Eurasian Journal of Veterinary Sciences

www.eurasianjvetsci.org

RESEARCH ARTICLE

Determination of the correlations between the morphological characteristics and metapodial radiometric measurements of Awassi sheep

Mucahit Kahraman[1*], Ismail Demircioglu[2], Gulsah Gungoren[1], Ozan Gundemir[3], Ermis Ozkan[3], Aydin Das[1], Bestami Yilmaz[2]

[1]Harran University, Veterinary Faculty, Department of Animal Science, Şanlıurfa, Turkey
[2]Harran University, Veterinary Faculty, Department of Anatomy, Şanlıurfa, Turkey
[2]Istanbul University, Cerrahpaşa Veterinary Faculty, Department of Anatomy, İstanbul, Turkey

Received:14.04.2022, Accepted: 17.08.2022
*mucahitkahraman@harran.edu.tr

İvesi koyunların morfolojik özellikleri ile metapodial radiometrik ölçümler arası ilişkilerin belirlenmesi

Eurasian J Vet Sci, 2022, 38, 2, 180-189
DOI: 10.15312/EurasianJVetSci.2022.381

Öz

Amaç: Bu çalışmada, İvesi koyunlarına ait dış yapı özellikleriyle osteometrik verileri arasındaki korelasyonların belirlenmesi amaçlandı.

Gereç ve Yöntem: Çalışmada 100 dişi, 50 erkek olmak üzere toplam 150 baş İvesi koyun (18-20 aylık yaşta) kullanmıştır. Koyunlara ait cinsiyet, vücut ağırlığı, cidago yüksekliği, sırt yüksekliği, sağrı yüksekliği, sağrı genişliği ve sağrı uzunluğu, sternum yüksekliği, vücut uzunluğu, incik çevresi, bicostal çap, göğüs çevresi ve pelvis genişliği ölçümleri alındıktan sonra DR sistemli dijital mobil röntgen cihazı ile metapodiumların radyografileri alındı.

Bulgular: Metapodiumlara ait radyometrik ölçüm değerleri incelendiğinde; metacarpus' da GL, Bp, SD, Bd, Be, WCL; metatarsus' da ise GL, Bp, SD, Bd, Be, WCM, WCL ve CM değerleri arasında istatistiksel olarak önemli düzeyde sexuel dimorfizm belirlendi ($p < 0.001$). Metapodial radyometri ile dış yapı özellikleri arasında korelasyon incelendiğinde ön bacak için en yüksek korelasyon değeri metacarpal kemiklerin radyometri ölçümlerinden GL değeri ile dış yapı ölçüm değerlerinden sırt yüksekliği arasında bulunmuştur (r: 0.684). Arka bacak için en yüksek korelasyon değeri metatarsal kemiklerin radyometrik ölçümlerinden SD değeri ile dış yapı ölçüm değerlerinden sırt yüksekliği arasında bulunmuştur (r: 0.679).

Öneri: Gelişimini vücutta erken tamamlayan metapodiumların vücut ölçümleri arasında kuvvetli ilişkiler tespit edildi. Çalışmadan elde edilen sonuçlar büyüme ve et verimi yönünden yapılan seleksiyon çalışmalarında metapodial radyometrik özelliklerin kullanım potansiyeli olduğunu göstermektedir.

Anahtar kelimeler: Büyüme, İvesi koyunu, morfolojik özellikler, metopodium

Abstract

Aim: The study aims to determine the correlations between external structural characteristics and osteometric data of Awassi sheep.

Materials and Methods: A total of 150 heads Awassi sheep (18-20 months of age), 100 females and 50 males were used in the study. After determining the sex and measuring the body weight, wither height, ridge height, rump height, rump width and rump length, sternum height, body length, shin circumference, bicostal diameter, chest circumference and pelvis width of sheep, metapodium radiographs were taken by digital mobile X-ray device with DR system.

Results: Between the values GL, Bp, SD, Bd, Be, WCL for metacarpus and GL, Bp, SD, Bd, Be, WCM, WCL and CM for metatarsus, sexual dimorphism was statistically significant when the radiometric measurement values of the metapodiums are examined ($p < 0.001$). The highest correlation value for the front leg was found between the GL value from the radiometry measurements of the metacarpal bones and the back height from the external structure measurement values (r: 0.684) when the correlation between metapodial radiometry and external structure features were examined. The highest correlation value for the hind limb was found between the SD value from the radiometric measurements of the metatarsal bones and the back height from the external structure measurement values (r: 0.679).

Conclusion: Metapodiums, which they complete their development early in the body had strong relationships with the body measurements. The results obtained from the study show that metapodial radiometric features have the potential to be used in selection studies in terms of growth and meat yield.

Keywords: Awassi sheep, growth performance, morphological characteristics, metapodium

Introduction

Sheep were one of the first domesticated animals. It has met many vital human needs with its milk, meat, wool, skin, and manure since the beginning of civilization and continues to do so to this day. These animals have provided benefits to people in many ways for thousands of years and still contribute to human needs today with their products and economic value (Kaymakçı 2010).

Considering the geographical and climatic characteristics of Turkey, sheep farming, which has a very important role in livestock breeding, is widely carried out in almost every region of the country. Sheep species make up the majority of the animal populations grown, especially in the eastern and southeastern Anatolia region. In Turkey, sheep breeding is usually done for meat, milk, and wool production. Although product yields vary by race, they are usually low (Akçapınar and Özbeyaz 1999, Akçapınar 2000).

Awassi sheep are a combined breed of sheep named after the El Awas tribe between the Tigris and Euphrates rivers. It has a fatty tail and is given different names according to the region. The body measurements reported in Awassi sheep were mean head length 19.63±0.12, chest depth 30.35±0.11, chest width 18.73±0.10, body length 65.09±0.20, withers height 61.05±0.15, and rump height 58.77±0.16 cm (Özbeyaz et. al., 2018). This sheep has fully adapted to the harsh climatic conditions of Southwest Asia (Epstein 1982). It is the most common sheep breed of non-European origin (Galal et al 2008).

The body size of animals gives important information about their morphology. Determining the external structural characteristics of animals (withers height, ridge height, rump height, rump width and length, sternum height, body length, bicostal diameter, chest circumference, and pelvic width) is useful in determining the yield characteristics of breeds, breed registration, and genealogy log registration studies. There are significant relationships between these morphometric characteristics and body weight (Akçapınar 2000, Çankaya et al 2009).

By examining the fossil metapodium (metacarpus and metatarsus) of even-toed ungulates, such as sheep and cattle, one can obtain information about the dates of domestication of these animals and estimate the body measurements of the population at that time (Guintard and Lallemand 2003, Lallemand 2002).

There are many relationships between body measurements. In a study conducted in Uda sheep, medium and high correlations (r = 0.43-0.76; P≤0.01) were found between body weight and morphometric characteristics (chest circumference, shoulder width, rump width, body length and face length) (Yakubu, 2012). Linear body characteristics in sheep can predict live weight with 92% accuracy (Birteeb and Ozoje, 2012). By revealing the relationships between these measurements, body measurements can be estimated from the remains of the animal species living in that period (Gezer Ince et al 2019, Onar et al 2002, Onar and Belli 2005, Onar et al 2018, Reitz and Wing 2008). There are studies that estimate withers height by considering the relationship between the length of the extremity bones and the height of the animal, and one of the most important methods for this purpose is to make osteometric measurements (O'Connor 2008).

The age in which the animals will be used without any significant regression in their yield level and constitution is called the age of use in the first breeding. In general, farm animals can be used for breeding when they reach 65%-70% of the average weight of the breed they represent (Akçapınar 2000). Body morphometric characteristics are used on farms and enterprises to track the growth and development of animals. However, it is impossible to access live animal material in matters such as forensic cases and archaeological excavations. In this case, correlations between morphological characteristics and live weight are used to determine the live weight of animals. Furthermore, phenotypic correlations between morphological characteristics are widely used in livestock farming for breeding purposes (Akçapınar and Özbeyaz 1999, Akçapınar 2000). It was stated that the models created with artificial neural network models showed high correlations (r: 0.893 - 0.910) with lactation milk yield in Akkaraman sheep (Karadas et. al., 2017). A high correlation (r:0.79; p<0.05) was determined between body length and cold carcass weight in Morkaraman lambs (Yaprak et. al., 2008). The metapodium completely develops in sheep in the 20th month on average and is unaffected by growth and environmental conditions in the following periods (Silver 1963). The present study was carried out to determine the correlations between external structural characteristics and osteometric data using metapodial radiography and to examine the use of these correlations for selecting animals for breeding. Metapodial bones are long bones that fuse with each other in the early period in ungulates. These bones of III and IV. metacarpal and metatarsal bones ossify with each other to form carrier metapodiums. In addition to these carrier metacarpals in the front leg, II. and V. metacarpals, on the hind leg II. metatarsal bone is secondary or secondary (Bahadır and Yıldız, 2016; Demircioğlu and Gezer İnce, 2020).

Material and Methods

In this study, 150 Awassi sheep (100 females and 50 males) kept in the Harran University Animal Experiment Application and Research Center/Farm Animals Unit were used. The sheep used in the study were in the age range of 18-20 months. Sex, live weight, height at withers, back height, rump height and length, sternum height, body length, shank circumference, bicostal diameter, chest circumference, and pelvic width were measured (Figure 1). A digital mobile X-ray device with DR system (Hasvet 838 HF50 Protable X-ray Veterinary System, Turkey, 70 kv, 30 mas) was used to obtain the X-ray of the metapodium of the right and left legs (metacarpus and metatarsus) (Figure 1). A measuring strip (Hauptner, Germany) was used to determine morphological measurements. There are differences in the number of animals in the tables because the radiographic images are not used in the software that are not suitable for measurement.

Firstly, normality (Shapiro-Wilk test) and homogeneity (Levene test) tests were applied to the data obtained from the research. After normality and homogeneity of the data were checked, Independent-Sample T Test was performed for metacarpus and metatarsus to determine the differences between male and female animals. All results were analyzed by the Pearson Correlation test using SPSS version 22 data analysis software.

Morphometric measurements taken from radiography images of Awassi sheep (Gündemir 2020, Gürbüz 2018, Pazvant et al 2015, Onar et al 2008, Von den Driesch 1976) (Figure 2):

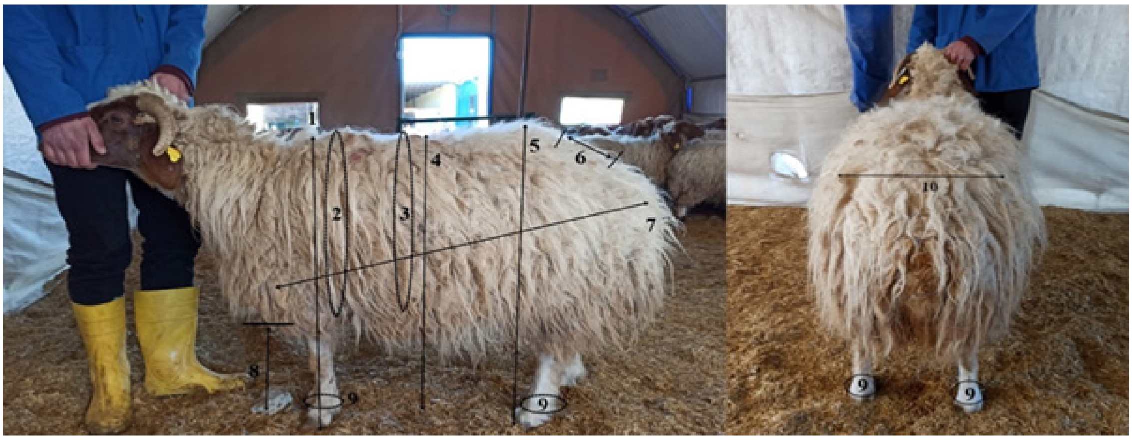

Figure 1. The regions where external structure measurements were taken in Awassi sheep. 1: Wither Height, 2: Chest Circumference, 3: Bicostal Diameter, 4: Ridge Height, 5: Rump Height, 6: Rump Length, 7: Body Length, 8: Sternum Height, 9: Shin Circumference, 10: Pelvis Width

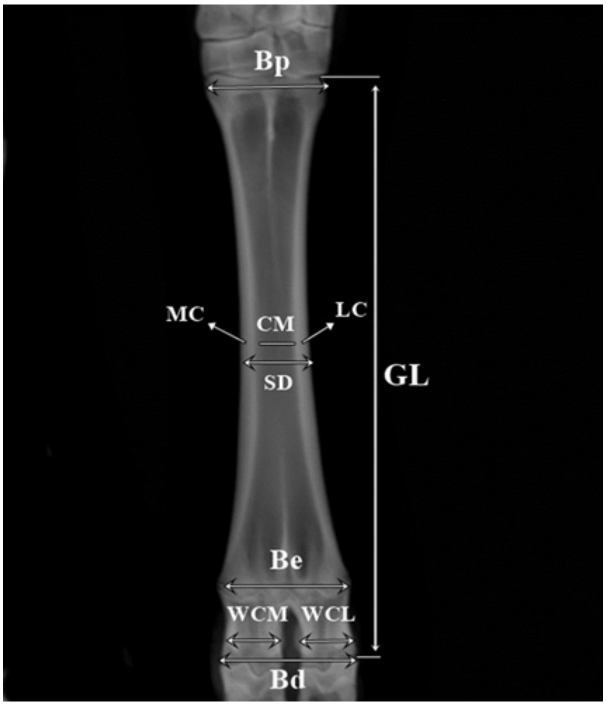

Figure 2. Morphometric measurement points taken on metapodial radiography images (Laterolateral exposure)

GL: Maximum length

Bp: Width of proximal tip

SD: Smallest width of the diaphysis

Bd: Maximum width of the distal tip

Be: Maximum width of metaphysis

WCM: Mediolateral width of medial condylus

WCL: Mediolateral width of lateral condylus

MC: Medial cortex width at the midpoint of the diaphysis

LC: Lateral cortex width at the midpoint of the diaphysis

CM: Mediolateral cavum medullare width at the midpoint of diaphysis

External structural measurements of the sheep (Akçapınar and Özbeyaz 1999, Akçapınar 2000, Akçapınar et al 2000, Kul 2002, Koncagül 2012) (Figure 1):

Wither Height (1): It is the vertical distance from the highest point of withers to the ground.

Chest Circumference (2): Circumference measurement taken right behind the scapula.

Bicostal Diameter (3): Distance between the two arcus costa from the dorsal plane.

Ridge Height (4): Vertical distance from the last ridge vertebrae protrusion to the ground.

Rump Height (5): Vertical distance from the highest point of the sacrum to the ground.

Rump Length (6): Length between the cranial point of os coxae and the caudal point of tuber ischii.

Body length (7): Distance between articulatio humeri and tuber ischii.

Sternum Height (8): Vertical distance of the manibrum sternum to the ground.

Shin Circumference (9): Circumferential length of metapodium.

Pelvic Width (10): Distance between the outermost extrusions of tuber coxae.

Table 1. Means and standard deviations of metacarpus measurement values

Metacarpus (mm)	Sex	N	Mean±SEM	Minimum	Maximum	p
GL	Male	100	143.23±0.83	115.00	160.70	***
	Female	200	136.72±0.59	111.50	162.50	
Bp	Male	100	27.52±0.20	21.10	32.00	***
	Female	200	26.20±0.15	18.70	33.50	
SD	Male	100	15.38±0.14	11.10	18.90	***
	Female	200	14.69±0.11	8.90	18.70	
Bd	Male	100	31.18±0.19	25.80	36.20	***
	Female	200	29.91±0.15	23.00	35.20	
Be	Male	100	28.92±0.23	22.90	33.70	***
	Female	200	27.39±0.15	19.00	32.30	
WCM	Male	98	13.45±0.10	11.10	16.00	NS
	Female	192	13.19±0.08	9.10	15.80	
WCL	Male	98	13.33±0.11	10.70	16.10	***
	Female	192	12.78±0.09	9.50	16.00	
MC	Male	100	3.15±0.07	1.60	4.90	NS
	Female	200	3.01±0.04	1.10	4.60	
CM	Male	100	9.11±0.13	6.10	11.50	**
	Female	200	8.69±0.10	5.20	12.50	
LC	Male	100	3.18±0.06	1.80	4.90	NS
	Female	200	3.09±0.04	1.60	4.50	

**: $p<0.01$; ***: $p<0.001$; NS: No Significant

Results

The difference in metacarpus and metatarsus measurement values between male and female animals is shown in Table 1 and Table 2. According to Table 1, a significant difference was found between GL, Bp, SD, Bd, Be, and WCL values ($p < 0.001$), a significant difference was found between CM values ($p < 0.01$), and no significant difference was found between WCM, MC, and LC values. As seen in Table 2, a significant difference was found between GL, Bp, SD, Bd, Be, WCM, WCL, and CM values ($p < 0.001$), whereas no difference was found between MC and LC values. The mean value of metacarpi and metatarsi measurements was higher in males than in females. Homotypic variations of the data are given in Table 3. WCM and LC values of metacarpus measurement values showed homotypic variation at the $p < 0.01$ level. Homotypic variation was found between WCM and LC values in metatarsus measurement values at the $p < 0.05$ level, and no homotypic variation was observed in other parameters ($p > 0.05$).

The correlations between metacarpus and metatarsus radiometric measurement values and external structural measurement values are given in Table 4 and Table 5. The highest correlation for the front leg was found between the GL value of the metacarpal bones and ridge height (r: 0.684). The highest correlation for the hind leg was found between the SD value of the metatarsal bones and ridge height (r: 0.679).

Table 2. Means and standard deviations of metatarsus measurement values

Metatarsus (mm)	Sex	N	Mean±SEM	Minimum	Maximum	p
GL	Male	100	150.12±0.96	118.60	170.60	***
	Female	197	143.98±0.70	97.80	173.70	
Bp	Male	100	24.44±0.17	19.40	29.60	***
	Female	197	23.39±0.13	18.90	23.65	
SD	Male	100	13.70±0.14	10.20	18.10	***
	Female	193	13.09±0.10	8.20	16.60	
Bd	Male	98	29.90±0.20	24.70	34.30	***
	Female	194	28.33±0.14	21.50	33.00	
Be	Male	100	27.01±0.21	21.00	31.70	***
	Female	194	25.67±0.15	19.30	32.20	
WCM	Male	94	13.19±0.12	9.50	15.50	***
	Female	190	12.68±0.08	9.30	15.20	
WCL	Male	94	12.38±0.12	9.00	14.70	***
	Female	190	11.83±0.09	8.10	14.60	
MC	Male	100	3.13±0.07	1.20	4.70	NS
	Female	193	2.99±0.04	1.30	4.70	
CM	Male	100	7.48±0.10	5.10	10.40	***
	Female	193	7.10±0.08	4.90	10.90	
LC	Male	100	3.20±0.07	1.70	5.50	NS
	Female	193	3.15±0.04	1.70	4.70	

***:p<0.001; NS: No Significant

Table 3. Values of metapodial bones between right and left samples

Metacarpus (mm)					Metatarsus (mm)			
		N	Mean±SEM	p		N	Mean±SEM	p
GL	FL	150	138.83±0.72	0.91	HL	149	145.71±0.83	NS
	FR	150	138.95±0.74		HR	148	146.38±0.84	
Bp	FL	150	26.54±0.18	0.41	HL	149	23.54±0.15	NS
	FR	150	26.75±0.18		HR	148	25.45±1.51	
SD	FL	150	14.78±0.13	0.12	HL	147	13.18±0.12	NS
	FR	150	15.06±0.13		HR	146	13.41±0.12	
Bd	FL	150	30.17±0.17	0.19	HL	146	28.69±0.18	NS
	FR	150	30.50±0.17		HR	146	29.03±0.17	
Be	FL	150	27.94±0.17	0.73	HL	147	25.94±0.17	NS
	FR	150	27.85±0.20		HR	147	26.31±0.19	
WCM	FL	146	13.12±0.09	0.01	HL	141	12.70±0.10	*
	FR	144	13.44±0.09		HR	143	13.00±0.09	
WCL	FL	146	13.03±0.10	0.41	HL	141	12.09±0.11	NS
	FR	144	12.90±0.11		HR	143	11.93±0.10	
MC	FL	150	3.01±0.05	0.20	HL	147	2.97±0.05	NS
	FR	150	3.10±0.05		HR	146	3.10±0.05	
CM	FL	150	8.87±0.11	0.65	HL	147	7.24±0.09	NS
	FR	150	8.79±0.12		HR	146	7.21±0.09	
LC	FL	150	3.02±0.05	0.01	HL	147	3.09±0.05	*
	FR	150	3.22±0.05		HR	146	3.24±0.05	

*: p<0.05; NS: No Significant

Table 4. Correlation of metacarpus (mm) values to body measurements (cm)

	Live Weight	Wither Height	Ridge Height	Body Length	Rump Height	Rump Width	Rump Length	Pelvis Width	Sternum Height	Bicostal Diameter	Chest Circumference
GL	0.477**	0.675**	0.684**	0.503**	0.665**	0.403**	0.435**	0.506**	0.462**	0.460**	0.513**
Bp	0.475**	0.479**	0.563**	0.461**	0.522**	0.406**	0.414**	0.391**	0.309**	0.433**	0.446**
SD	0.637**	0.595**	0.656**	0.626**	0.633**	0.541**	0.519**	0.560**	0.308**	0.597**	0.622**
Bd	0.308**	0.346**	0.417**	0.263**	0.402**	0.259**	0.356**	0.260**	0.217**	0.318**	0.305**
Be	0.175**	0.249**	0.307**	0.147*	0.297**	0.229**	0.288**	0.183**	0.231**	0.179**	0.192**
WCM	0.275**	0.259**	0.260**	0.239**	0.254**	0.299**	0.281**	0.192**	0.047	0.291**	0.253**
WCL	0.268**	0.278**	0.285**	0.233**	0.292**	0.255**	0.355**	0.159**	0.104	0.324**	0.251**
MC	0.482**	0.357**	0.362**	0.403**	0.387**	0.404**	0.233**	0.321**	0.065	0.479**	0.457**
CM	0.294**	0.368**	0.438**	0.355**	0.397**	0.241**	0.391**	0.309**	0.311**	0.262**	0.275**
LC	0.470**	0.317**	0.325**	0.380**	0.349**	0.377**	0.219**	0.278**	0.014	0.443**	0.449**

*. Correlation is significant at the 0.01 level

. Correlation is significant at the 0.05 level

Tablo 5. Correlation of metatarsus values to body measurements

	Live Weight	Wither Height	Ridge Height	Body Length	Rump Height	Rump Width	Rump Length	Pelvis Width	Sternum Height	Bicostal Diameter	Chest Circumference
GL	0.494**	0.590**	0.616**	0.466**	0.614**	0.400**	0.384**	0.538**	0.311**	0.531**	0.535**
Bp	0.057	0.039	0.055	0.063	0.064	0.039	0.003	0.032	-0.027	0.089	0.068
SD	0.600**	0.635**	0.679**	0.643**	0.676**	0.484**	0.533**	0.547**	0.342**	0.534**	0.557**
Bd	0.404**	0.407**	0.473**	0.393**	0.437**	0.362**	0.381**	0.309**	0.190**	0.357**	0.388**
Be	0.133*	0.115*	0.114	0.102	0.117*	0.068	0.021	0.035	0.025	0.121*	0.129*
WCM	0.326**	0.292**	0.279**	0.285**	0.290**	0.292**	0.263**	0.226**	0.044	0.304**	0.314**
WCL	0.359**	0.406**	0.404**	0.289**	0.414**	0.358**	0.366**	0.261**	0.095	0.377**	0.338**
MC	0.576**	0.418**	0.409**	0.419**	0.421**	0.495**	0.280**	0.360**	-0.063	0.512**	0.528**
CM	0.141*	0.277**	0.339**	0.298**	0.351**	0.098	0.280**	0.263**	0.415**	0.112	0.124*
LC	0.510**	0.402**	0.383**	0.388**	0.385**	0.450**	0.293**	0.358**	-0.018	0.486**	0.514**

**. Correlation is significant at the 0.01 level

*. Correlation is significant at the 0.05 level

Discussion

Sheep are used for a variety of human needs, including meat, milk, and wool. In this regard, sheep have lived alongside humans in many parts of Europe for centuries and have witnessed many historical changes (Bläuer et al 2019, Rannamäe et al 2016). To document this change, body measurements are estimated using osteometric measurements of osteoarcheological materials. There are different formulas used in the body measurement estimation for this purpose. It is especially important to ensure these formulas are applicable to sheep with varying yield characteristics and breeding conditions. In this study, the external structural characteristics of Awassi sheep were measured and metapodial radiometry was used to investigate which of the existing formulas produced accurate results. In addition, it was also investigated whether the formula best suited to the sheep breed in question could be used to select early breeders. When the existing in Kıvırcık sheeps formulas and the formula of Gezer İnce et al (2019) were used to estimate height at withers, the most accurate data were obtained in male metacarpi ([maximum length of metacarpi*0.331] + [SD*1.851] – 6.831), ([maximum length of metatarsi* 0.327] + [SD*2.304] –11.935).

Osteometry is the most commonly used method of gender determination (Steyn 2009, Torimitsu et al 2015). Determining sexual dimorphism in species using osteometry is important for veterinary forensic sciences, zooecology, re-identification, and clinical sciences. In the present study, statistically significant sexual dimorphism was determined in GL, Bp, SD, Bd, Be, WCL values of the metacarpus, and CM value ($p < 0.01$, $p < 0.001$). There was no statistical difference among the WCM, MC, and LC values ($p > 0.05$). In a study performed on Masham sheep, Bacınoğlu (2006) reported that there was no statistical difference in the GL value of the metacarpus between males and females, but sexual dimorphism was determined for other values (Bp, SD, Bd, Be, WCL, and WCM) ($p < 0.001$). For metatarsus data, no significant difference was found in GL value, but sexual dimorphism was determined in Bp, Bd, SD, Be, WCM, and WCL values ($p < 0.001$). In their study on Kosovo Bardhoka sheep, Gündemir et al (2020) reported that sexual dimorphism was observed in GL and Bp values ($p < 0.01$) and in SD, Bd, Be, WCM, and WCL values ($p < 0.001$) of the metacarpus. In metatarsal data, sexual dimorphism was observed in GL, SD, and WCL values ($p < 0.01$) and in Bp, Bd, Be, and WCM values ($p < 0.001$). In their study on the metapodia of Morkaraman and Tuj sheep, Demiraslan et al (2015) reported that the effects of GL, Bp, SD, GL, Bd, Be, WCM, and WCL values of metacarpi and of GL, Bp, SD, Bd, Be, and WCM values of metatarsi had a statistically significant effect on dimorphism ($p < 0.05$). In Tuj sheep, WCM and WCL values of metacarpi and only SD values of metatarsi had a significant effect on dimorphism ($p < 0.05$).

Homotypic variations are asymmetric and are caused by the internal and external effects on bones during growth (Nandi et al 2018). Severe problems may arise if homophobic variations between bones are not considered in studies and operations. In the present study, when homotypic variations of metapodia in Awassi sheep were examined, a statistically significant difference was found in both WCM and LC values ($p < 0.05$). No significant difference was found among other data ($p > 0.05$). In their study on Masham sheep, Bacinoğlu (2006) reported that homotypic variation was not observed in any of the metapodia data.

When wither height estimation formulations were taken into account, it was concluded that all formulas could be used in Awassi sheep, a combined breed, and the most accurate one was found to be the formula reported by Gezer et al (2019) on Masham sheep. In addition, strong correlations were detected between body measurements of metapodia that had completed their development early. Morphological characteristics form the phenotypic profile of sheep species (Pourlis 2011). Body structure greatly affects the market value in sheep sales in traditional markets (Price 2020). Shoulder height, body length, ridge circumference, and chest circumference are the most important sources of variation in live weight (Pourlis 2011). There is a strong positive correlation between body length (r: 0.79), chest circumference (r: 0.66), and cold carcass weight in 8 months of age Morkaraman lambs (Yaprak et al 2008). Although weak, there are significant phenotypic correlations between morphological characteristics (live weight) and wool yields (Akraim et al 2008). The correlation values between body weight and body measurements (chest depth, chest width, body length, rump height) ranged from 0.13 to 0.77 in karayaka lambs aged between 8-18 months (Cam et. al., 2010). In a study conducted with Mehrbani, Zandi, Shaal and Macoeip sheep reared in Iran, withers height, chest girth, body length and hip width were also significantly related to body weight in all four breeds. It has been reported that the feature with the highest correlation (0.95) with body weight is body length (Shirzeyli et. al., 2013). The correlations between scrotal circumference linear measurements, body weight (r: 0.83), and height at withers (r: 0.85) in rams (Mukasa-Mugerwa and Ezaz 1992) reveal the effect of morphological characteristics on reproductive performance. The correlations between the morphological characteristics and rodometric parameters determined within the scope of the present study show the potential of radiometric measurements in the evaluation of yield characteristics. We believe that by conducting further extensive studies, metapodial radiometry can be used in the selection of breeders, especially in terms of meat yield.

Imaging techniques are used in animal breeding, as well as in animal health, forensic events and archaeological excavations. Ultrasound and infrared imaging systems have been used for a long time to determine meat and product quality. With the help of the results obtained by these methods, selection of breeders and the growth of fat, muscle and other tissues are determined by selection in the early stages of live animals (Şireli, 2018). The results we obtained from the study reveal that osteometric findings have similar results with other imaging techniques, especially in terms of meat yield. It is a costly practice to have an x-ray device in every animal breeding enterprise, but the use of radiometric osteometry can be recommended in enterprises with intensive production, especially for the features determined after slaughter.

Conclusion

In conclusion, in the present study, significant differences were found between sex groups in terms of metapodial radiometric parameters in Awassi sheep. Significant correlations were found between osteometric findings with body weight and morphometric characteristics. Metapodial radiometric data of Awassi sheep obtained in this study will serve as a reference for future research in various fields, such as osteo-archaeology, surgery, and anatomy, by helping in the creation of an osteometric database, as well as evaluation of meat yield.

Conflict of Interest

The authors did not report any conflict of interest or financial support.

Funding

This study was supported by the Scientific Research Projects Coordination Unıt, Harran University (Project Number: 20082).

References

Akçapınar H, 2000. Koyun Yetiştiriciliği, İsmat Matbaacılık, 2. Baskı, Ankara, Türkiye; pp; 2-9.

Akçapınar H, Özbeyaz C, 1999. Hayvan Yetiştiriciliği Temel Bilgiler, 1. Baskı, Kariyer Matbaacılık, Ankara, Türkiye; pp; 27-30.

Akraim F, Milad IS, Abdulkarim AA, Ganem M, 2008. Wool characteristics of Libyan Barbary sheep in north-eastern Libya: I. fiber diameter and staple length. Livest Res Rural Dev, 20(8), 1-4.

Bacınoğlu D, 2006. Kıvırcık ırkı koyunlarda metapodium'ların morfometrik ve stereolojik metodlarla incelenmesi. Doktora Tezi. İstanbul Üniversitesi Sağlık Bilimleri Enstitüsü, İstanbul.

Bahadır A, Yıldız H, 2016. Veteriner Anatomi Hareket Sistemi ve İç organlar, 7. Baskı. Ezgi Kitabevi, Bursa, Türkiye; 35-40.

Birteeb PT, Ozoje MO, 2012. Prediction of live body weight from linear body measurements of west African long-legged and west African dwarf sheep in northern Ghana. Online Journal of Animal and Feed Research, 2(5), 427-434.

Bläuer A, Harjula J, Helamaa M, Lehto H, et al., 2019. Zooarchaeological evidence of large-scale cattle metapodial processing in the 18th century in the small town of Rauma, Finland. Post-Mediev Archaeol, 53(2), 172-185.

Cam MA, Olfaz M, Soydan E, 2010. Body measurements reflect body weights and carcass yields in Karayaka sheep. Asian J Anim Vet Adv, 5(2), 120-127.

Çankaya S, Altop A, Kul E, Erener G, 2009. Faktör analiz skorları kullanılarak Karayaka kuzularında canlı ağırlık tahmini. ANAJAS, 24(2), 98-102.

Demiraslan Y, Gürbüz I, Aslan K, Akbulut Y, 2015. The stereological and morphometrical analysis of metapodium in Tuj and Morkaraman sheep. ARC J Anim Vet Sci, 1(1), 12-23.

Demircioğlu İ and Gezer İnce N, 2020. Three-dimensional modelling of computed tomography images of limb bones in gazelles (Gazella subgutturosa), Anat Histol Embryol, 49(6), 695-707.

Driesch Von den A, 1976. A guide to the measurements of animal bones from archaeological sites. Peabody museum bulletin, 1, 1-136.

Epstein H, 1982. Awassi sheep. Wld Anim Rev, 44(1), 10-27.

Galal S, Gürsoy O, Shaat I, 2008. Awassi sheep as a genetic resource and efforts for their genetic improvement. Small Ruminant Res, 79(2-3), 99-108.

Gezer İnce N, 2019. Koyunlarda metapodial radiogrammetrik yöntemle cidago yüksekliği ve vücut ağırlığı tahmin hesaplamaları, TUBİTAK 1002 (2170363), Proje Kapatma Raporu.

Guintard C, Lallemand M, 2003. Osteometric study of metapodial bones in sheep. Ann. Anat, 185, 573-583

Gündemir O, Pazvant G, Jashari T, Dayan MO, 2020. A morphometrıc study of metapodıum in bardhoka sheep. RAVS, 4(1),30-38.

Gürbüz İ, Demiraslan Y, Kırbaş G, Aslan K, 2018. Hemşin koyunlarında metapodiumların morfometrik ve stereolojik incelenmesi. MAKÜ Sag Bil Enst Derg, 6(1), 1-14.

Karadas K, Tariq M, Tariq MM, Eyduran E 2017. Measuring Predictive Performance of Data Mining and Artificial Neural Network Algorithms for Predicting Lactation Milk Yield in Indigenous Akkaraman Sheep. Pakistan Journal of Zoology, 49(1), 1-7.

Kaymakçı M, 2010. İleri Koyun Yetiştiriciliği, Meta Basım Matbaacılık, Genişletilmiş 3. Baskı, İzmir, Türkiye; pp; 1-5.

Koncagül S, Akça N, Vural ME, Karataş A, et al., 2012. Zom koyunlarının morfolojik özellikleri. Kafkas Univ Vet Fak Derg, 18(5), 829-837.

Kul S, Akcan A, 2002. İvesi ve Ost-Friz x İvesi Melez (F1) Kuzularda büyüme, yaşama gücü ve bazı vücut Ölçüleri. Uludağ Univ J Fac Vet Med, 21, 109-114.

Lallemand, M, 2002. Etude osteometrique de metapodes de mouton (Ovis aries,L). PhD Thesis, Ecole Nationale Veterinaire de Nantes, Nantes.

Mukasa-Mugerwa E, Ezaz Z, 1992. Relationship of testicular growth and size to age, body weight and onset of puberty in Menz ram lambs. Theriogenology, 38(5), 979-988.

Nandi ME, Olabiyi OA, Okubike EA, Iheaza EC, 2018. A study of bilateral asymmetry of upper extremities and its effects on stature reconstruction amongst Nigerians. AJFSFM, 1(8), 978-988.

O'Connor T, 2000. The archaeology of animal bones, Texas A&M University Press. Texas, USA, pp; 22-23.

Onar V, Armutak A, Belli O, Konyar E, 2002. Skeletal remains of dogs unearthed from the Van-Yoncatepe necropolises. Int J Osteoarchaeol, 12, 317-334.

Onar V, Belli O, 2005. Estimation of shoulder height from long bone measurements on dogs unearthed from the Van-Yoncatepe early Iron Age necropolis in Eastern Anatolia. Revue Méd Vét, 156, 53-60.

Onar V, Kahvecioğlu KO, Erdikmen DO, Alpak H, et al., 2018. The estimation of withers height of ancient horse: New estimation formulations by using the metacarpal measurements of living horse. Revue Méd Vét, 169, 157-165.

Onar V, Pazvant G, Belli O, 2008. Osteometric examination of metapodial bones in sheep (Ovis aries L.) and goat (Capra hircus L.) unearthed from the Upper Anzaf Castle in Eastern Anatolia, Revue Méd Vét, 159(3), 150-158.

Özbeyaz C, Bilgiç ÖF, Kocakaya A, Ünal N, 2018. Eskişehir de Yetiştirici Koşullarındaki İvesi Koyunlarında Bazı Özelliklerin İncelenmesi. Lalahan Hay Araşt Enst Derg, 58(1), 1-6.

Pazvant G, Onar V, Alpak H, Gezer Ince N, et al., 2015. Osteometric examination of metapodial bones in sheep (Ovis aries L.) and goat (Capra hircus L.) unearthed from the Yenikapı Metro and Marmaray excavations in Istanbul. Kafkas Univ Vet Fak Derg, 21, 147-153.

Pourlis AF, 2011. A review of morphological characteristics relating to the production and reproduction of fat-tailed sheep breeds. Trop Anim Health Prod, 43(7), 1267-1287.

Price MA, 2020. Development of carcass grading and classification systems, In: Quality and grading of carcasses of meat animals, ed; Morgan Jones, SD, CRC Press, Florida, USA, pp; 173-199.

Rannamäe E, Lõugas L, Niemi M, Kantanen J, et al., 2016. Maternal and paternal genetic diversity of ancient sheep in Estonia from the Late Bronze Age to the post-medieval period and comparison with other regions in Eurasia. Anim Genet, 47(2), 208-218.

Reitz EJ, Wing ES, 2008. Zooarchaeology, Cambridge University Press, Cambridge, United Kingdom, pp; 274-275.

Shirzeyli FH, Lavvaf A, Asadi A, 2013. Estimation of body weight from body measurements in four breeds of Iranian sheep. Songklanakarin Journal of Science & Technology, 35(5), 507-511.

Silver IA, 1963. The ageing of domestic animals. In science in archaeology, In: A survey of progress and research, ed; Don Brothwell and Eric Higgs, Basic Books, New York USA, pp; 252-253

Steyn M, Patriquin ML, 2009. Osteometric sex determination from the pelvis— Does population specificity matter? Forensic Sci Int, 191(1–3), 113.e1-113.e5.

Şireli HD, 2018. Karkaslarda et kalitesinin belirlenmesinde kullanılan geleneksel yöntemler ve yeni teknikler. DUFED, 7(3), 126-132.

Torimitsu S, Makino Y, Saithoh H, Sakuma A, et al., 2015.

Morphometric analysis of sex differences in contemporary Japanese pelves using multidetector computed tomography, Forensic Sci Int, 257, 530.e1- 530.e7.

Yaprak M, Koycegiz F, Kutluca M, Emsen E, et al., 2008. Canonical correlation analysis of body measurements, growth performance and carcass traits of Red Karaman lambs. J Anim Vet Adv, 7(2), 130-136.

Yakubu A 2012. Application of regression tree methodology in predicting the body weight of Uda sheep. J Anim Sci Biotechnol, 45(2), 484-490.

Author Contributions

Motivation / Concept: Mücahit Kahraman, İsmail Demircioğlu
Design: Mücahit Kahraman, İsmail Demircioğlu
Control/Supervision: Aydın Daş, Bestami Yılmaz
Data Collection and / or Processing: Mücahit Kahraman, İsmail Demircioğlu, Gülşah Güngören
Analysis and / or Interpretation: Mücahit Kahraman, İsmail Demircioğlu
Literature Review: İsmail Demircioğlu, Gülşah Güngören
Writing the Article: Mücahit Kahraman, İsmail Demircioğlu
Critical Review: Ozan Gündemir, Ermiş Özkan

Ethical Approval

Harran University Experimental Research and Application Center, Animal Experiments Ethics Committee 13.07.2020, 2020/003/01-12 Number Ethics Committee Decision.

CITE THIS ARTICLE: *Kahraman M, Demircioglu I, Gungoren G, Gundemir O, et al, 2022. Determination of the correlations between the morphological characteristics and metapodial radiometric measurements of Awassi sheepEurasian J Vet Sci, 38, 3, 248-254.*