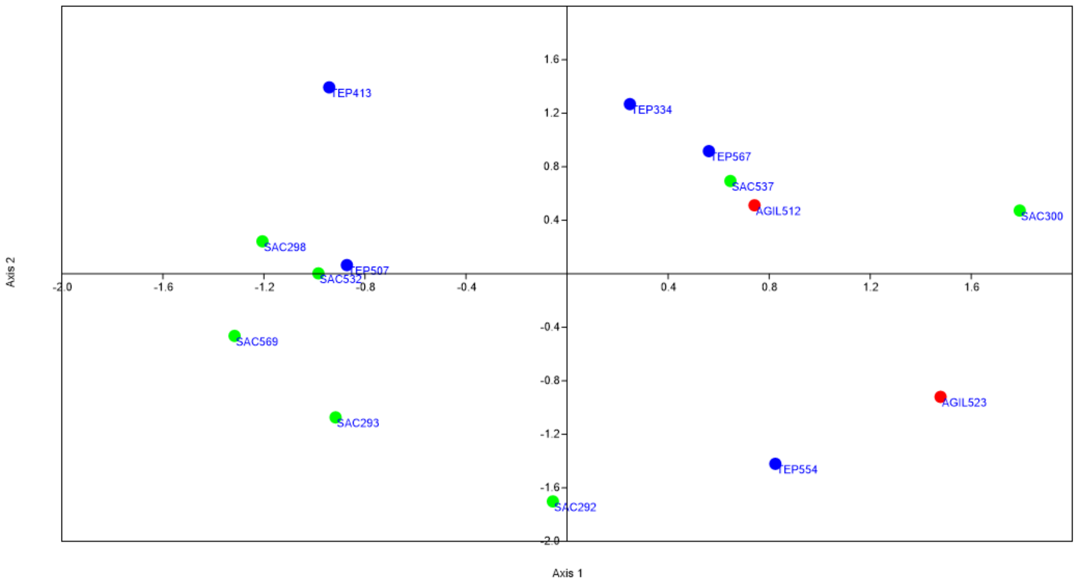


Figure 27: MANOVA/CVA Scores plotted for *Capra hircus* astragalus from all areas.

4.1.2 Metacarpal Anaylsis Results

Thirty-one metacarpal data, a total of nine Ağılönü (three of these are from Sacrificial Area) and twenty-two Tepelerarası, both from *Ovis aries* and *Capra hircus* were separately conducted to principle component and MANOVA/CVA analyses by using PAST software computer program. Twenty *Ovis aries* and eleven *Capra hircus* specimens were prepared as two separated datasets to detect morphological changes based on the classifiers.

A. Ovis aries

Twenty *Ovis aries*, consisting of three Ağılönü, one Sacrificial Area and sixteen Tepelerarası specimens, were analyzed in principle component analysis. Eight different measurements were taken from each specimens' metacarpal (Table 1 and see Appendix A for the measurements). Although there are some small clusters, the variation between data is mostly seen in the PCA graph (Fig. 28). The specimens TEP431, TEP448, and TEP463 on the upper right of the graph and, TEP750 and TEP461 display similar morphological features. All the specimens on the upper right, TEP431, TEP463, TEP750, TEP461, and TEP761, were discovered at the west of Building E. However, TEP448 and TEP350 were found in workshop area, which is close to Building E. Although the specimens AGIL515, AGIL516, and AGIL757 indicate morphological differences in this graph, on the contrary, these specimens tend to cluster in GMM results on the *Ovis aries* metacarpal (Fig. 16). TEP420, TEP771, TEP352 were found in the workshop trenches and indicate more sharp morphological differences than other data.

Unfortunately, MANOVA/CVA could not be applied to *Ovis aries* metacarpal.

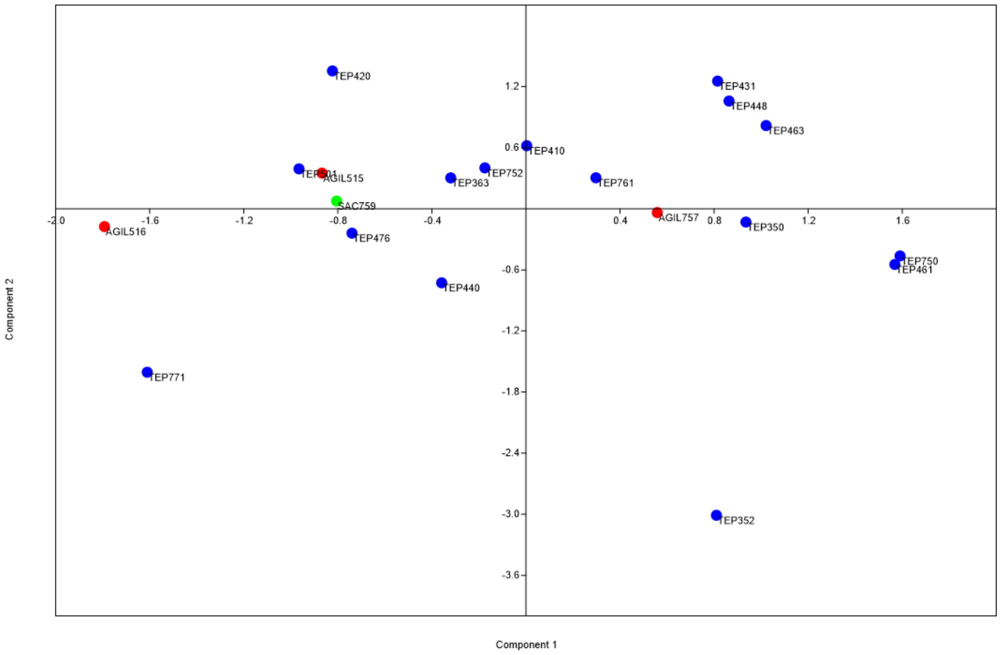


Figure 28: Principal Component Scores plotted for *Ovis aries* metacarpal from all areas.

B. Capra hircus

Eleven *Capra hircus* specimens, including three Ağılönü, two Sacrificial Area and six Tepelerarası, were analyzed in principle component analysis. Eight different measurements were taken from each specimens' metacarpal (Table 1 and see Appendix A for the measurements). The data from Tepelerarası, TEP360, TEP484, TEP460, TEP502, and one from Ağılönü, AGIL762 show morphological differences with the rest of the data. All the other specimens from Ağılönü and Sacrificial Area are plotted on the left side of the graph except for AGIL762 (Fig. 29). The specimens TEP460 and AGIL762 on the lower right were also plotted close together, and AGIL767 was displayed as an outlier in GMM PCA results on the *Capra hircus* metacarpal (Fig. 18). In addition to this, TEP400, TEP774, and SAC773 created a small cluster together with TEP484 and TEP360 in GMM PCA results as well. The specimens AGIL745 and AGIL767 were discovered from the same trench (Trench no: 3), while AGIL762 were found in the same area but different trench.

The graph plotted as a result of MANOVA/CVA indicates clear separation based on the three excavation areas in Figure 30, although statistical results did not indicate statistically significant ($p>0.05$). On the upper right of the graph, we see a group comprising of the specimens AGIL745, AGIL762, and AGIL767, on the lower right, the specimens TEP771, TEP484, TEP460, TEP360, TEP502, and TEP400 are positioned and on the far left of the graph, the specimens SAC749 and SAC773 are plotted against Axis 1. GMM also gave the same results; however, the clusters within groups were seen better in GMM rather than in biometrical results.

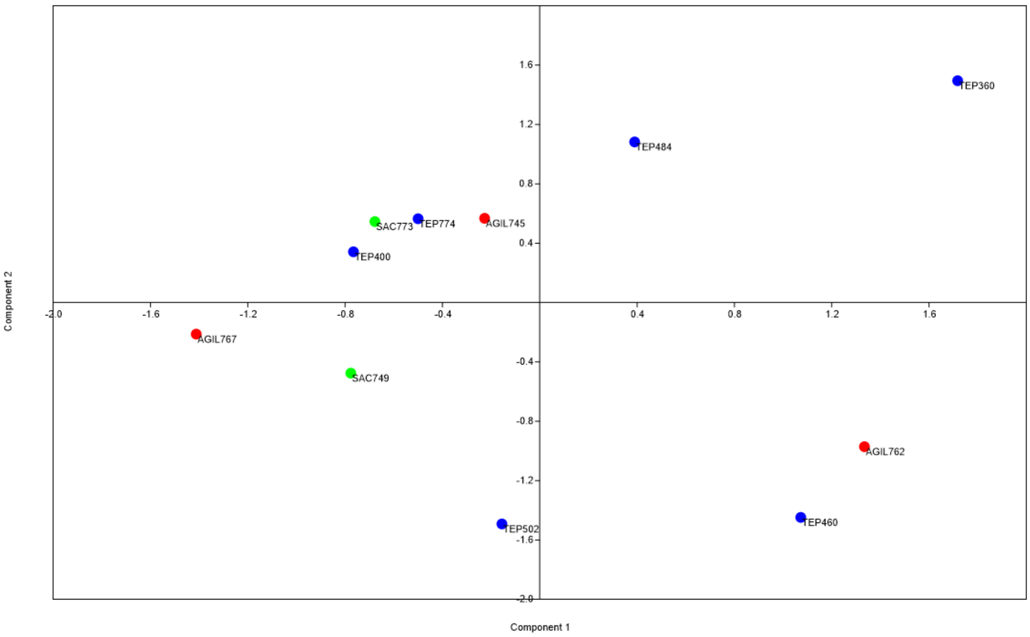


Figure 29: Principal Component Scores plotted for *Capra hircus* metacarpal from all areas.

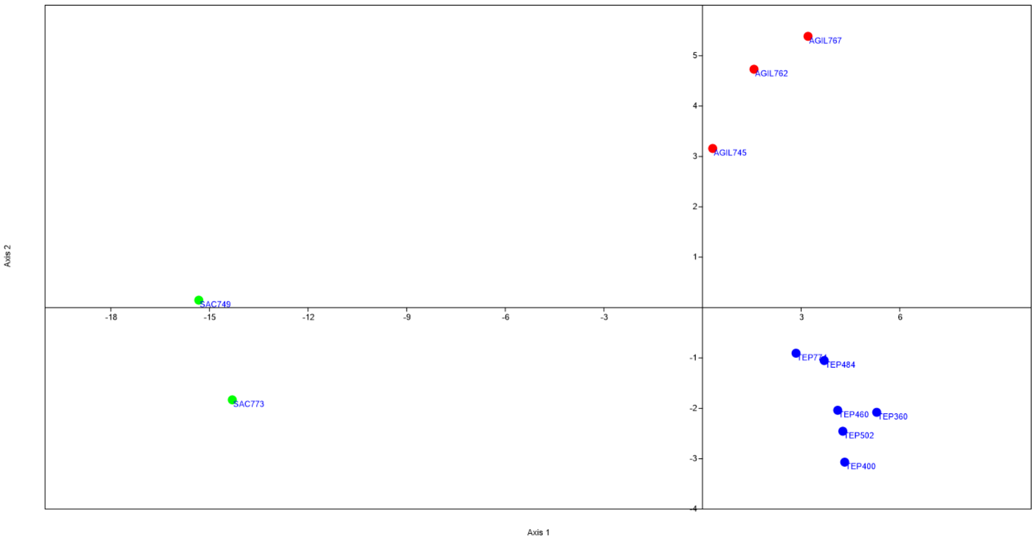


Figure 30: MANOVA/CVA Scores plotted for *Capra hircus* metacarpal from all areas.

4.1.3 Metatarsal Analysis Results

Forty-six metacarpal data, a total of twelve from Ağılönü (six of these are from Sacrificial Area) and thirty-four from Tepelerarası, both from *Ovis aries* and *Capra hircus* were separately conducted to principle component and MANOVA/CVA analyses by using PAST software computer program. Thirty-nine *Ovis aries* and seven *Capra hircus* were prepared as two separated datasets to detect morphological changes based on the classifiers.

A. Ovis aries

Thirty-nine *Ovis aries* specimens, including six from Ağılönü, four from Sacrificial Area and twenty-nine from Tepelerarası, were analyzed in principle component and MANOVA/CVA analyses. Fifteen different measurements were taken from each specimens' metacarpal and added into the database (Table 1 and see Appendix A for the measurements). As shown in Figure 31, there is no cluster, but most of the specimens are spread around the principle component axıs 1. An extreme variation is given by the specimen TEP389, which is plotted on the upper right of the graph. The specimens; AGIL732 and AGIL699 display variation compared to the rest of the data and indicate slight morphological differences. The result of PCA on the *Ovis aries* metacarpal by GMM (Fig. 20) shows small clusters within the groups, unlikely this result.

The graph plotted as a result of MANOVA/CVA (Fig. 32) indicates slight separation of specimens based on three areas. Most of the specimens from Tepelerarası are placed on the right half of the graph and the specimens from both Ağılönü and Sacrificial Area on the left half of the graph except for AGIL716. The data from Ağılönü are spread all over the left of the graph, although AGIL696 and AGIL722 are clustered together closely meaning that they are similar in morphology. The specimens from Tepelerarası; TEP378, TEP723, TEP692, and TEP691 display more differences in morphology, as it is the case for AGIL699 compared to the other data in the dataset. Interestingly, similar separation was also detected from the result of GMM on the *Ovis aries* metatarsal in CVA analysis; however, in GMM, the variation between the specimens from Ağılönü and Tepelerarası were more solid than it is in this graph because Ağılönü data were seen closely clustered together rather than a loose distribution (Fig. 21).

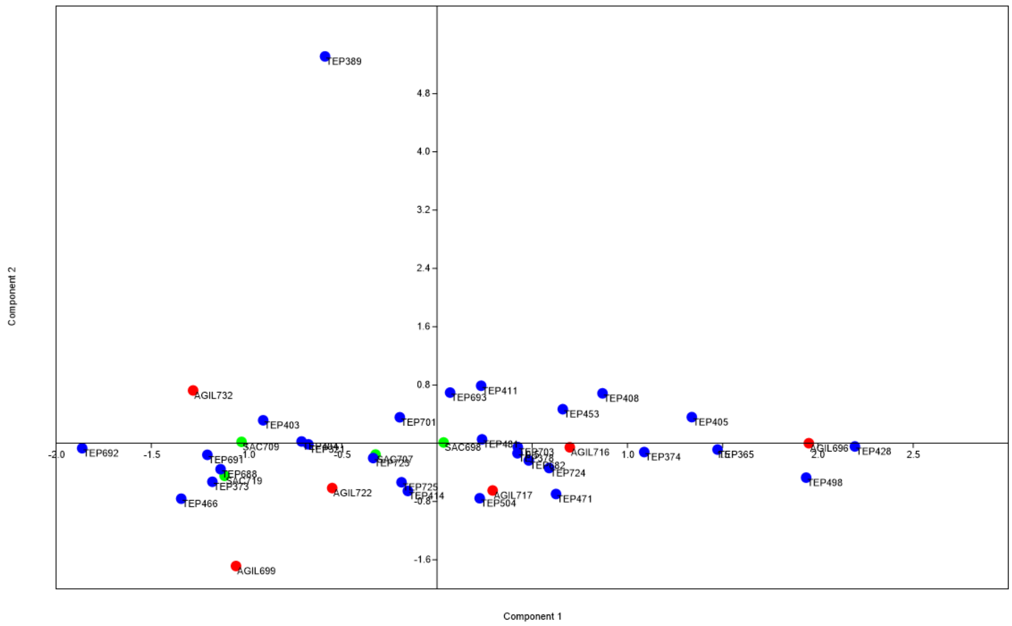


Figure 31: Principal Component Scores plotted for *Ovis aries* metatarsal from all areas.

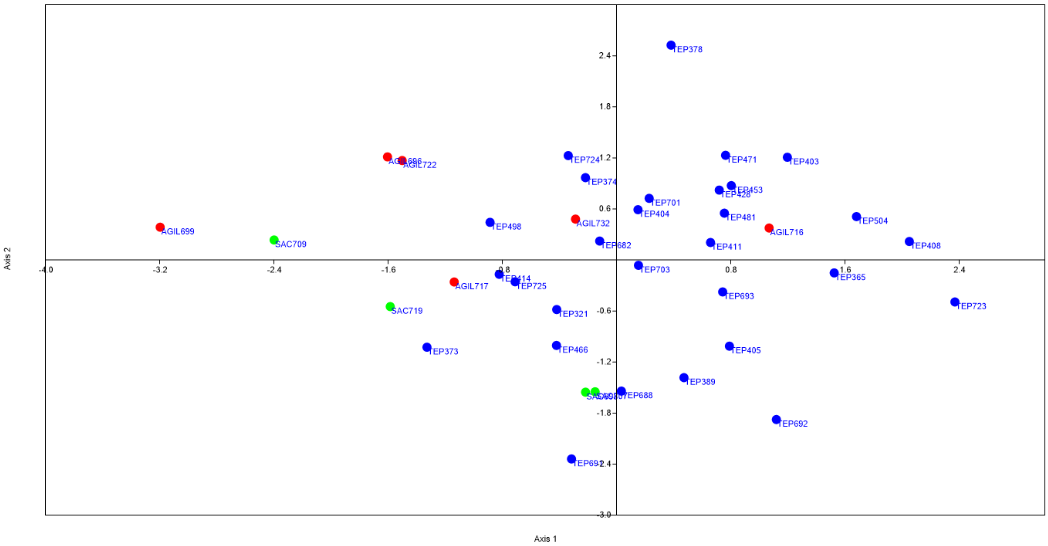


Figure 32: MANOVA/CVA Scores plotted for *Ovis aries* metatarsal from all areas.

B. Capra hircus

Seven *Capra hircus* including one Ağılönü, one Sacrificial Area and five Tepelerarası specimens were analyzed in principle component analysis. Fifteen different types of measurements were taken from each specimens' metatarsal and added into the database (Table 1 and see Appendix A for the measurements). The variation between individuals is clearly seen in principle component analysis, but there is no cluster based on three areas (Fig. 33). While TEP462, SAC728, AGIL683, and TEP394 are plotted close to each other, TEP447, TEP503, and TEP489 display more morphological differences than rest of the data. However, these results could not be detected by GMM; on the contrary, there are specimens' groups based on two areas that are Tepelerarası and Ağılönü in Figure 22 (GMM).

Unfortunately, MANOVA/CVA could not be applied to *Capra hircus* metatarsal.

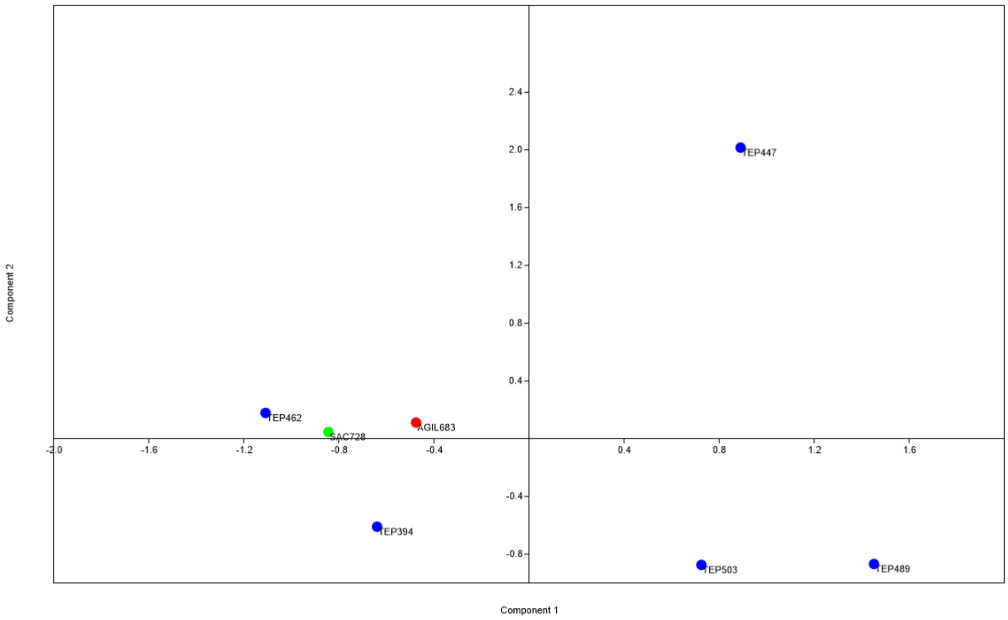


Figure 33: Principal Component Scores plotted for *Ovis aries* metatarsal from all areas.

4.3 Conclusion

As a result, the multivariate statistical analyses that are principal component and canonical variate analyses in GMM suggested in many cases of morphological differences between specimens within and between archaeological location based groups. The clusters observed may signal different breeds. However, the same clear separation could not be detected throughout zooarchaeological biometry. In fact, small sample sizes may have been biased the biometric analysis and prohibited it from sufficiently measuring and indicating the shape differences. The maximum number of data were obtained for GMM rather than traditional zooarchaeological statistical methods.

Overall, we could say that astragalus was the bone that showed the best separations in GMM whilst the result of the biometric methods for the same element were dissapointing. Metacarpal showed a good separation for Ovis aries but not for Capra hircus in GMM but it was a relatively good indicator of variation using the biometric method. Metatarsal had the poorest result in GMM and biometry for both species. In all analyses outliers were observed indicating the presence of exeptional individuals in the flocks which may have come from areas outside Šapinuwa.

CHAPTER 5

DISSCUSSION

Both zooarchaeological biometric and geometric morphometric methods have been applied to understand the local animal management strategies of the Hittite city Šapinuwa and exchange of the animals within the city based on the spatial function/division of the three areas, namely Tepelerarası, Ağılönü and Sacrificial Area as well as trying to find evidence for presence of the large-scaled mobility in the Late Bronze Age period. The geometric morphometric method (GMM) was applied to depict the shape differences of *Ovis aries* and *Capra hircus* specimens from the three areas. To answer two main questions of the thesis, that is the application of selective breeding and animal mobility refering to animals brought in the settlement as taxes, booty and ritual offerings from different settlements (or even different areas in the Hittite state), morphological variation of animal bones had to be analyzed. In this thesis, both zooarchaeological biometry which is applied to find morphological differences of the animals and geometric morphometrics, had been applied to describe morphological variations as well as compare the result of two methods.

The statistical results of geometric morphometrics are a crucial point for interpreting morphological variation. As mentioned in previous chapters, principal component analysis (PCA) as a descriptive multivariate statistical method is not conducted with a hypothesis. Instead, it is applied for understanding the variation among uncorrelated principal components (Haruda, 2014, p. 255). Unlike canonical variate analysis (CVA), predetermination of group membership (classifiers) is not given; however, it is still useful analysis for detecting some group membership between species. The separation between specimens from different locations is clearer to see with CVA, which is a significant analysis that shows the variation between the means of groups based on edited classifiers (identified groups). On the other hand, discriminant analysis, which is also a significant application for archaeology, paleontological and geological researches, is critical for producing the rules to determine the group relations (Kovarovic et al., 2011).

The PCA results given in Figure 12, Figure 14, Figure 16, Figure 18, Figure 20, and Figure 22 suggest some variation between specimens; however, separation of data based on activity areas is not clear. Figure 12 (*Ovis aries* astragalus) and Figure 22 (*Capra hircus* metatarsal) slightly indicates variation between the three areas more precisely than other PCA results. Moreover, in Figure 12, Agıl533 is grouped with a few data from Tepelerarası, and in Figure 23, Tep731 is clustered together with a few data from Ağılönü. Based on these results, it can be suggested that there was an exchange of animals between two areas. In addition to that, In Figure 18, SAC749 is clustered with some data from Tepelerarası suggesting that the animal might have been sent from Tepelerarası to the area for sacrificial purposes but raised in Tepelerarası. Another interesting result is seen in Figure 22, where Agıl735 and Sac695, which looks like an outlier, are displaying different morphological variations than the rest of the *Capra hircus* metatarsal dataset. These two data are from the ritual place, and as it is questioned in this thesis, this kind of outlier data might have been related to animal mobility. In fact, this animal might have been brought to the city from different places to either being used for as sacrificial purposes related to taxes and booty from various parts of the Empire (See pages 62-63).

The CVA was conducted with 1000 permutations founded on the Mahalanobis distances and gave results with p-values measuring the significance of the variation between groups. In Table 10, 11, 12, the result of CVA was given with p-values. The CVA results of both Astragalus and Metacarpal ovicaprid specimens have a $p \leq .05$, which means rejection of the null hypothesis, which means that there is no statistically significant difference amongst the groups studied. This result therefore suggests that specimens show significant morphological differences based on the three areas. However, the same result could not be obtained for the Metatarsal specimens of both species. The differences for *O. Aries* metatarsal were not seen with the comparison between Sacrificial Area-Ağılönü, and Tepelerarası- Sacrificial Area. For *C. hircus* metatarsal, there is no difference between Tepelerarası and Sacrificial Area with a $p>0.5$, suggesting failure to reject the null hypothesis. It means there are no significant morphological differences between the animals of these areas. This result may have been related to the small sample size of the Sacrificial Area. The CVA results of both astragalus and metacarpal ovicaprid specimens indicate morphological differences between the three areas. Significantly, the $p \leq .0001$, which means rejection of null hypothesis, is found for the comparison of Tepelerarası and Sacrificial Area for *O. aries* astragalus and of Tepelerarası and Ağılönü for *O. Aries* metacarpal. It means that there are significant differences between these areas based on animal morphology. In other words, based on astragalus and metatarsal ovicaprid CVA results, the animals from Ağılönü, Tepelerarası and Sacrificial Area are displaying morphological differences that support the idea of multi herding strategies of animals within the city.

It is mentioned that temples might had their own herds in Hittite states (Beckman, 1988, p. 35). It can be supported with faunal analyses of Sapinuwa that Ağılönü, which is thought of as a Temple area, may have raised their own animals different than the rest of the city. The Sacrificial Area, which is identified as the third area in this thesis but is actually located in Ağılönü, is also displaying evidence for morphological differences amongst the animals found there except for *O. aries* metatarsal result. The reason for identifying this area differently from Ağılönü is that Sacrificial Area is thought to have been the place where sacrificial pits found and the actual rituals have taken place. It is supported by the shreds of evidence taken from written records that the ovicaprid remains from this area might have been brought from different regions/states for performing sacrificial rituals. In chapter 2, the written records about rituals and festivals mentioned that many cattle, sheep, and goats were sent from different places for this kind of activity to a specific Hittite state (see the quotation down below).

"In one instance the god Telipinu of Kasha receives a delivery of 50 cattle and 100 sheep from the chief shepherd of the town of Ankuwa, and Queen Puduhepa issues 287

female sheep, 100 male sheep, and 11 goats from the property of the palace to the goddess Lelwani." (Beckman, 1988, p. 34). [16]

There appears to be variation overall in the bones I examined, suggesting the existence of many animal phenotypes. Moreover, it is also seen that some animals form clusters around specific location data, suggesting that these clusters most likely represent differences related to the distinct function of these three areas and the varied social status of the people living at each of them in the Late Bronze Age city. The most obvious evidence of this was from the analyses of *Ovis aries* specimens (Fig. 12, 14, 16). Since *Ovis aries* were more important to the Hittites because of wool production (Beckman, 1988; Pişkin & Durdu, 2021), they probably paid more attention and aimed to raise advanced and selective breeds of *Ovis aries*.

Besides the meat, the secondary products of *Ovis aries* were considered necessary for the Hittites as mentioned in Chapter 2. For the exploitation of secondary products, the mortality profile of ovicaprid is also significant evidence. Logically, in order to get more product from the animals, the survivorship should be longer. The kill-off age of ovicaprid between three and ten is higher than young animals and at Ağılönü 66.2% and Tepelerarası 70.2% of animals were killed in between these ages (Pişkin et al., 2020, p. 58; Pişkin & Durdu, 2021). Moreover, an important pattern was found that *Ovis aries* survivorship and kill-off ages are higher than *Capra hircus* in both areas; however, there are older *Ovis aries* in Ağılönü than Tepelerarası according to the TUBITAK report written by Evangelia Pişkin (2020) and her colleagues.

The main reason for this should be related to secondary products such as wool, milk and cheese. It is also mentioned about the flocks' products like butter "Ì.NUN", and milk "EZEN.GA"[17] as a secondary product in Hittite archives.To understand herders' decisions and choices about those products, the animal frequencies and quantity of the different species plays an important role (Redding, 1984). In addition to this, it has

[16] CTH 585

[17] See Süel, Aygül, 1985:82-83

also been argued that raising various and less valued species of animals such as *Capra hircus* can be interpreted as decentralization. Similarly, raising more *Ovis aries* to *Capra hircus* can be one indication of the importance of the wool production in a centralized economic system (Arbuckle, 2014). Because I only chose *Ovis aries* and *Capra hircus* species, a number of identified specimens can be given as *Ovis aries*, *Capra hircus* and *Ovis aries/Capra hircus* based on my data. Although the elements that are astragalus, metacarpal and metatarsal are the best elements of the animals in respect of separating *Ovis aries* and *Capra hircus*, a small percentage of animals could not be identified as *Ovis aries* or *Capra hircus* both because of the different morphology of animals and some damages on the diagnostic part of the bones. However, the third category of animals as *Ovis aries/Capra hircus* were not included in both biometric and geometric morphometric analyses. As seen in Figure 34, *Ovis aries* outnumber the *Capra hircus* in Ortaköy faunal remains and when kill-off age patterns, and quantity of *Ovis aries* are taken into account, as Arbuckle (2014) argued, that could be evidence of activities and importance of wool production. It is known that wool production was significant both for the Hittite economy and religion. As Beckman (1988) mentioned, the usage of wool as a magical material in rituals is a common tradition in Hittite culture. The wool was collected by the palace from local specialists who produced wool and possessed a dyed wool (Beckman, 1988, p. 35).

In addition, apart from data that formed groups, I also encountered some outliers that did not fit any group. In the intra-site GMM application, this kind of data are seeing as outliers, and were generally interpreted as not being native to the region where the dataset was created (Haruda, 2014, p. 265). These outliers may be animals brought from regions other than Sapinuva. This explanation is supported both by the statements in the Hittite tablets and by finding animals with Sr values that do not match the reference values in the Šapinuwa region. It was determined that *Capra hircus* showed more variability than *Ovis aries*, formed less distinct clusters, and Sr values also showed much more variability than *Ovis aries* (Pişkin et al., 2020).

In addition, another aim is to determine the existence of different “landraces”/breeding of animals at intra-site level, as stated in Chapter 1. When there is a large amount of variation within the site with a single species (such as only *Ovis aries* or *Capra hircus*), it is possible to talk about selective breeding of animals. The mean shape in GMM can be changed according to the different phenotypes (Haruda, 2014, p. 265). The phenotypic differences should be visible within the group variation, and this can be seen both with PCA and CVA. Some small subclusters within groups in the analyses suggest different breedings of animals in the dataset. This situation indicates that animals from different geographic areas form different morphological groups and it is visible when there are different groupings among a single species in the inter-site level. For example, the graphic of the CVA result in Figure 17 (*Ovis aries* metacarpal) displays some variation within particular groups. AGIL515 (AGIL763 as well) is clustered far from the other Ağılönü data group. Likewise, TEP501 is also showing morphological differences from the rest of the Tepelerarası data group. Interestingly, in Figure 12, Figure 14, Figure 15, Figure 16, the data from Ağılönü display broad clustering within the group and clustered wider than the data from Tepelerarası and Sacrificial Area. This might be evidence of local breeding practices taking place in Ağılönü; however, this might also be related to the limited amount of data from Ağılönü just for the data seen in Figure 22 and Figure 23.

Other than GMM, zooarchaeological biometry analyses were conducted to see the differences between both methods and compare the results for answering the thesis questions. There are two main reasons why the research was conducted using both traditional and geometric morphometric analysis. The first reason is to observe whether it will give the same answer to my research questions as a result of these two analyzes or to determine which one offers a clearer response to our question and to reveal which of these two methods is more suitable for this type of research. Secondly, as I mentioned in my thesis hypothesis, the Hittites developed a good understanding of animal husbandry. It is thought that they could have bred different breeds of animals due to their advanced veterinary activities. The results of my research so far confirm the correctness of the hypothesis I have established. The results of available data from both methodology, geometric morphometrics and biometry indicate that animal bones morphologically form various groups according to the areas in the settlement but the subgroups are clearer with GMM.

The results of the analysis of the animal bones from Ağılönü and Tepelerarası areas include different groups, and this indicates the existence of different phenotype features which may indicate different breeds. This confirmed the hypothesis I stated. Because Ağılönü is a ritual area, it is thought that at least some of the animals here were sent from the other areas in the settlement as well as other settlements under the Hittite control. In addition to this, Tepelerarası is both an administrative and workshop area and contains the bones of animals consumed by the people working here. In summary, it is thought that the bones excavated from the workshop area are leftovers consumed by the artisans who are neither high administrative officiers nor priests working here and that they are second quality animals compared to the bones found in the Ağılönü ritual area because the animals sent to the Agilonu ritual area might have been selected and sent by the temple as first quality animals. (A. Süel, 1985). It is also mentioned that the animals have been offered to the god are different/special (fattened and big) than the other animals consumed by people based on a Hittite text bellow.

"If any cattle or sheep have been sent for the god to eat, you take away this fattened cattle or fattened sheep and instead put the weak animal you have slaughtered inside and either devour that fattened cattle or leave it in your barn/stable, or if you take it to yourself, or leave the fat sheep in your sheep pen, or slaughter it, or use it according to your own will, or give it to another human being to change it and get a wage for it, then you have swept that food out of God's mouth...God is strong in spirit does not rush to catch up. But when he's caught, he won't let go anymore. So be very respectful to the spirit of the gods." (A. Süel, 1985, pp. 37–41).

The data were analyzed in both PCA and MANOVA/CVA. The first handicaps were faced during the analyses conducted with the measurements taken with traditional zooarchaeological standards. In MANOVA/CVA, unlike GMM, there should be more than one data for each classifier/group. Because there is only one specimen in the two datasets, both *Ovis aries* metacarpal and *Capra hircus* metatarsal datasets, these were excluded from this analysis as it is mentioned in previous chapter. This is the main disadvantage of the MANOVA/CVA analysis with the data produced with the standard zooarchaeological measurement tehcniques. That is, unlike GMM, you need more data to be able to run the analyses.

On the one hand, some results of PCA conducted with the measurements based on the zooarchaeological biometry are displaying pretty similar results with GMM such as these obtained for the *Ovis aries* astragalus (see Figure 12 and 24). On the other hand, some other results of PCA could not capture enough variation so as to discern clusters within the groups compared to the GMM. However, the result of traditional zooarchaeological measurements for *Capra hircus* astragalus is the only one exception for better separation rather than GMM (see Figures 14 and 26). Overall, the results of PCA conducted with the measurements based on standard zooarchaeological biometry (SZB) display almost similar data distribution in the graphics; it is hard to see small subclusters within certain groups. As it is mentioned above, the subclusters within a group may indicate different breedings and/or ecozones related, and GMM is more successful in getting this kind of evidence.

In order to compare a fair round between GMM and SZB, MANOVA/CVA was run to see the differences and similarities of both methodologies. The graphs and statistical results clearly show that GMM is displaying clear separation based on the groups/areas rather than SZB analyses except for *Capra hircus* metacarpal analyses. SZB analyses indicate clear separation based on the areas more than GMM analyses only for the *Capra hircus* metacarpal. It may be related to the complex landmark system of GMM for metacarpal or the amount of data that is more limited in SZB. Interestingly, some data are seen as an outlier in SZB MANOVA/CVA, such as SAC300 in Figures 26, however, the same specimen is located close to the data from Tepelerarası in GMM analysis (see Fig. 14). Although the clear separation of most data based on variation was demonstrated with GMM, some specimens such as TEP413, TEP507 and AGIL523 specimens in Figures 14 and 26 in both methodologies displayed different morphology than the rest of the datasets. Unfortunately, it was not possible to analyze *Capra hircus* metatarsal and *Ovis aries* metacarpal data were not able to be analyzed due to the limited amount of data.

The following can be said about the results obtained using traditional zooarchaeological measurements and geometric morphometric techniques: first, there was not a big difference between these two methods in PCA; however, the geometric morphometric method gives more concrete results in general. Furthermore, CVA results of the geometric morphometric method give significant results more often than traditional zooarchaeological measurements. With the geometric morphometric method, the animal bones from the three main areas excavated in the settlement, Tepearası, Ağılönü and Sacrificial Area, are displaying morphological differences. In addition, it was observed that there were different animal sub-groups in both areas. As a result, it was observed that the GMM method gave clearer results because the geometric morphometric analysis is capable of capturing sensitive measuring system; the distinction within the obtained groups could be observed more clearly.

CHAPTER 6

CONCLUSION

This thesis investigated the variability based on animal morphology of *Ovis aries* and *Capra hircus* between three areas within the Hittite settlement Şapinuwa in the Late Bronze Age period. Both geometric morphometric methods and zooarchaeological biometry (traditional morphometric techniques) were applied to detect inherited characteristics of the morphology of animals and to discuss the results of two methodologies. Morever, two techniques that are geometric morphometris and traditional zooarchaeological biometry were applied to the elements astragalus, metacarpal and metatarsal of the species *Ovis aries* and *Capra hircus* to investigate if there is any phenotype differences of animals based on three different areas used by people who were from different social status carrying out different activities in one of the major Hittite period site Šapinuwa.

As it is mentioned in Chapter 2, animal mobility as taxes, booty and sacrificial offerings has been mentioned in the Hittite archives (Beckman, 1988). Morever, the zooarchaeological evidences show good knowledge of animal breeding practice in the Hittite period states as well. Although it is hard to examine this argument with principle component analysis, in the graphs created by this technique, some clusters indicating phenotypic groups of animals were attested. Even if there is not a strong division between the three areas of Šapinuwa, the different phenotypes have been observed at the principle component analyses. On ther other hand, canonical variate analysis is the best choice in a way of searching both ontological and phenotypic differences. Based on the canonical variate analyses of Šapinuwa materials, there are different phenotypes between animals and the grouping/clustring of animals is mostly based on the areas that I identified as Tepelerarası, Ağılönü and Sacrificial Area.

As it is discussed in Chapter 2, Tepelerararası is where administrative and workshop place located, Ağılönü is where priests lived in and Sacrificial area is where the actual sacrificial rituals were done by the people living in Ağılönü. As Beckman (1988) indicated, the temple area might have their own flocks. In addition to that, based on the archaeological evidence excavated from this site, the Temple might have their own living areas as a small settlement with their own ovens, buildings, flocks and other spaces where daily life activities might have been maintained. It can be argued that the animals from Ağılönü seem different than the animals from Tepelerarası and Sacrificial Area. Since the p-value is less than 0.001, the null hypothesis that all areas within the settlement have similar morphological phenotypes can be rejected based on the analyses for *Ovis aries* specimens. However, the same division based on three areas in *Capra hircus* elements was not provided neither with principle component nor canonical variate analysis except for *Capra hircus* astragalus. It still can be argued that there is a division based on these areas but it is not strong nor statistically significant for every area in the analysis.

On the other hand, the Sacrificial area is a location just for conducting religious rituals in Šapinuwa. These three areas were used by people who are from different social status (e.g. if a person is administrative officier or artisan, this person spent her/his most of time in Tepelerarası, or if a person is a priest, he spent his most of the time in Ağılönü). The differences of Sacrificial Area are mentioned in Chapter 2 and this is a special area compared to the other two because this is a place where selected aniamls were offered for sacrifice to gods. According to the result, the animal remains from this place actually indicates morphological differences. The reason of this might have been related to the offerings possibly sent from the other states under the Hittite control because the 'outliers' of the analyses were mostly from the Sacrificial Area.

The limitation of this thesis is the unbalanced number of data from the three excavated locations. This is related with the requirements of the geometric morphometric methods which needs to have almost complete elements to plot landmarks. It also affects analysis conducted with traditional zooarchaeological measurements because all the data is chosen from the dataset which used for geometric morphometrics. While it was possible to position certain landmarks in 2D geometric morphometric spaces, the traditional measurement techniquw needs 3D completeness of bone for taking measurements. In addition to that, the analaysis MANOVA/CVA chosen for the comparison of traditional measurements to CVA in geometric moprhometric, could not be run if there was a single measurement missing in the data. Lastly, for the further researches, geometric morphometric method can be applied to the animals which are more mobile such as horses and cattle to understand the morphology of local breeds of these species. These results of further studies can also be compared to the data from other sites of Hittite period.

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APPENDICES

APPENDIX A- GEOMETRIC MORPHOMETRIC RESULTS AND BIOMETRIC MEASUREMENT LIST

Table 10: P-values from CVA of *Ovis aries* and *Capra hircus* Astragalus from all the areas.

Ovis aries Astragalus

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.0010	
Tepelerarası	0.0001	<.0001

Capra hircus Astragalus

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.0110	
Tepelerarası	0.0075	0.0001

Table 11: P-values from CVA of *Ovis aries* and *Capra hircus* Metacarpal from all the areas.

Ovis aries Metacarpal

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.0324	
Tepelerarası	<.0001	0.0096

Capra hircus Metacarpal

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.0076	
Tepelerarası	0.0077	0.0033

Table 12: P-values from CVA of *Ovis aries* and *Capra hircus* Metatarsal from all the areas.

Ovis aries Metatarsal

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.8750	
Tepelerarası	0.0003	0.3295

Capra hircus Metatarsal

P-values from permutation tests (10000 permutation rounds) for Mahalanobis		
	Ağılönü	Sacrificial Area
Sacrificial Area	0.0097	
Tepelerarası	0.0141	0.8823

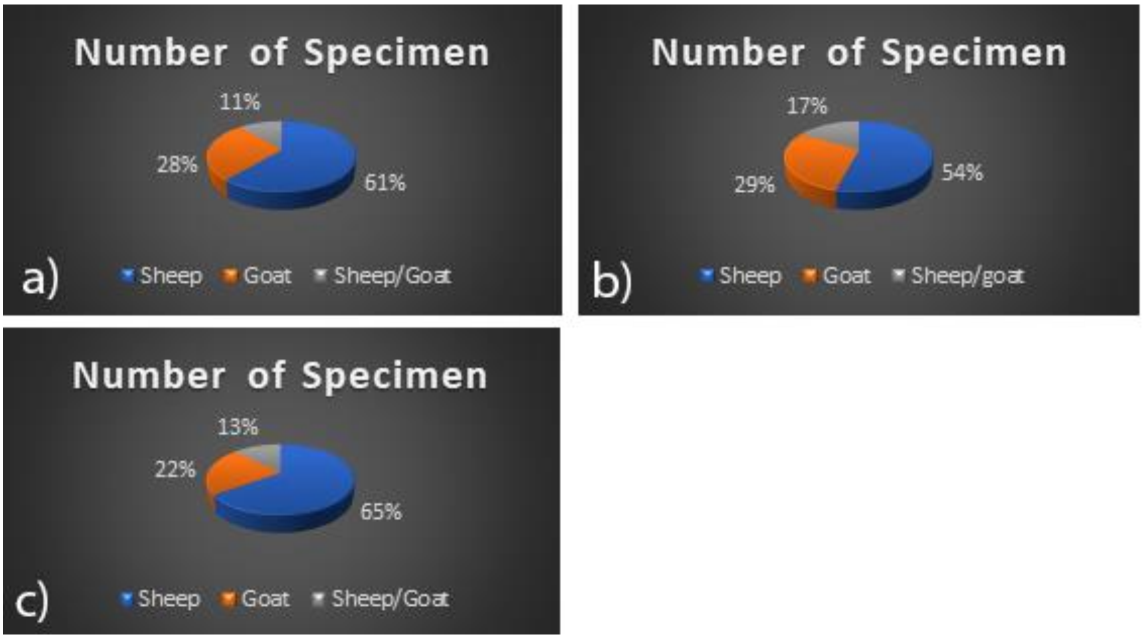

Figure 34: All data collected from the site without exclude any data for the analyses a) Astragalus, b) Metacarpal, c) Metatarsal.

Table 13: Specimen measurements of Astragalus in mm.

Specimen	AREA	SPECIE	GL1	GLm	Bd
AGIL512	Ağılönü	*Capra hircus*	30	27.6	19.6
AGIL520	Ağılönü	*Ovis aries*	30.5	28.6	20.2
AGIL523	Ağılönü	*Capra hircus*	30.3	28.4	19.1
AGIL531	Ağılönü	*Ovis aries*	29.7	27.7	18.8

AGIL533	Ağılönü	*Ovis aries*	27.8	26.7	18.3
AGIL561	Ağılönü	*Ovis aries*	29.8	28.5	19.4
AGIL563	Ağılönü	*Ovis aries*	30	27.5	19.9
SAC290	Ağılönü	*Ovis aries*	30	27.7	19.2
SAC292	Ağılönü	*Capra hircus*	27.1	25.7	17.1
SAC293	Ağılönü	*Capra hircus*	26.1	24.8	16.9
SAC294	Ağılönü	*Ovis aries*	30	28.6	19.7
SAC295	Ağılönü	*Ovis aries*	30.5	29.2	19.7
SAC296	Ağılönü	*Ovis aries*	29.3	28.6	20.2
SAC298	Ağılönü	*Capra hircus*	26.6	25.2	17.8
SAC299	Ağılönü	*Ovis aries*	30.8	29.5	19.8
SAC300	Ağılönü	*Capra hircus*	31.9	29.8	20.6
SAC313	Ağılönü	*Ovis aries*	31.9	30.1	19.7
SAC532	Ağılönü	*Capra hircus*	26.6	24.4	17.6
SAC537	Ağılönü	*Capra hircus*	30	27.7	19.7
SAC569	Ağılönü	*Capra hircus*	26	25.2	17.2
SAC570	Ağılönü	*Capra hircus*		24.5	17.6
TEP334	Tepelerarası	*Capra hircus*	29.8	27.7	19.9
TEP376	Tepelerarası	*Ovis aries*	29.6	26.5	18.8
TEP412	Tepelerarası	*Ovis aries*	27.5	26.8	17.6
TEP413	Tepelerarası	*Capra hircus*	28.1	27.2	19.2
TEP483	Tepelerarası	*Ovis aries*	32.9	31.2	21.1
TEP491	Tepelerarası	*Ovis aries*	28.9	27.1	18.3
TEP496	Tepelerarası	*Ovis aries*	30.1	29	20
TEP497	Tepelerarası	*Ovis aries*	31	29	19.7
TEP499	Tepelerarası	*Ovis aries*	28.9	27.8	18.6
TEP506	Tepelerarası	*Ovis aries*	29.7	29.2	19.6
TEP507	Tepelerarası	*Capra hircus*	27	25.4	17.9
TEP544	Tepelerarası	*Ovis aries*	31.7	30.6	21.7
TEP546	Tepelerarası	*Ovis aries*	29.9	28.8	19.2
TEP548	Tepelerarası	*Ovis aries*	30.5	28.6	19.6

TEP550	Tepelerarası	*Ovis aries*	31.7	30.4	19.4
TEP554	Tepelerarası	*Capra hircus*	28.7	26.6	18
TEP556	Tepelerarası	*Ovis aries*	28.9	27.5	19.2
TEP567	Tepelerarası	*Capra hircus*	30	27.6	19.8

Table 14: Specimen measurements of Metacarpal in mm

ID	**Area**	**Species**	**Greatest depth of the distal end**	**Greatest depth of the distal end**	**Depth of the medial trochlear**	**Depth of the medial verticillus**	**Width of the medial condyle**	**Depth of the lateral trochlear**	**Depth of the lateral verticillus**	**Width of the lateral condyle**
AGIL515	Ağılönü	*Ovis aries*	25.5	16.5	10.8	16.1	11.6	11.8	16.5	12
AGIL516	Ağılönü	*Ovis aries*	25	15.7	10.3	14.6	11	11.3	15.7	11.6
AGIL715	Ağılönü	*Ovis aries*	27.7		11.5	16.3	12.2	12.1		
AGIL742	Ağılönü	*Ovis aries*	25.8		9	15.4	11	9.8		
AGIL745	Ağılönü	*Capra hircus*	26.8	16.1	9.4	16	12.4	10	16.1	12.5
AGIL757	Ağılönü	*Ovis aries*	27.6	17.1	11.5	17	12.6	12.2	17.5	12.9
AGIL762	Ağılönü	*Capra hircus*	29.1	17.1	12.4	16.5	12.8	13.4	17.4	13
AGIL763	Ağılönü	*Ovis aries*								
AGIL764	Ağılönü	*Capra hircus*	27.6		9.5		12.2	10.7		12.5
AGIL767	Ağılönü	*Capra hircus*	24.8	14.5	8.7	14.4	11.3	9.2	14.6	11.5
SAC748	Ağılönü	*Capra hircus*	26.2		9	14.8	11.5	9.4		12.3
SAC749	Ağılönü	*Capra hircus*	25.2	15.6	9.4	15.6	11.4	10.1	15.5	11.6
SAC759	Ağılönü	*Ovis aries*	25.8	16.7	10.4	16.1	11.8	11.4	16.7	12
SAC773	Ağılönü	*Capra hircus*	25.9	15.9	8.6	15.5	11.9	9.6	15.9	12.2
TEP350	Tepelerarası	*Ovis aries*	28	17.8	11.8	16.2	12.9	12.7	17.9	13.3
TEP351	Tepelerarası	*Ovis aries*	25.4							
TEP352	Tepelerarası	*Ovis aries*	27	17.3	11.2	16.4	11.9	12.5	17.4	16.7
TEP360	Tepelerarası	*Capra hircus*	30.2	18.6	10.8	18.1	13.9	11.7	18.5	14.1

TEP363	Tepelerarası	*Ovis aries*	26.2	17	10.9	16.3	12	12.1	17	12.3
TEP400	Tepelerarası	*Capra hircus*	26.1	15.6	8.9	15.3	11.5	9.5	15.5	12
TEP401	Tepelerarası	*Ovis aries*	28.8	18.8	11.9	17.8		13.8	18.7	13.6
TEP410	Tepelerarası	*Ovis aries*	26.6	17.1	11.7	16.4	11.8	12.6	17	12.4
TEP420	Tepelerarası	*Ovis aries*	24.8	16.8	11.3	16	11.5	12.6	17	11.7
TEP430	Tepelerarası	*Ovis aries*	29.2		12.4		12.9	13.4		13.8
TEP431	Tepelerarası	*Ovis aries*	26.8	18.3	12.1	17.6	12.2	12.8	18.1	12.7
TEP432	Tepelerarası	*Ovis aries*	26.2	16.5	12	16.5	11.7	12.5		11.7
TEP435	Tepelerarası	*Capra hircus*	25.8	16.9	11.5			12		12.1
TEP439	Tepelerarası	*Ovis aries*	25.6		10.8	14.9	11.6	11.8		12.3
TEP440	Tepelerarası	*Ovis aries*	26.8	16.6	10.6	15.8	12.1	11.8	16.6	12.8
TEP448	Tepelerarası	*Ovis aries*	27.1	18.1	12.2	17.3	12.2	12.9	18.1	12.8
TEP455	Tepelerarası	*Ovis aries*	24.8	16.3	10.8	15.5	11.3		16.3	11.8
TEP460	Tepelerarası	*Capra hircus*	27.1	17.6	12.3	17.5	12.3	13	17.6	12.7
TEP461	Tepelerarası	*Ovis aries*	29.5	18	11.6	17.2	13.1	12.5	18	13.5
TEP463	Tepelerarası	*Ovis aries*	27.7	18	12	17.3	12.5	13	18	12.8
TEP476	Tepelerarası	*Ovis aries*	26.2	16.3	10.8	15.6	11.7	11.8	16.4	12.3
TEP484	Tepelerarası	*Capra hircus*	28.2	16.8	9.7	16.6	12.8	10.4	16.8	13.2
TEP501	Tepelerarası	*Ovis aries*	25.5	16.4	11	15.6	11.5	11.9	16.4	11.9
TEP502	Tepelerarası	*Capra hircus*	25.6	16.1	10.8	15.7	11.2	11.8	16.1	12.2
TEP746	Tepelerarası	*Ovis aries*	26.8		12.1	17.4	12.3	13		12.5
TEP750	Tepelerarası	*Ovis aries*	29.8	17.5	11.7	17.4	13	12.6	18	13.3
TEP752	Tepelerarası	*Ovis aries*	26.5	17.4	10.7	16.6	11.6	11.9	17.4	12.2
TEP761	Tepelerarası	*Ovis aries*	27.2	17.5	11.3	16.8	12.1	12	17.5	12.5
TEP766	Tepelerarası	*Ovis aries*	27.9	16.8				12.4	16.9	13.3
TEP768	Tepelerarası	*Capra hircus*								
TEP769	Tepelerarası	*Ovis aries*	28.4	17.2				12.4	17.2	12.8
TEP770	Tepelerarası	*Ovis aries*	27.9		11		12.2	11.8	17.1	12.3

TEP771	Tepelerarası	*Ovis aries*	25.8	15.9	9	15.6	11.5	9.6	15.9	12.2
TEP772	Tepelerarası	*Ovis aries*	26.8		11.5	16.4	12.1	12.4		
TEP774	Tepelerarası	*Capra hircus*	26.4	16	8.9	15.4	12	9.8	16	12.4
TEP776	Tepelerarası	*Ovis aries*		15.7				11.9		

Table 15: Specimen measurements of Metatarsal in mm.

ID	**Area**	**Species**	**Greatest depth of the distal end**	**Greatest depth of the distal end**	**Depth of the medial trochlear condyle**	**Depth of the medial verticillus**	**Width of the medial condyle**	**Depth of the lateral trochlear condyle**	**Depth of the lateral verticillus**	**Width of the lateral condyle**
AGIL683	Ağılönü	*Capra hircus*	25.1	16.1	9.4	15.4	10.8	9.7	16.2	11.2
AGIL685	Ağılönü	*Capra hircus*								
AGIL686	Ağılönü	*Capra hircus*	24	15.3	8.9	14.8	10.4	9.4		11.1
AGIL696	Ağılönü	*Ovis aries*	27.8	17.9	11.9	17.5	12.4	12.7	17.9	13.2
AGIL699	Ağılönü	*Ovis aries*	24.9	15	8.8	14	10.7	10.2	15	11.7
AGIL716	Ağılönü	*Ovis aries*	26.1	17.4	10.9	16.4	10.9	11.3	17.4	12.1
AGIL717	Ağılönü	*Ovis aries*	25.8	16.7	10.1	16	11.1	11	16.7	12.3
AGIL718	Ağılönü	*Ovis aries*	24.3	16.2	10.3	15.5		11	16.3	
AGIL722	Ağılönü	*Ovis aries*	24.7	15.9	9.8	14.9	10.7	11	15.8	11.5
AGIL729	Ağılönü	*Ovis aries*	28	17.2	12	16		12.2	17.2	12.5
AGIL732	Ağılönü	*Ovis aries*	22.3	15.8	10.1	14.6	9.9	11.4	15.8	10.7
AGIL735	Ağılönü	*Capra hircus*	24.2		8.9		10.8	9.5		11.1
AGIL737	Ağılönü	*Ovis aries*	26.3					11.7	16	12.7
AGIL739	Ağılönü	*Capra hircus*								
SAC695	Ağılönü	*Capra hircus*								
SAC698	Ağılönü	*Ovis aries*	24.9	16.6	10.5	15.9	10.8	11	16.8	12
SAC707	Ağılönü	*Ovis aries*	24.6	16.3	10.2	15.7	10.5	10.5	16.4	11.7

SAC709	Ağılönü	*Ovis aries*	23.7	15.3	10.3	14.7	10.2	11	15.3	11.2
SAC719	Ağılönü	*Ovis aries*	23.6	15.4	9.5	14.7	10.5	10.5	15.4	11.2
SAC728	Ağılönü	*Capra hircus*	24.3	15.4	9.1	14.8	10.5	9.7	15.5	11.5
TEP321	Tepelerarası	*Ovis aries*	23.8	16	10.1	15.4	11	10.5	15.9	11.3
TEP365	Tepelerarası	*Ovis aries*	26.9	18.3	10.9	17.2	11.3	11.8	18.4	12.8
TEP372	Tepelerarası	*Capra hircus*	24.2	15.4	8.7			9.3	15.4	10.9
TEP373	Tepelerarası	*Ovis aries*	23.9	14.9	9.7	14.7	10.5	10.8	15.1	10.6
TEP374	Tepelerarası	*Ovis aries*	26.5	17.6	10.9	16.7	11.4	12.1	17.6	12.5
TEP378	Tepelerarası	*Ovis aries*	25.7	17.2	10.8	15.5	11.3	11.4	17	12.1
TEP389	Tepelerarası	*Ovis aries*	10.3	16.8	15.9	16	10.5	11.2	16.7	11.6
TEP393	Tepelerarası	*Ovis aries*	23.8	15.4	10.1	15.3		11	15.4	
TEP394	Tepelerarası	*Capra hircus*	24.8	15.8	8.8	15.3	11.3	9.1	15.7	11.6
TEP403	Tepelerarası	*Ovis aries*	23.2	16.4	10.1	14.9	10.4	10.4	16.1	11
TEP404	Tepelerarası	*Ovis aries*	23.9	16.3	10	15.3	10	10.6	16.1	11.2
TEP405	Tepelerarası	*Ovis aries*	26.3	17.7	11.4	17.7	12.2	12.1	17.8	12.2
TEP408	Tepelerarası	*Ovis aries*	25.2	18	11.1	16.8	11.4	11.9	18	12.1
TEP411	Tepelerarası	*Ovis aries*	24.3	17.4	10.8	16.5	10.5	11.7	17.3	11.8
TEP414	Tepelerarası	*Ovis aries*	25.5	16.1	10.1	15.5	10.6	11	16.2	11.6
TEP428	Tepelerarası	*Ovis aries*	28	18.4	11.7	17.3	12.5	13.1	18.7	13.1
TEP447	Tepelerarası	*Capra hircus*	26.5	18.4	11.1	17.3	11.3	12.1	18.3	12.6
TEP453	Tepelerarası	*Ovis aries*	25.4	17.5	11.1	16.4	11	12	17.5	12
TEP462	Tepelerarası	*Capra hircus*	23.6	15.3	9	15	10.3	9.3	15.1	10.8
TEP466	Tepelerarası	*Ovis aries*	23.6	15.4	9.1	14.4	10.1	9.7	15.4	11.1
TEP471	Tepelerarası	*Ovis aries*	26.4	17.3	10.2	16.1	11.1	11.2	17.2	12.1
TEP481	Tepelerarası	*Ovis aries*	25.2	17	10.6	15.7	10.8	11.6	17.1	11.8
TEP489	Tepelerarası	*Capra hircus*	29.3	17.9	10.8	17.9	13.3	11.2	17.5	13.4
TEP498	Tepelerarası	*Ovis aries*	27.9	18.1	11.2	17.5	12.5	12.1	18.1	13.4
TEP503	Tepelerarası	*Capra hircus*	28.2	17.2	9.8	16.6	12.2	10.4	17.2	12.6

TEP504	Tepelerarası	*Ovis aries*	24.8	16.5	10	15.5	15.4	10.7	16.3	11.4
AGIL514	Ağılönü	*Capra hircus*	23.3	15.2	9.2		10.7	9.5	15.1	11.2
TEP682	Tepelerarası	*Ovis aries*	25.7	17.2	10.4	15.9	10.8	11.5	17.3	12.4
TEP688	Tepelerarası	*Ovis aries*	23.6	15.7	9.5	15	9.9	9.8	15.7	11.1
TEP690	Tepelerarası	*Capra hircus*	23.5		8.3	14.1	10.2	8.9		10.8
TEP691	Tepelerarası	*Ovis aries*	23.1	15.5	9.4	14.8	10.1	10.6	15.8	11
TEP692	Tepelerarası	*Ovis aries*	22.1	15.3	9.1	14.2	9.7	9.7	15.4	10.4
TEP693	Tepelerarası	*Ovis aries*	24.1	17.2	10.6	16.3	10.5	11.6	17.2	11.7
TEP700	Tepelerarası	*Ovis aries*								
TEP701	Tepelerarası	*Ovis aries*	24	17	10.1	15.8	10.2	11.6	16.9	11.6
TEP703	Tepelerarası	*Ovis aries*	25.1	17.3	10.2	16	11.2	11.7	17.4	12.3
TEP705	Tepelerarası	*Ovis aries*	26.2							
TEP706	Tepelerarası	*Ovis aries*	26.8		10.7		12.1	11.9		12.5
TEP713	Tepelerarası	*Ovis aries*	24.5		10.2		10.3	11.4		11.4
TEP723	Tepelerarası	*Ovis aries*	24.6	16.7	9.9	15.5	10.2	10.7	16.8	11.1
TEP724	Tepelerarası	*Ovis aries*	26.2	17	10.7	16	11.1	11.7	17	12.1
TEP725	Tepelerarası	*Ovis aries*	25.1	16.4	10	15.4	10.7	10.6	16.4	12
TEP731	Tepelerarası	*Capra hircus*	22.9	15.2		14.7	10	9.3	15.3	
TEP734	Tepelerarası	*Ovis aries*	26.6	16.5	10.9	15.9		12	16.4	

B. TURKISH SUMMARY / TÜRKÇE ÖZET

Hitit dönemi Anadolusunda ekonominin temeli hayvancılığa dayalıydı. Çeşitli Hitit yerleşmelerinden elde edilmiş fauna analizleri ve Hitit arşivlerinde, gelişmiş hayvancılığa ve hayvan ıslahına dayalı bilgiler verilmiştir (Beckman, 1988; Dörfler et al., 2011). *Ovis aries* (evcil koyun) ve *Capra hircus* (evcil keçi) Geç Tunç Çağı Orta Anadolusunda pastoral aktivitenin temelini oluşturmuştur. Bu tezin amacı, Hitit Geç Tunç Çağı dönemindeki hayvancılık yönetimi, hayvan mobilitesi ve ıslah çalışmaları hakkında disiplinler arası araştırma yoluyla ve Šapinuwa (Ortaköy) kazısı fauna kalıntıları vaka çalışması olarak ele almak ve araştırmaktadır. Milattan önce 14. Yüzyılda Hitit İmparatorluğunun ikinci başkenti olduğu düşünülen Šapinuwa, Orta Anadolu bozkırında yer almaktadır. Bu araştırmada, Šapinuwa kenti içinde üç farklı alandan elde edilen veriler ışığında, bu üç alanda bulunan ve toplum içinde farklı statülerde bulunan insanların hayvan üretimi ve tüketimi üzerinde farklı yöntemler izleyip izlemediği hakkında çalışılmıştır. Bunun yanında hem yerleşim yeri içinde ve yerleşimler arası hayvan mobilitesi olup olmadığı sorusuna cevap aranmıştır. *Ovis aries* ve *Capra hircus* astragalus, metacarpal ve metatarsal kemikleri çeşitli analizlere tabi tutulmuş ve morfolojik farklılıkları araştırılmıştır. Geleneksel zooarkeoloji yöntemlerinden olan biyometrik ölçümler ve disiplinelerarası bir yöntem olan geometrik morpfometrik metotlar kullanılarak en küçük farklılılar bile kaçırılmadan hesaplamalar yapılmıştır. Çünkü geometrik morfometrik metot ile yapılan ölçüm ve analizler, osteometri ölçümlerinde elde edilen verilere göre çok daha hasas çalışmakta ve buna göre daha net sonuçlar verdiği düşünülmektedir (A. F. Haruda, 2017; Koolstra ve digerleri, 2019; Pöllath ve diğerleri, 2019; Zelditch ve diğerleri, 2004).

Osteometri, uzun yıllardır zooarkeolojik araştırmalarda kumpas kullanarak boyut ve şekli/morfolojyi değerlendirmek için kullanılan geleneksel bir ölçüm tekniğidir.

Ölçüm tekniklerinin standardizasyonu Von Den Driesch (1976) tarafından disipline tanıtıldı. Geometrik morfometrik ise şekil varyasyonunu araştırmak için kullanılan bir tekniktir (Rohlf ve Marcus, 1993; Bookstein, 1996; Adams, Rohlf ve Slice, 2004; Zelditch ve diğerleri, 2004; Slice, 2005). Landmarklara dayalı geometrik morfometrinin kullanımı biyoloji, antropoloji, tıp, paleontoloji gibi çeşitli disiplinlerde uygulanmıştır (Lawing ve Polly 2010) ve yöntem birçok zooarkeolog tarafından gruplar arasındaki ve içindeki morfolojik farklılıkları incelemek için uygulanmıştır.

Bu araştırmada iki ana soruyu cevaplamaya çalıştım:

a) Hitit Devleti tarafından yönlendirilen ve kontrolünde olan hayvan ıslah çalışmalarına dair herhangi bir kanıt var mı?

b) Šapinuwa'da bulunan hayvanlar farklı ortamlardan mı geliyorlar ve eğer öyleyse bunun bu şehirde yaşayan farklı sosyal sınıflarla nasıl bir ilgisi var? Yani bu hayvanlar başka bir coğrafi bölgeden vergi, ganimet veya kurban olarak mı geliyordu? Ayrıca Tapınak, Saray veya Kurbanlık Alana ait sürülerin morfolojik açıdan hayvanlar arasında herhangi bir farklılık var mı? (Tapınak – Saray – Kurban Alanı hayvanlarını farklı şekilde otlatıp yönetirler veya farklı "ırklara" erişimleri olmuş olabilir mi?).

Genel olarak Hitit kenti Šapinuwa'nın farklı bölgelerinden gelen hayvan kalıntılarından elde edilen kanıtlarla, farklı sosyal statüdeki kişilerin hayvanlara erişmesinde bir farklılık olabilir mi sorusuna odaklanıyorum. Geometrik morfometri ve geleneksel zooarkeolojik biyometri (oestrometri) olmak üzere iki tekniğin karşılaştırılması için *Ovis aries* ve *Capra hircus* türlerinin astragalus, metacarpal ve metatarsal elementlerine uygulanarak insanlar tarafından kullanılan üç farklı alana göre hayvanlarda fenotip farklılıkları olup olmadığı araştırıldı. Hitit döneminin önemli yerleşimlerinden biri olan Šapinuwa'da farklı sosyal statülerdeki insanların kullandığı üç lokasyon olarak tanımlanmış Ağılönü, Tepelerarası ve Kurban alanı çevresindeki hayvanların farklı fenotipik özellikler sergileyerek bu alanlara göre gruplaşma oluşturmuş olabileceği düşünülerek analizler yapılmıştır.

Geç Tunç Çağı'nda Hitit İmparatorluğu Mısır, Babil, Asur ve Mitanni arasında Yakın Doğu'daki büyük güçlerden biriydi ve onlarla benzer çıkarlar için mücadele ediyordu. İmparatorluk döneminde diğer imparatorluklarla ilişkilerde daha eşitlikçi bir politika izlense de (Gavaz Sir 2008; Alp 2001, 145; De Martino 2006, 81), yazılı kaynaklar Kuzey Anadolu'daki pastoral kabileler olarak bilinen Kaška halkı ve Hitit devleti arasındaki çatışmadan bahseder (Glatz ve Matthews 2005; Matthews ve Glatz 2009; Yakar 2008).

Hitit devleti teokratik ve feodal bir yapıya sahipti ve idari, ekonomik ve örgütsel yönlerden merkezi bir yönetim anlayışı benimseniyordu (Ünal 2005, s. 100–101; Alp 2001, s. 147). Sosyal yapı, yönetici/kraliyet ailesini ve/veya seçkin kişileri, dini faaliyetlerden sorumlu kişileri (tapınaklara bağlı olarak), sıradan insanları ve köleleri içeriyordu. Toprakların mülkiyeti tanrılara aitti ve toprakların örgütlenmesi ve yönetimi, gücünü tanrılardan alan kralların/yöneticilerin yetkisi altındaydı (Ünal 2005, 144; De Martino 2006, 77). Aslında, krallar genellikle kafatasları takan ve ayak bileklerine kadar uzanan uzun bir cübbe giyen yüksek rahipler olarak tasvir edilir ve kralı tanrıların temsilcisi veya 'tanrının çobanı' olarak tasvir ederlerdi (Bryce 2002, 20). Kral, Hitit devletinin komutanı ve hakimi olarak da anılırdı (Bryce 2002, 21). Kraliçe ayrıca idari, sosyal ve dini konularda da önemli rol oynuyordu. Kraliçeler, aslında Hitit Krallığı'nda önemli bir konuma sahiptiler; Kraliçenin resmi unvanı olan Tawananna, kraliyet ailesinin bir kadın üyesinden seçilir, siyasi ve dini faaliyetlerde kendi haklarına sahip olurlardı (Bin-Nun 1975; Bryce 2005, 92).

Hitit krallığının, merkezi dışındaki toprakları merkeziyetçi bir anlayışla yönetiliyordu. Yüksek memurlar, kralların/prenslerin oğulları ve hatta bazen krala yakın olan seçkin/elit kişiler daha büyük eyaletlere atanırken, yerel yöneticiler daha küçük eyaletleri yönetmek üzere seçilmiştir (Alp 2001, 147; Yiğit 2004, 220). Hitit arşivlerinde ev olarak tanımlanan daha küçük birimlerden de söz edilmektedir ve bu daha küçük birimler genellikle daha büyük evlere bağlıydı (Bryce 2002, 75; Karauğuz 2019, s.119–22; Sevinç-Erbaşı 2014). Daha küçük birimlerde yaşayan halk, hem tarlalarında hem de sarayda ve tapınak tarlalarında çalışarak üretime katkıda bulunmuştur. Merkeziyetçi otorite tarafından toplanan fazla ürünler, hiyerarşik bir düzende depolanarak topluma dağıtılırdı (Reyhan 2009). Yani toplumda hiyerarşik bir düzenden ve yine bu düzenin sosyal ve ekonmik alanlardaki rolleri, üretimi ve tüketimi etkilediği görülmektedir.

Daha önceki araştırmalara göre; pastoralizmin Hitit ekonomisi için çok önemli bir bileşen olduğu kuşkusuzdur, ancak Hitit Anadolu'sunda hayvancılık stratejileri için ne tür ve ne kadar özel tekniklerin kullanıldığı kesin değildir. Hitit sosyal yapısında tüm tarlalar/topraklar tanrılara aittir ve insanlar aslında hiyerarşik bir düzen içinde tanrılara hizmet etmektedirler (Demirel, 2014, p. 2; MacQueen, 2015, p. 115).. Arazi/tarla düzenlemeleri, hayvancılıkla ilgili tarla kullanımlarının dağılımı ve hatta askerlere ait hayvanlar devlet tarafından gözetildi (Beal, 1992, p. 135,401).. Ayrıca Hitit arşivlerinde tapınağın kendine ait geniş tarlaları, sürüleri (Reyhan 2009, s. 161; Beckman 1988, s. 35) ile özellikle tarım ve hayvancılıkla ilgili bu faaliyetlerden sorumlu uzman görevli personelin bulunduğu belirtilmektedir. Yetkililerin uyması gereken kurallar ve tapınağa özel olarak ayrılan alanlar Hitit talimatlarında açıkça belirtilmiştir (Sir Gavaz 2012; A. Süel 1985).

Hayvanlar için kullanılan çeşitli isimler olduğunu Hitit kaynaklarından biliyoruz; “UDU=koyun", GU4=sığır", "MAŠ, UZ6=keçi", ŠAH=domuz", "ANŠE=eşek", "ANŠE.GiR.NUN.NA= katır", "ANŠE.KUR.RA=at ", "UR, UR.GI7=köpek. Hitit devletinin hayvancılığa müdahale ettiğini, saraya ve tapınaklara hayvan tahsis ettiğini de biliyoruz. Hitit metinlerinde (en büyük ve en iyi hayvanlar tanrıların hayvanlarıdır) “Tanrılar” için hayvanlardan söz edilmesi de aynı anlama gelmektedir. Hitit devleti teokratik olduğu için hayvan kurban etmenin de merkeziyetçi bir anlayışlar yapıldığı ve çok sayıda bayram devlet merkezlerinde ve kutsal şehirleride düzenleniyordu. Bu hayvanlar tapınak veya saray hayvanlarından veya/ve halktan gelen adak hayvanlar olarak seçiliyordu. Ayrıca Hititçe bir metinden hareketle tanrıya sunulan hayvanların insanlar tarafından tüketilen diğer hayvanlardan farklı/özel (besili ve iri) olduklarından bahsedilmektedir.

“ [Eğer] tanrının yemesi için (herhangi) [bir sığır ya da] koyun sevk edilmiş ise, siz bu besili sığır ya da besili koyunu alıp götürürseniz ve (onun yerine) siz kesmiş olduğunuz zayıf (hayvanı) içeriye bırakır[sanız] ve o (besili) sığırı ya yiyip bitirirseniz ya da onu (size ait olan) ahıra bırakırsanız ya da onu boyunduruğa koşarsanız ya da (besili) koyun (size ait olan) ağıla bırakırsanız ya da onu keserseniz ya da kendi isteklerinize uygun [kullanırsanız] ya da onu başka bir insana değiştirmek için [verirseniz] ve onun için bir ücret alırsanız sonra tanrının [o yiyeceğini] ağzından çekmiş olursunuz...Tanrıların ruhu kuvvetlidir. Yakalamak için acele etmez. Fakat yakaladığı zaman artık bırakmaz. (onun için) tanrıların ruhuna (karşı) çok saygılı olunuz.” (A. Süel, 1985, pp. 37–41).

Aynı zamanda Hitit devleti de İmparatorluğun çeşitli bölgelerinden vergi ve savaşlardan ganimet olarak çok sayıda hayvan alındığı da bilinmektedir.

“Bir örnekte Kasha'nın tanrısı Telipinu, Ankuwa kasabasının baş çobanından 50 sığır ve 100 koyun teslim alır ve Kraliçe Puduhepa sarayın mülkünden 287 dişi koyun, 100 erkek koyun ve 11 keçi sarayın mülkünden tanrıça Lelwani'ye verir.” (Beckman 1988, s. 34).

Hitit'in en genel ganimet hayvanı koyun ve sığırdı ve Goetze'nin belirttiği gibi koyun, bazı kişilerin Hatti ülkesi için Arina'nın Güneş Tanrıçası'na düzenli olarak koyun bağışlamak zorunda kaldığı genel bir vergiydi (Beckman 1988, s. 34). Bunlar, devletin hayvancılıkla yakından ilgilendiğini ve hayvancılığa sıkı sıkıya bağlı olduğunu gösteriyor. Aynı zamanda, vergi, ganimet veya tanrılar için kurban olarak İmparatorluk boyunca çok aktif bir hayvan hareketini gösterir.

Buna ek olarak Beckman, Hititçe bir metinden hareketle Hititlerde gütmenin düşük statülü insanların bir faaliyeti olarak görüldüğünü belirtmiştir (Beckman 1988, s. 38), ancak metnin bir idari/kraliyet belgesinin parçası olduğunu belirtmekte fayda vardır, sürülerin korunması yasalar ve kısıtlamalarla sağlanıyordu. Hayvan yönetiminin devlet tarafından kontrol edildiği ve korunduğu açıktır ve hayvancılığın merkezi kontrolünü gösterir (Adcock, 2020, s. 26).

Orta Hitit Krallığı döneminde Hitit İmparatorluğu'nun ikinci başkenti olduğu düşünülen Šapinuwa (URUsa-pi-id-du-wa), orta Anadolu bozkırının kuzeyinde yer almaktadır (Şekil 1). Kazılar sırasında bulunan tabletlerden şehrin adı doğrulanmıştır. Ortaköy olarak da bilinen yer Çorum ili sınırları içerisinde olup, Çorum şehir merkezinin 53 km güneydoğusunda ve Boğazköy'ün 60 km kuzeydoğusunda yer almaktadır. Kafkaslar üzerinden Anadolu'ya açılan bir tür kapı olan Kelkit vadisinin yakınında yer almaktadır. Yerleşim alanı yaklaşık. 9 km metrekare büyüklüğünde olup, alt ve üst kısımdan oluşmaktadır (Şekil 3). 1987 yılında Aygül ve Mustafa Süel tarafından üç yıllık yüzey araştırmaları sonucunda bulunmuş ve 1990 yılından beri kazı çalışmaları sürdürülmektedir (A. Süel ve Süel 2017, s. 29-30). Bir Hitit kenti olan Šapinuwa, Hurrilerin etkisinde bir dini merkez olarak biliniyordu ve şehir keşfedilmeden önce 20. Yüzyılın başlarında tercüme edilen Boğazköy metinlerindede adı geçmektedir. Ayrıca bu metinlerde Hurri ağız yıkama ritüellerinin (itkalzi ritüelleri) metninin burada yazıldığı ve diğer Hitit devletlerine gönderildiği belirtilmektedir.

Kazı ekibine göre Hititler gelmeden önce düz yerleşim yoktu. Bunun yerine inşaat işleri, teraslama ve tesviye Hitit döneminde insanlar tarafından yapılmıştır (A. Süel ve Süel 2017, 2s. 9). Alanın kazısı iki ana alana odaklanmaktadır; Ağılönü ve Tepelerarası ve iki alan arasındaki mesafe yaklaşık. 1 km’dir (Şekil 3). Kazılar sırasında bulunan Hitit tabletlerine göre Šapinuwa'nın sadece Hitit devletinin bir idari merkezi değil, Büyük Kral döneminde de devlet merkezi olduğu belirtilmiştir (A. Süel 1998, s. 37). Kazıda bulunan tabletler genellikle MÖ 14. yüzyıla tarihlenmektedir ve sitenin sosyo-ekonomik ve politik durumu hakkında önemli bilgileri gösterir (A. Süel 1998, s. 37).

Otuz bin metrekare büyüklüğündeki Ağılönü alanı şehrin kuzeyinde yer alır ve Šapinuwa'nın kutsal alanı olarak kabul edilir. 2000 yılında kazının başladığı Ağılönü'nde, özel bir teknikle inşa edilmiş bir ritüel alanına ait olduğu düşünülen 1500 metrekare büyüklüğünde, alışılmadık ve masif (kuzey-güney yönlü) bir taş döşeme ortaya çıkarıldı. Ağılönü alanı içindeki ritüel alan dışında, birkaç atölye, değirmen taşı ve fırın da tespit edilmiş olup, günlük yaşam aktiviteleri için kullanılan bazı mekanların da bulunduğu belirtilmektedir. Ritüel alanın bir diğer önemli unsuru da taş döşemenin güneyinde bulunan hayvan kemikleriyle dolu çeşitli kurban çukurlarıdır (Pişkin 2019). Hitit döneminde hayvan kurban etme yaygın bir gelenekti ve Hitit arşivlerinde kurban törenlerinden genel olarak bahsedilir. Kanıt olarak yüksek memurlara ait mühürler, tabletler ve içi hayvan kemikleriyle dolu kurban çukurları, buranın önemli bir ayin alanı olduğunu göstermektedir.

Kurban çukurlarının ortaya çıkarıldığı ritüel/adak alanı kötü organize edilmiş duvarlarla çevrilidir ve çukurlar çeşitli büyüklüklerde tekli, ikili, üçlü ve dörtlü olarak açılmıştır. Bu cılız duvarların yanında, taş döşemeye ve kurban çukurlarına yakın çeşitli yapılar yer almaktadır. Bu çukurlarda hayvan kemikleri bazen yanmış, çok parçalanmış, hatta bazen bir bütün olarak bulunmuştur. Süel'e (2015) göre Hitit döneminde törenlerde kuşlar, koyunlar, keçiler (ve dağ keçileri) birlikte yakılırdı. Ayrıca Hitit arşivlerine göre kurban törenleri öncesinde hayvanları sersemletmek için başlarına bir taş ve/veya alet vurulmuştur. Arkeolojik kanıtlara göre Ağılönü'ndeki çukurların içinde ve dışında hafif yontulmuş veya yontulmamış taşlar bulunmuştur. Bir rahip tarafından kurban edildikten sonra, hayvanın kanı çukurlara dökülür ve vücut parçaları yenilir veya imha edilirdi. Ancak hayvanların bazı unsurları (kafatası, kaburga, çene, bacak kemiği, diş, omurlar) da çukurlara konulurmuş. Yine Ortaköy kurban çukurlarında da bu elementlere rastlanmıştır. Kurbanlık çukurlarında hayvan kemiklerinin yanında mühürler, ağırşaklar ve taşlar bulunsa da çukurun altları genellikle boştur (A. Süel 2015a, s. 104). Ayin yapıldıktan sonra çukurların üstleri toprakla kapatılırdı çünkü çukurlar kullanıldığında kirlendiği düşünülürdü.[18]

[18] KBo 10.45 (III 26)

Tepelerarası, şehrin merkezinde yer alır ve içinde anıtsal ve idari yapıların bulunduğu savunma surları ile çevrilidir. Bu alanda bir hafriyat projesi başlatılmış ve kentin önemli binaları ortaya çıkarılmıştır. Tepelerarası'nda bugüne kadar A, B, C, D ve G yapıları ve G alanı incelenmiştir. G alanı ayrıca metal kalıplar, çok miktarda çanak çömlek parçaları, metal çekiçler, metal oklar, kil kalıpların bulunduğu atölye alanı olarak tanımlanmaktadır. Alışılmadık bir simetrik mimariyle inşa edilen A Binası, çeşitli kraliyet mühürlerinin keşfedildiği anıtsal bir yapı olarak düşünülmüştür (A. Süel 2015b, s. 102). Kentin depolarının sergilendiği bir depo olarak tanımlanan B Binası kalıntıları, A Binasının 150 m doğusunda ortaya çıkarılmıştır ve 1.5 m yüksekliğinde kerpiç duvarlı bir kiklopik temelden oluşmaktadır. Hem C Binası hem de D Binası şehrin güney terasında yer almaktadır. C binasında üzerinde üzerinde "Büyük Kral" yazan çivi yazılı bir balta ve mızrak uçları bulunmuştur. Ayrıca kentin D Binası'nda hem bir hanenin hem de tüm toplumun kirlenen enerjisini temizlemek, ancak özellikle kraliyet ailesini arındırmak için gerçekleştirilen "Itkalzi" adlı bir arınma ritüelinin gerçekleştiği düşünülmektedir (A. Süel 2015b, s. 102). D Binası'nın girişinde, Tanrı Teššub zırhlarıyla binaya girenleri karşılarken tasvir edilmiştir (Şekil 10).[19]

Kentin hem idari hem de dini merkez olarak önemini gösteren arkeolojik kanıtların yanı sıra, kentte bulunan 4000'den fazla tablet ve tablet parçası ile Hitit dönemine ait büyük arşiv, kentin önemine bir kanıt olarak gösterilebilir (A. Süel ve Süel 2017, s. 30).[20] Hatta kazı ekibine göre, alanda bulunan tabletler, Kral Tudhaliya III ve karısı Kraliçe Taduhepa döneminde şehrin kutsallığını hakkında kanıtlar olduğunu ifade etmişlerdir (A. Süel, 2015a, p. 101). Araştırmamda Ağılönü bölgesini tek lokasyon olmasına rağmen mekânsal işlevine göre iki farklı lokasyona ayırdım çünkü kurban törenlerinin yapıldığı ritüel alan yeri ile Tapınak alanının geri kalanı arasında bir ayrım olabileceğini düşündüm çünkü rahiplerin yaşadığı ve muhtemelen bazı sıradan yaşam aktivitelerinin de gerçekleştiği yerler ayrı, ritüel aktiviteler ayrı bir bölgede yapılmaktaydı (mekânların işleviyle ilgili ayrıntılar için 2. Bölüme bakınız). Kurban çukurlarının ortaya çıkarıldığı belirli yere 'Kurban Alanı' adı, fırın ve bazı binalar gibi

[19] Bakınız Süel, A. 2015.
[20] Sapinuwa Arşivleri için , bknz. Süel, A.,1997; Süel, A.,1998; Süel, A.,1999.

ortak alan ve yapıların keşfedildiği Tapınak alanı 'Ağılönü Alanı' olarak tanımlanmıştır. Araştırmada geometrik morfometri ve oestrometri, hem gruplar arasındaki varyasyonu tespit etmek hem de belirli bi alan içindeki hayvanların morfolojik bir farklılık gösterip göstermediğini anlamak için bu ölçüm tekniklerini ve analizleri uygulanmıştır.

Morfoloji, kemiklerin tanımlanması, adaptasyon ve türleşme için varyasyonların değerlendirilmesinde önemli noktalardan biridir. Bir organizmanın hem kalıtsal hem de gelişimsel özelliklerini içeren karmaşık bir sürecin sonucu olarak oluşur. Kemiklerdeki varyasyon hem çevresel hem de biyolojik koşullarla ilgilidir. Biyolojik varlıkların kalıtsal özellikleri olan filogeni, DNA tarafından belirlenir. Hox genleri, bir popülasyondaki bir örneğin morfolojisini yönlendirir ve herhangi bir geçerli morfolojik farklılık bu genlerin sonucudur (Burke ve diğerleri, 1995).

Omurgalıları karakterize etmek için önemli kavramlardan biri hareket davranışıdır. Hareket modları kemik eklemlenmesini ve epifiz ve diyafiz şekillerini etkiler. Örneğin; bir yandan ovicapridler hareket tarzlarına uygun uzun metapodiaları ile bilinirken, diğer yandan Ovis orientalis (yabani koyun) kısa metakarplarını sadece koşmak için değil tırmanmak için de kullanırlar (Haruda, 2014: s. 139). Ovakapridlerin hareket davranışını değerlendirerek, metapodial kemikler bir tür içindeki varyasyonu incelemek için anahtar kemiktir.

Evcilleştirmeden bu yana insan, iyi bir yün kalitesine sahip olan Merinos koyunu ve kalın kuyruklu olan Karakul koyunu gibi hayvanlardan elde edilen ürünlerin kalite ve miktarını en üst düzeye çıkarmak için kalıtsal özellikleri değiştirerek *Ovis aries* ve *Capra hircus* üzerinde kontrol sahibidir (Mason 1996). Ancak ıslah denilen bu tür bir eylem, biyolojik olarak tanımlanmış bir kelime değildir. Aynı şekilde en yakın biyolojik terim ise, çoğunlukla türün yaşadığı coğrafi bölgelere göre belirli özelliklere sahip bir grup hayvan anlamına gelen 'alttür'dür. Haruda (2014) bu terimi, morfolojik olarak bölgelere göre değişen özellikler gösterebildiği için 'yerel tür' olarak tanımlamıştır.

Bölgelere dayalı bu morfolojik farklılıklar, bir organizmanın bir yaşam süresi içindeki tüm gelişmelerini içeren ontogeniden ziyade hayvanların fenotipik özellikleri ile tanımlanmaktadır. Ayak bileği eklemindeki kemiğin morfolojisi olan Astragalus, belirli ortamlara ve coğrafi/topografik farklılıklara dayalı bu tür morfolojik farklılıkları tanımlamak için anahtar kemiklerdir. Ayak bileği eklemlerinin esnekliği ve ekozon etkisiyle oluşan fenotipik karakterler astragalus morfolojisine bakılarak anlaşılabilir. Bu araştırmada coğrafi farklılıkların neden olduğu kemik varyasyonlarını tespit etmek için ontojenik özelliklerden ziyade bu tür fenotipik özellikler analiz edilmekte ve değerlendirilmektedir.

Geometrik morfometrinin istatistiksel sonuçları, morfolojik varyasyonu yorumlamak için çok önemli bir noktadır. Daha önceki bölümlerde bahsedildiği gibi, tanımlayıcı çok değişkenli istatistiksel bir yöntem olan temel bileşenler analizi (PCA), bir hipotezle yapılmaz. Bunun yerine, ilişkisiz temel bileşenler arasındaki değişimi anlamak için uygulanır (Haruda, 2014, s. 255). Kanonik değişken analizinden (CVA) farklı olarak, grup üyeliğinin (sınıflandırıcılar) önceden belirlenmesi yapılmaz; ancak, türler arasındaki bazı grup üyeliklerini tespit etmek için yine de faydalı bir analizdir. Farklı konumlardan numuneler arasındaki ayrım, tanımlanmış gruplar dayalı ve bu grupların ortalamaları arasındaki farkı gösteren önemli bir analiz olan CVA ile daha net görülür. Öte yandan arkeoloji, paleontoloji ve jeoloji araştırmaları için de önemli bir uygulama olan diskriminant analizi, grup ilişkilerini belirlemeye yönelik kuralların üretilmesi ve gözlenmesi açısından kritik öneme sahiptir (Kovarovic ve digerleri, 2011).

CVA, Mahalanobis uzaklıklarına dayalı 1000 permütasyon ile gerçekleştirilmiş ve gruplar arası değişimi gösteren p değerleri ile sonuçlar vermiştir. CVA'da şekil uzayı, varyasyona dayalı mesafe olan Mahalanobis mesafesi ile ölçülür. Tablo 10, 11, 12'de CVA sonucu p değerleri ile verilmiştir. Hem astragalus hem de metacarpal ovicaprid numunelerinin CVA sonuçları $p \leq .05$ göstermiştir, bu da ‘null hypothesis’ sıfır hipotezinin reddedildiği anlamına gelir. Eğer bir sıfır hipotezi reddedilirse, araştırmacının verdiği hipotez doğrulanmakta olup, benim araştırmamda örneklerin üç alana dayalı olarak önemli morfolojik farklılıklar gösterdiğini öne sürmek mümkündür. Ancak metatarsal ovicaprid örnekleri için aynı sonuç çok güçlü bir şekilde görülmemektedir. O. Aries metatarsal için tek farklılık, Kurban Bölgesi-Ağılönü ve Tepelerarası-Kurban Bölgesi karşılaştırmasında görülmektedir. C. hircus metatarsal için Tepelerarası ile Kurbanlık Alan arasında p değeri $p>0.5$ elde edilmiş yani hayvanlarda morfolojik bir fark bulunmamaktadır, bu da sıfır hipotezinin reddedilemeyeceğini göstermektedir. Bu hayvanların bu bölgeleri arasında morfolojik olarak önemli bir fark olmadığı anlamına gelir. Bu sonuç, Kurban Alanındaki örneklem sayısının kısıtlı (sayıca az) olması ile ilgili olabilir. Hem astragalus hem de metakarpal ovicaprid örneklerinin CVA sonuçları, üç alan arasındaki morfolojik açıdan farklılıklar olduğunu göstermektedir. O. aries astragalus için Tepelerarası ve Kurban Alanı ile O. Aries metacarpal için Tepelerarası ve Ağılönü karşılaştırmasında anlamlı olarak sıfır hipotezinin reddi anlamına gelen $p \leq .0001$ görülmektedir. Bu, hayvan morfolojisine göre bu alanlar arasında önemli farklılıklar olduğu anlamına gelir. Başka bir deyişle, astragalus ve metatarsal ovicaprid CVA sonuçlarına göre Ağılönü, Tepelerarası ve Kurbanlık Bölgesi'nden gelen hayvanlar, şehir içinde hayvanların çoklu sürü stratejileri fikrini destekleyen morfolojik farklılıklar göstermektedir.

Hitit devletlerinde tapınakların kendilerine ait sürü ve sürülere sahip olabileceğinden bahsedilmektedir (Beckman, 1988, s. 35). Tapınak alanı olarak düşünülen Ağılönü'nün şehrin geri kalanından farklı olarak kendi hayvanlarını yetiştirmiş olmaları, Sapinuwa'nın faunal analizleri ile desteklenmektedir. Bu tezde üçüncü grup olarak tanımlanan ancak aslında Ağılönü'nde bulunan Kurbanlık Alandan çıkan kemiklerin analizlere göre, *O. aries* metatarsal sonucu dışında hayvanların farklı morfolojik karakterlerde olduğu gözlenmiştir. Bu bölgenin Ağılönü'nden farklı olarak tanımlanmasının nedeni, Kurban Alanının, kurban çukurlarının bulunduğu ve asıl ritüellerin gerçekleştiği yer olduğu düşünülmesidir. Analizler bu bölgeden ovikaprid kalıntılarının farklı bölgelerden/eyaletlerden muhtemelen kurban törenlerine adak olarak getirilmiş olabileceğini kanıtlar nitelikte sonuçlar vermekte ve yine bu durum Hitit metinleri ile de desteklenmektedir. 2. Bölümde (sayfa 8) ritüeller ve festivallerle ilgili yazılı kaynaklar, birçok sığır, koyun ve keçinin bu tür faaliyetler için farklı yerlerden belirli bir amaçla Hitit devletine gönderildiği belirtmiştir.

İncelediğim kemiklerde genel olarak çeşitlilik göstermekte olup, bu da birçok hayvan fenotipinin varlığını göstermektedir. Ayrıca bazı hayvanların belirli veriler etrafında kümeler oluşturdukları da görülmekte olup, bu kümelerin büyük olasılıkla Geç Tunç Çağı kentinde farklı sosyal statülerden olan insanların kullandığı bu üç alanın gruplarını temsil ettiği görülmektedir. Bunun en bariz kanıtı, *Ovis aries* örneklerinin analizlerinden elde edilmiştir (Şekil 8). Hititler için *Ovis aries* türünün daha önemli olduğunu bilmekteyiz, muhtemelen bu önemden dolayı *Ovis aries* türüne daha fazla ilgi göstermişler, bu hayvanların gelişimini ve ıslah çalışmalarını amaçlamış olabilirler.

Ayrıca gruplandırılmış veriler dışında herhangi bir gruba uymayan bazı aykırı 'outlier' değerlerle de karşılaşılmıştır. Tek bir yerleşim yeri içindeki GMM uygulamasında, aykırı değer olarak görülen bu tür veriler, genellikle veri setinin oluşturulduğu bölgeye özgü olmadığı şeklinde yorumlanmıştır (Haruda, 2014, s. 265). Bu aykırı değerler Sapinuva dışındaki bölgelerden getirilen hayvanlar olabilir. Bu açıklama hem Hitit tabletlerindeki ifadelerle hem de Šapinuwa bölgesindeki referans değerlerle uyuşmayan Sr değerlerine sahip hayvanların bulunmasıyla desteklenmektedir (Pişkin ve ark., 2020). *Capra hircus*'un *Ovis aries*'e göre daha fazla değişkenlik gösterdiği, daha az belirgin kümeler oluşturduğu ve Sr değerlerinin de *Ovis aries*'e göre çok daha fazla değişkenlik gösterdiği belirlendi (Pişkin ve diğerleri, 2020).

Ayrıca, Bölüm 1'de belirtildiği gibi, yerleşim yeri içindeki farklı alttürlerin/ıslah hayvanlarının varlığının belirlenmesi de diğer bir amaçtır. GMM'deki ortalama şekil (mean shape), farklı fenotiplere göre değişmektedir (Haruda, 2014, s. 265). Fenotipik farklılıklar grup varyasyonu içinde görünür olmalıdır ve bu hem PCA hem de CVA ile görülebilmektedir. Analizlerdeki gruplar/anlar içindeki bazı küçük alt kümeler, veri kümesindeki farklı hayvan alttürlerini, ıslah çalışmalarını önermektedir. Bu durum, diğer bölgelerdeki hayvanların farklı morfolojik gruplar oluşturduğunu ve tek bir alandan ve tek bir tür arasında farklı gruplaşmalar/varyasyonlar olduğunda tepit edilebilir olduğunu göstermektedir. Örneğin, Şekil 13'teki CVA sonucu grafiği (*Ovis aries* metacarpal) belirli gruplar içinde bazı farklılıklar gözlemlenmektedir. AGIL515 (AGIL763 de) diğer Ağılön veri grubundan uzakta kümelenmiştir. Aynı şekilde

TEP501 de Tepelerarası veri grubunun geri kalanından morfolojik farklılıklar göstermektedir. İlginçtir ki Şekil 12, Şekil 13, Şekil 14, Şekil 15'te Ağılönü'den alınan veriler, grup içinde geniş yayılımlı bir kümelenme sergilemekte ve Tepelerarası ve Kurban Bölgesi'nden alınan verilerden de daha geniş yayılımlı kümelenme göstermektedir. Bu, Ağılönü'nde gerçekleştirilen yerel ıslah uygulamalarının kanıtı olabilir; ancak bu sadece Şekil 10 ve Şekil 11'de görülen veriler için Ağılönü'nden gelen verilerin sınırlı olmasıyla da ilgili olabilir.

GMM dışında, her iki yöntem arasındaki farklılıkları görmek ve sonuçları karşılaştırmak için zooarkeolojik biyometri analizleri yapılmıştır. Araştırmanın hem geleneksel hem de geometrik morfometrik analiz kullanılarak yapılmasının iki ana nedeni vardır. Birinci sebep, bu iki analiz sonucunda araştırma sorularına aynı cevabı verip vermeyeceğini gözlemlemek veya sorumuza hangisinin daha belirgin bir cevap vereceğini belirlemektir. Sonuç olarak bu iki yöntemden hangisinin buna daha uygun olduğunu ortaya çıkarmaktır. İkincisi, tez hipotezimde belirttiğim gibi Hititler bir gelişmiş bir hayvancılık anlayışına sahiplerdi. Gelişmiş veterinerlik faaliyetleri nedeniyle farklı cins hayvanlar yetiştirmiş olabilecekleri düşünülmektedir. Şimdiye kadar yaptığım araştırmaların sonuçları, kurduğum hipotezin doğruluğunu teyit ediyor. Eldeki veriler, hayvan kemiklerinin yerleşmedeki alanlara göre morfolojik olarak çeşitli gruplar oluşturduğunu göstermektedir. Ağılönü ve Tepelerarası alanlarından alınan hayvan kemiklerinin analiz sonuçlarının farklı grupları içermesi, farklı alttürlere işaret edebilecek farklı fenotip özelliklerinin varlığını göstermektedir. Bu, belirttiğim hipotezi doğruladı. Ağılönü'nün bir ritüel alanı olması nedeniyle buradaki hayvanların Hitit kontrolündeki diğer yerleşim birimlerinin yanı sıra yerleşimdeki diğer bölgelerden gönderildiği analizlerdeki istatistiksel sonuçlar ile doğrulanmaktadır. Bunun yanı sıra Tepelerarası hem idari hem de atölye/işik alanıdır ve burada çalışan insanların tükettiği hayvanların kemiklerini içerir. Özetle, atölye alanından çıkarılan kemiklerin ne yüksek idari memur ne de burada çalışan rahip olmayan zanaatkarlar tarafından tüketilen artıklar olduğu ve hayvanlar olduğu için kurban alanından ve Ağılönünden çıkarılan kemiklere göre ikinci kalite hayvanlar oldukları düşünülmektedir. Kurban alanına gönderilenler tapınak (Ağılönü) tarafından birinci kalite hayvanlar olarak seçilip gönderilmiş olabilir. (A. Süel 1985).

Veriler hem PCA hem de MANOVA/CVA'da analiz edildi. Geleneksel zooarkeolojik standartlarla alınan ölçümlerle yapılan analizlerde ilk engel MANOVA/CVA'da GMM'den farklı olarak her sınıflandırıcı/grup için birden fazla veri olması zorunluluğu ile karşılaşılmıştır. İki veri setinde sadece bir örnek bulunduğundan, önceki bölümde bahsedildiği gibi hem *Ovis aries* metacarpal hem de *Capra hircus* metatarsal veri setleri bu analizin dışında tutulmuştur. Bu, geleneksel biyometrinin ana dezavantajlarıdır, GMM'den farklı olarak, analizleri yapabilmek için daha fazla veriye ihtiyacınız vardır.

Bir yandan zooarkeolojik biyometriye dayalı ölçümlerle yapılan bazı PCA sonuçları, *Ovis aries* astragalus gibi, GMM ile oldukça benzer sonuçlar gösterirken (bkz. Şekil 8 ve 20), diğer yandan PCA'nın diğer sonuçları için bu durum geçerli değildir. GMM ile gruplar içindeki kümeleri daha belirgin görülmektedir. Bununla birlikte, *Capra hircus* astragalus için geleneksel zooarkeolojik ölçümlerin sonucu, GMM'ye kıyasla iyi bir kümeleme gösteren tek istisnadır (bkz. Şekil 14 ve 26). Genel olarak, standart zooarkeolojik biyometriye (SZB) dayalı ölçümlerle gerçekleştirilen PCA sonuçları, grafiklerde hemen hemen benzer veri dağılımını göstermektedir fakat belirli gruplar içinde küçük alt kümeler görmek zordur. Yukarıda bahsedildiği gibi, bir grup içindeki alt kümeler, ilgili farklı alttürleri ve/veya ekozonları gösterebilir ve GMM bu tür kanıtları elde etmede daha başarılıdır.

Bu tezin sınırlılığı, üç bölgeden gelen dengesiz veri sayısıdır. Bu, landmarkların belirli noktalara konması için, neredeyse eksiksiz öğelere sahip olması gereken geometrik morfometrik yöntemlerle ilgilidir. Ayrıca oestrometri verileri, geometrik morfometrik veri setinden seçildiği için oldukça etkilenmiş ve eksik sayıda dataya neden olmuştur. Buna ek olarak, geleneksel ölçümlerin geometrik moprometrik olarak CVA ile karşılaştırılması için seçilen MANOVA/CVA analizi, verilerde tek bir ölçüm eksik olduğu durumlarda analiz yapılamamıştır. Son olarak, daha sonraki araştırmalar için, farklı türlerin öğrneğin at ve sığır gibi daha hareketli hayvanlara, yerel ırklarının morfolojisini anlamak için geometrik morfometrik yöntem uygulanabilir.

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