Institute of Experimental Morphology, Pathology and Anthropology with Museum
Bulgarian Anatomical Society

Acta morphologica et anthropologica, 29 (1-2)
Sofia ● 2022

Morphological and Craniometrical Studies on the Skull of the South Karaman Sheep

Zekeriya Özüdoğru[1], Dervis Özdemir[2], Bumin Emre Teke[3], Mesut Kirbas[3]*

[1] Balikesir University, Faculty of Veterinary Medicine, Department of Anatomy, Balıkesir, Turkey
[2] Atatürk University, Faculty of Veterinary Medicine, Department of Anatomy, Erzurum, Turkey
[3] Bahri Dagdas International Agricultural Research Institute, Konya, Turkey.

*Corresponding author e-mail: dozdemir2544@hotmail.com, dozdemir@atauni.edu.tr

In this study, it was aimed to determine the craniometric measurements of the skull of the South Karaman sheep breed and to reveal the differences between them and other sheep breeds. The skull length was 238.37±4.18, the frontal width (ectorbitale – ectorbitale), which is the widest part of the skull was 115.75 ± 4.45. The distance between the supraorbitales was determined to be 50.01±3.94. There is a strong negative correlation between L9 (akrokranio – bregma) and L14 (greatest length of the lacrimal (most lateral point of the lacrimal – the most oral point of the lacrimo-maxillary suture) and positive correlation was found among other features. As a result, it is thought that the difference between the craniometric values of the South Karaman sheep, which are accepted as the native breeds of Turkey in the study, and other sheep breeds, depending on the skull morphology, may be due to the breed of the sheep.

Keywords: craniometrical, morphology, skull, south Karaman

Introduction

The size of the skull can provide valuable information about changes in the breed over time [5, 8]. Therefore, it was noted that the differences in races were found in the head of the animal, and it was reported that the differences in skull level defined a species more than those found in the rest of the skeleton [2, 22]. Thus, craniocephalic topography provides topometric data that facilitates sex discrimination [14].

Morphometric analysis is a preferred method in zoo archaeological studies, osteological evaluations, to reveal shape differences due to internal and external factors and differences between sexes [4].

Many authors have used the geometric dimensions of the skull bones of small ruminants for species identification [11, 23, 25, 27]. Kaymakci [12] states that there are many types of Akkaraman race and the variety called “South Karaman” is found in the foothills of the Taurus Mountains facing Central Anatolia. He reported that the breed, which is grown in the Taurus Mountains, is highly productive in terms of meat

and milk, and is among the most preferred species in aquaculture, with its resistance to environmental conditions.

The Southern Karaman Sheep are small in general appearance, have white, gray, brown and mottled colours, the males are horned, the females are generally hornless and have a fat tail [18, 21].

To date, some studies on craniometric measurements Tuj and morkaraman sheep [19], Hemşin sheep [6], Suffolk Down Sheep [3], Kosava's Barkhoka sheep) [7], Zell sheep [13] although no craniometric studies were found on the South Karaman sheep breed, this study was concerned with the head structure of Turkey's native sheep breed, which is common in the Mediterranean region.

Materials and Methods

Material

In the study, eight South Karaman sheep (male) skulls, ranging in weight from 38-56 kg, obtained from Bahri Dagdas International Agricultural Research Institute were used. After the animals were duly slaughtered, the skulls were subjected to maceration. Measurements were made using Mitutoyo digital caliper from 46 points on the skull of the South Karaman sheep. The anatomical terms used were based on Nomina Anatomica Veterinaria [16]. This study was approved by the Experimental Animals Ethics Committee of Atatürk University (Ethical number: 23.10.2015, 8/148).

The following measurements by using definitions of measuring points [6, 7, 17, 19, 20] on the cranium were made:

L1. profile length (akrokranion – prosthion),
L2. condylobasal length,
L3. basal length (basion – prosthion),
L4. short skull length (basion premolare),
L5. premolare – prosthion,
L6. ossa cranii length (basion – nasion),
L7. ossa faciei length (nasion prosthion),
L8. median frontal length (akrokranion – nasion),
L9. akrokranion - bregma,
L10. frontal length (bregma – nasion),
L11. upper ossa cranii length: Akrokranion – supraorbitale,
L12. facial length (supraorbitale – prosthion),
L13. Akrokranion-infraorbitale of one side,
L14. greatest length of the lacrimal (most lateral point of the lacrimal – the most oral point of the lacrimo-maxillary suture,
L15. greatest length of the nasals (nasion-rhinion),
L16. short lateral facial length (entorbitale – prosthion),
L17. from the aboral border of one occipital condyle to the infraorbitale of the same side,
L18. dental length (postdentale – prosthion),
L19. oral palatal length (palatinoorale – prosthion),

L20. lateral length of the premaxilla (nasointermaxillare – prosthion),
L21 length of the cheektooth row (measured along the alveoli),
L22. length of the molar row (measured along the alveoli on the buccal side),
L23. length of the premolar row (measured along the alveoli on the buccal side),
L24. zygomatic width (the distance between two zygomatic arches),
L25. greatest inner length of the orbit (ectorbitale – entorbitale),
L26. greatest inner height of the orbit (measured in the same way as measurement),
L27. greatest mastoid breadth (otion – otion),
L28. greatest breadth of the occipital condyles,
L29. greatest breadth at the bases of the paraoccipital processes,
L30. greatest breadth of the foramen magnum,
L31. eight of the foramen magnum (basion – opisthion),
L32. least breadth of parietal: Least breadth between the temporal lines,
L33. greatest ossa cranii Breadth-Greatest breadth of the braincase (euryon – euryon),
L34. least breadth between the orbits (entorbitale – entorbitale),
L35. greatest breadth across the orbit-greatest frontal breadth-greatest breadth of skull (ectorbitale – ectorbitale),
L36. facial breadth (breadth across the facial tuberosities),
L37. greatest breadth across the nasals,
L38. greatest breadth across the premaxillae,
L39. greatest palatal breadth (measured across the outer borders of the alveoli),
L40. the distance from infraorbital foramen to facial tuberosity,
L41. the distance from facial tuberosity to root of alveolar tooth,
L42. distance between first premolar teeth,
L43. distance between first molar teeth,
L44. distance between the last molar teeth,
L45. distance from orbital arcus,
L46. supraorbital foramina distance.

Craniofacial indices [19]**:**

I1. Nasal index: greatest breadth across the nasals x 100/ greatest length of the nasals
I2. Facial index: zygomatic width x 100/viscerocranial length
I3. Ossa cranii index: maximum width of the ossa cranii x 100/Ossa cranii length
I4. Basal index: maximum width of ossa cranii x100/basal length
I5. Skull index: zygomatic width x 100/skull length
I6. Orbital index: Greatest inner height of the orbit x100/ Greatest inner length of the orbit
I7. Foramen Magnum index: the height of the foramen magnum× 100/the width of the foramen magnum

Statistical analysis

The mean values, standard deviations, coefficient of variations and craniofacial indices were calculated with SPSS (version 22). Independent samples *t* test was used for *p* values. The values determined are indicated in Tables 1-4.

Results

In the study, 46 morphometric measurements of South Karaman sheep were made. The reference points for these measurements are presented in **Figs. 1-6**, the morphometric values obtained are presented in **Table 1**, and the calculated index values are presented in **Table 2**.

In the study, as seen in **Table 1**, the skull length of the South Karaman sheep was 238.37±4.18, the condylus occipitalis 51.51±1.65, proc. The base of the jugularis is 72.37±3.79 and the smallest parietal width is 52.34±2.43 for the distance between the supraorbitales was determined as 50.01±3.94.

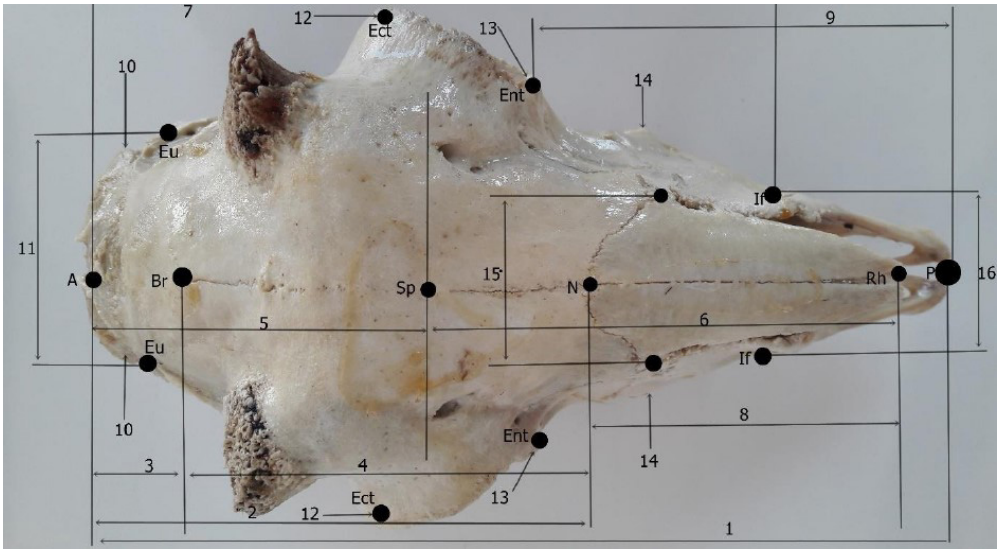

Fig. 1. Measurements of the skull of the South Karaman sheep (dorsal view). **1**. profile length, **2**. median frontal length, **3**. akrokranion-bregma, **4.** frontal length, **5**. upper ossa cranii length, **6.** facial length, **7.** akrokranion-infraorbitale of one side, **8.** greatest length of the nasals, **9.** short lateral facial length, **10.** least breadth of parietal: Least breadth between the temporal lines, **11**. greatest ossa cranii breadth-Greatest breadth of the braincase, **12**. greatest breadth across the orbit-greatest frontal breadth-greatest breadth of skull, **13**. least breadth between the orbits, **14.** facial breadth, **15.** greatest breadth across the nasals, **16**. greatest breadth across the premaxillae.

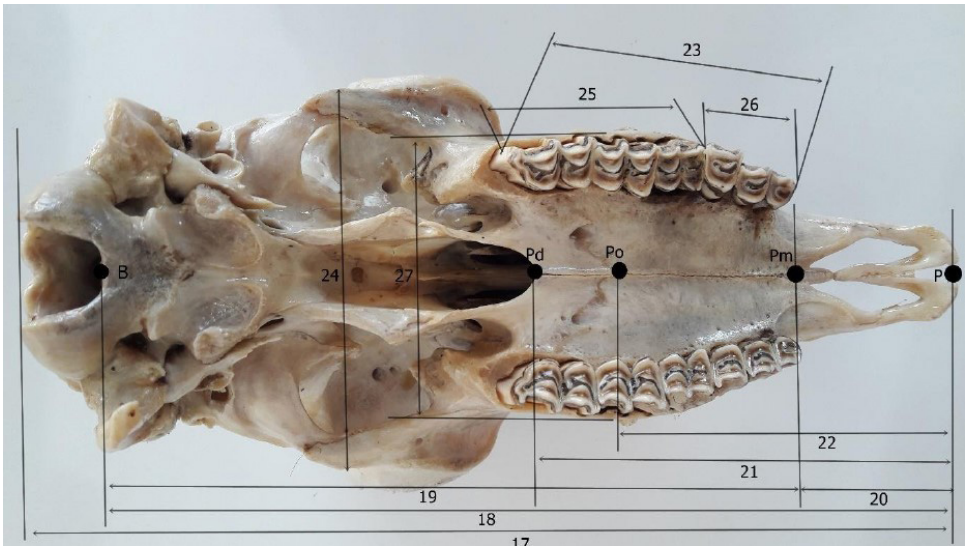

Fig. 2. Measurements of the skull of the South Karaman sheep (ventral view). **17.** condylobasal length, **18.** basal length, **19**. short skull length, **20.** premolare-prosthion, **21.** dental length, **22.** oral palatal length, **23.** Length of the cheektooth row, **24.** zygomatic width, **25.** Length of the molar row, **26.** Length of the premolar row, **27.** greatest palatal breadth.

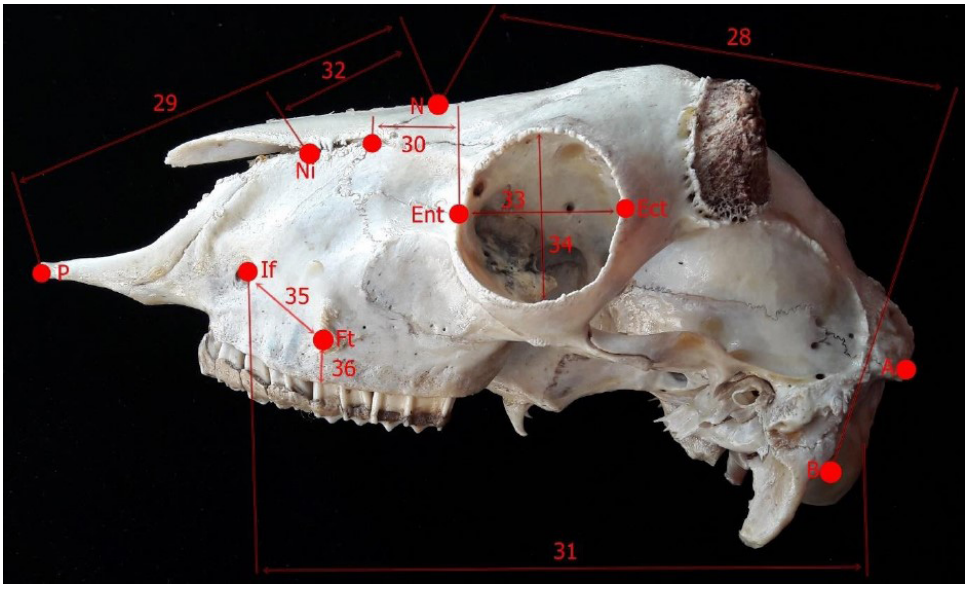

Fig. 3. Measurements of the skull of the South Karaman sheep (lateral view). **28.** ossa cranii length, **29.** ossa faciei length, **30**. greatest length of the lacrimal, **31.** from the aboral border of one occipital condyle to the infraorbitale of the same side, **32.** lateral length of the premaxilla, **33.** greatest inner length of the orbit, **34**. greatest inner height of the orbit, **35.** the distance from infraorbital foramen to facial tuberosity, **36.** the distance from facial tuberosity to root of alveolar tooth,

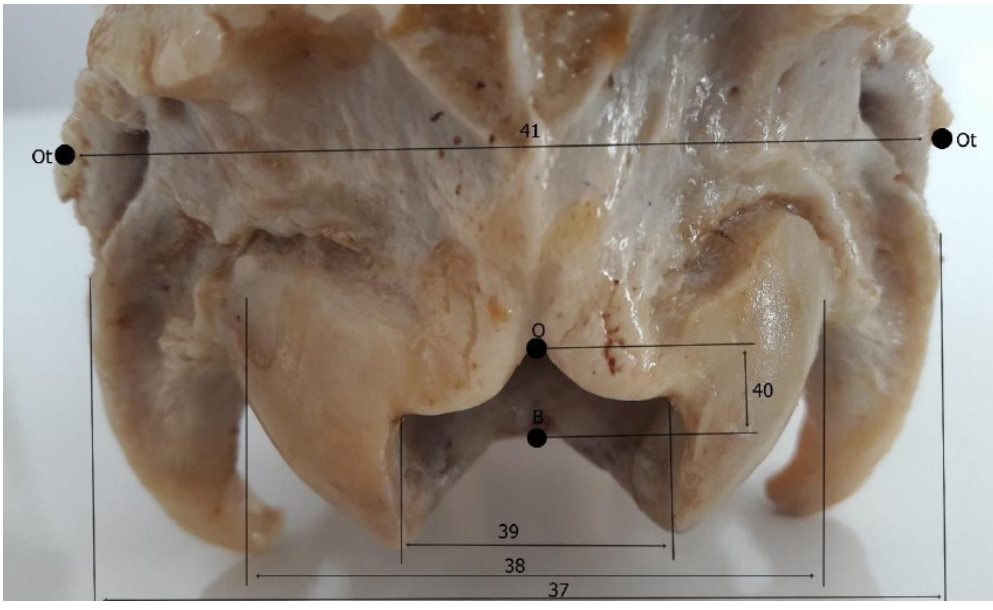

Fig. 4. Measurements of the skull of the South Karaman sheep (occipital view). **37.** greatest breadth of the bases of the paraoccipital processes, **38.** greatest breadth of the occipital condyles, **39.** greatest breadth of the foramen magnum, **40.** height of the foramen magnum, **41.** greatest mastoid breadth.

Fig. 5. Skull of the south Karaman sheep (ventral view). **42.** Supraorbital foramina distance, arrows. Naso-frontal suture like "U" shape; dashed arrows. Parieto-frontal suture like "V" shape.

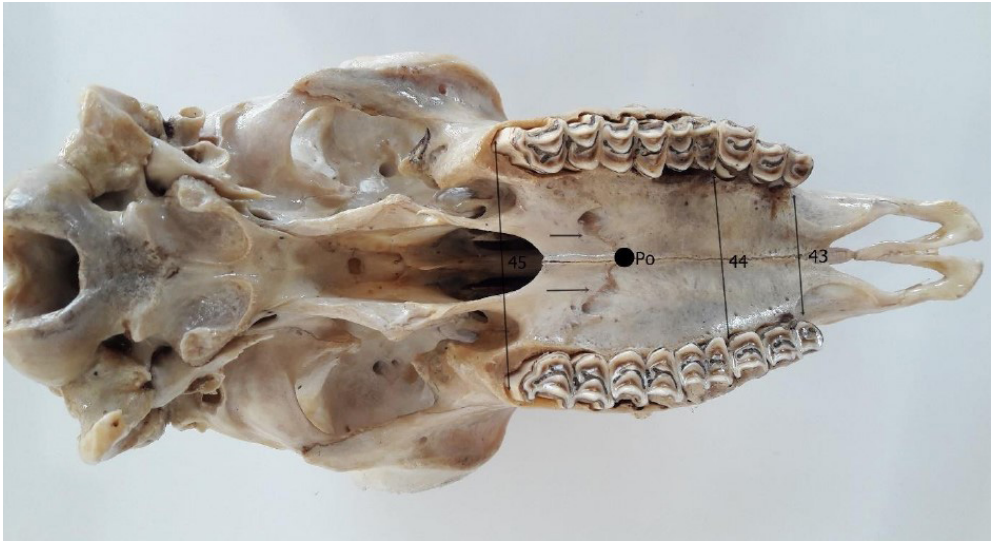

Fig. 6. Skull of the south Karaman sheep (ventral view) **43.** distance between first premolar teeth, **44.** distance between first molar teeth, **45.** Distance between the last molar teeth, arrows. "V" shape of the palatine bone with maxilla's palatine processes.

Table 1. The mean and standard deviations values of male South Karaman sheep.

Length	Mean ± Std Deviation	Length	Mean ± Std Deviation
L1	238.37 ± 4.183	L24	100.50 ± 2.850
L2	226.61 ± 6.874	L25	39.00 ± 1.589
L3	210.09 ± 7.835	L26	38.02 ± 2.222
L4	153.24 ± 6.599	L27	74.68 ± 3.047
L5	59.19 ± 2.124	L28	51.51 ± 1.653
L6	120.43 ± 6.081	L29	72.37 ± 3.788
L7	134.70 ± 3.203	L30	19.96 ± 2.308
L8	123.95 ± 5.259	L31	20.55 ± 1.882
L9	52.71 ± 6.503	L32	52.34 ± 2.433
L10	82.56 ± 5.313	L33	66.05 ± 2.170
L11	104.94 ± 4.951	L34	80.29 ± 3.758
L12	118.21 ± 4.453	L35	115.75 ± 4.450

L13	176.67 ± 5.557	L36	76.63 ± 2.386
L14	33.98 ± 1.516	L37	37.72 ± 3.572
L15	91.06 ± 3.188	L38	44.42 ± 3.769
L16	134.49 ± 4.157	L39	69.81 ± 3.020
L17	164.07 ± 6.539	L40	27.61 ± 2.412
L18	116.50 ± 4.057	L41	12.53 ± 3.126
L19	95.67 ± 3.930	L42	26.51 ± 2.716
L20	77.05 ± 4.012	L43	34.68 ± 2.603
L21	70.16 ± 3.771	L44	40.20 ± 1.164
L22	48.41 ± 1.993	L45	101.69 ± 5.465
L23	21.70 ± 1.655	L46	50.01 ± 3.935

Table 2. The mean and standard deviation values of craniofacial indices of male South Karaman sheep.

Craniofacial index	Mean ± Std Deviation
I1 Nasal index	74.61 ± 1.442
I2 Facial index	41.41 ± 3.612
I3 Ossa cranii index	54.98 ± 3.830
I4 Basal index	31.48 ± 1.663
I5 Skull index	42.16 ± 1.061
I6 Ortibal index	102.8 ± 6.048
I7 For. Mag. index	103.97 ± 14.659

When **Table 3**, which indicates the correlation between index values, is examined, it is seen that there is a statistically significant strong positive correlation between I3 (Ossa cranii index) and I4 (Basal index), but the relationship between other examined features is insignificant. Although the correlation between I3 and I6 index values was high (r=0.776), the correlation was found to be statistically insignificant (P=0.070). A similar situation was seen in I4 and I6 features (P=0.098).

Table 3. Correlation of craniofacial index.

	I1	I2	I3	I4	I5	I6
I2	-0.046					
I3	-0.616	-0.426				
I4	-0.615	-0.583	0.917**			
I5	0.312	-0.100	-0.310	-0.004		
I6	-0.690	0.094	0.776	0.732	0.016	
I7	-0.293	0.418	0.057	0.084	0.497	0.570

*: P<0.05; **: P<0.01

Statistically significant correlation values of skull measurements are shown in **Table 4**. When **Table 4** is examined, it is seen that there is a strong negative or positive correlation between the characteristics. It was determined that there was a strong negative correlation (-0.827) between L9 and L14 features, and positive correlation coefficients between other features. The highest positive correlation was observed between L7 and L34 features (0.992).

Table 4. The correlation values of skull male Güney Karaman sheep.

	L1	L2	L3	L4	L6	L7	L8	L9	L11	L12	L15	L16	L17	L18	L19	L20
L3		0.984 **														
L4		0.923 **	0.934 **													
L6		0.853*	0.823*													
L8	0.843*	0.894*	0.886*	0.849*	0.937 **											
L10					0.839*											
L12	0.917 **															
L14								-0.827*								
L15						0.915*										
L16	0.856*															
L18		0.965 **	0.972 **	0.848*												
L19	0.861*	0.935 **	0.933 **	0.919 **	0.836*		0.960 **							0.846*		
L20		0.887*	0.851*	0.935 **			0.842*		0.880*						0.932 **	
L22		0.838*												0.865*		
L25													0.846*			
L26			0.865*				0.810*							0.855*		
L27													0.902*			
L28									0.950 **							0.844*
L29					0.829*	0.830*			0.829*				0.815*			
L30										0.885*						
L31				0.863*					0.839*							0.809*
L32				0.913*					0.828*							0.895*
L34						0.992 **					0.924 **					
L35													0.894*			
L36					0.826*				0.879*			0.850*				
L37									0.974 **							0.915*
L38							0.902*								0.874	0.826*
L39												0.855*				

L41									0.945 **						0.882*
L42		0.962 **	0.946 **	0.886*	0.943 **		0.905*							0.920*	0.877*	
L43		0.894*	0.949 *	0.920 **			0.886*							0.869*	0.942 **	0.828*
L44						0.901*					0.891*					
L45													0.860*	0.868*		

*: P<0.05; **: P<0.01

Continuation of Table 4.

	L21	L22	L24	L25	L26	L27	L28	L29	L31	L32	L34	L36	L37	L38	L42
L22	0,938**														
L25	0,926**														
L29						0,868*									
L30					0,912*										
L31						0,824*									
L32									0,943**						
L34								0,859*							
L35						0,982**		0,924**							
L36								0,926**			0,832*				
L37							0,945**		0,818*	0,826*					
L38										0,843*					
L39		0,838*													
L41							0,922**						0,986**		
L42					0,864*										
L43					0,845*										0,843*
L44			0,908*								0,930**	0,851*			
L45	0,951**	0,932**		0,915*											
L46										0,848*				0,870*	

*:P<0.05; **: P<0.01

Discussion

In the study, the skull length was determined as 238.37±4.18 in South Karaman sheep. This value is 209±4.77 in Iranian domestic sheep [15], 200.6±0.6 in Mehraban sheep [11], 246.5±2.16 in Barbados Black Belly sheep [14], 246.5±2.16 in Tuj sheep [19], 198.08±7.69 and 241.20±25.17 in Hemsin sheep [6], Suffolk Down Sheep [3] 238.3±2.07, Kosava in Barkhoka sheep [7] 245.25±10.24, Zell sheep [13] 196.73±0.60 in Yankasa sheep [24] 325±0.99, in Ivesi sheep [28] was reported to be 241.30±14.01, in Xisqueta sheep [22] 265.51± 22.24 and in Sharri sheep [9] 247.47 ± 13.12. According to these reported values, it was observed that the skull length of the South Karaman sheep was smaller than the skull length of the Barkhoka sheep of Yankasa, Xisqueta, Barbados Black Belly, Sharri and Kosava, and it was almost equal to the Suffolk Down breed, but longer than all of the other breeds mentioned above.

Skull index value in morkaraman sheep [19] 51.36±0.69, Tuj sheep [19] 50.42±0.78, Mehraban sheep [11] 53.57±3.26, Avesi sheep [28] 47.77±3.23, Xisqueta sheep [22] 44.69± 4.29, Barkhoka sheep of Kosava [7] 41.69±1.74, Saanen goat [26] was measured as 53.45±1.55. This value was measured as 42.16 ± 1.06 in South Karaman sheep.

Yılmaz and Demircioglu [28] and Ozcan et al. [19] stated that the widest region of the skull in sheep is the frontal width (ectorbitale – ectorbitale) due to morphological differences. Accordingly, they reported that this length was 102.98±2.52 mm in Morkaraman sheep [19], 101.66±1.69 mm in Tuj sheep [19], and 115.07±7.74 mm in Avesi sheep [28]. In this study, it was determined that the widest region of the skull was the frontal width (ectorbitale – ectorbitale), similar to what the authors reported in sheep, and this distance was 115.75 ± 4.45 in South Karaman sheep.

The orbital region is a craniofacial structure that can be affected by many congenital, traumatic, neoplastic, vascular and endocrine disorders [1], as it plays a fundamental role in the assessment and recognition of the craniofacial complex [10].

Parés-Casanova et al. [22], in their study on the biometric appearance of the skull in Spanish Xisqueta sheep, reported that the orbital index value was 109.77±10.23. The mentioned orbital index was measured as 112.27±3.50 in Avesi sheep [28] and 93.46± 3.48 in Barkhoka sheep of Kosava [7]. In the study, it was determined that the measured value of 102.8 ± 6.048 in South Karaman sheep was greater than only Kosava's Barkhoka breed.

Although Sharri sheep [9], Bardhoka sheep of Kosovo [7] and Kagani goat [23] stated that the fronto-nasal sutura is in the form of the letter "V" sheep [6] has been reported to be in the shape of the letter "U". In the study, it was determined that the fronto-nasal sutura resembles the letter "U" in South Karaman sheep.

It is reported that the palato-maxillary sutura between the lamina horizantali of the os palatine and the processus palatinus of the os maxilla is in the form of the letter "U" in hellon sheep [11], and in the shape of the letter "V" in Bardhoka sheep of Kosovo [7] has been done. In the study, it was determined that the palato-maxillar sutura in South Karaman sheep resembles the letter "V" as in Bardhoka sheep. In addition, in the study, it was determined that the pariato-frontal suture was in the form of the letter "V", and this finding is consistent with the reports of Sharri sheep [9] that the sutura can be in the form of a straight line or the letter "V".

As reported in the correlation analysis of the measurements made on the skull index values of Hemsin sheep, it was determined that there is a statistically significant strong positive correlation between I3 (Ossa cranii index) and I4 (Basal index) in South Karaman sheep. However, there was no statistically positive correlation between nasal index (I1) and skull index [6], as reported in sheep. According to the statistical values of the skull measurements of the Southern Karaman Sheep, there is a strong negative correlation (-0.827) between L9 (akrokranio – bregma) and L14 (greatest length of the lacrimal (most lateral point of the lacrimal – the most oral point of the lacrimo-maxillary suture) and the correlation coefficients were positive among other features. The highest positive correlation value was observed between L7 and L34 features (0.992).

There is a positive strong correlation between the basal length and the short skull length in hemsin sheep while the greatest inner height of the orbit and the between the breadth of the occipital condyles there was a strong correlation in the negative direction.

This study is important because it is the first study on the mental structure of domestic sheep breeds in Turkey. It is thought that the difference between the skulls of South Karaman sheep and other sheep may be due to the breed of the sheep. In addition, this research will contribute to the scientific studies to be carried out in this direction and to the literature on the subject.

References

1. Acer, N., B. Sahin, H. Ergur, et al. Stereological estimation of the orbital volume: a criterion standard study. – *J. Craniofac. Surg.,* **20**, 2009, 921-925.

2. Agüera, S., F. Castejón, A. Diaz, F. Miró, J. López Rivero. Diferenciación radiológica en ovejas manchegas y merinas. – *Archivos de Zootecnia*, **37**, 1988, 205. [In Spanish]

3. Barra, R., A. M. Carvacal. Martinez. Variability of cranial morphometrical traits in Suffolk Down Sheep. – *Austral J. Vet. Sci.,* **52**, 2020, 25-31.

4. Cakır, A., I. G. Yildirim, O. Ekim. Craniometric measurements and some anatomical characteristics of the cranium in Mediterranean Monk Seal (Monachus monachus. Hermann 1779). – *Ankara Univ. Vet. Fak. Derg.,* **59**, 2012, 155-162.

5. Cobb, S., P. O´Higgins. The ontogeny of sexual dimorphism in the facial skeleton of the African apes. – *J. Hum. Evol.*, **53**, 2007, 176-190.

6. Dalga, S., K. Aslan, Y. Akbulut. A morphometric study on the skull of the Hemshin sheep. – *Van. Vet. J.*, **29**, 2018, 125-129.

7. Gundemir, O., S. Duro, T. Jashari, O. Kahvecioglu, I. Demircioglu, H. Mehmeti. A study on morphology and morphometric parameters on skull of the Bardhoka autochthonous sheep breed in Kosovo. – *Anat. Histol. Embryol.,* **49**, 2020, 365–371.

8. Ilayperuma, I. Evaluation of cephalic indices: A clue for racial and sex diversity. – *Int. J. Morphol.*, **29**, 2011, 112-117.

9. Jashari, T., S. Duro, O. Gundemir, T. Szara, V. Ilieski, D. Mamuti, O. P. Choudhary. Morphology, morphometry and some aspects of clinical anatomy in the skull and mandible of Sharri sheep. – *Biologia*, **77**, 2022, 423–433.

10. Ji, Y., Z. Qian, Y. Dong, et al. Quantitative morphometry of the orbit in Chinese adults based on a three-dimensional reconstruction method. – *J. Anat.,* **217**, 2010, 501-506.

11. Karimi, I., V. Onar, G. Pazvant, M. M. Hadipour, Y. Mazaheri. The Cranial Morphometric and Morphologic Characteristics of Mehraban Sheep in Western Iran. – *Global Veterinaria*, **6**, 2011, 111-117.

12. Kaymakci, M. *Advanced sheep breeding.* Bornova-İzmir, 2006. [In Turkish].

13. **Marzban, Abbasabadi B., O. Hajian, S. Rahmati.** Investigating the morphometric characteristics of male and female Zell sheep skulls for sexual dimorphism. – *A.S.J.,* **17**, 2020, 13-20.
14. **Mohamed, R., M. Driscoll M, N. Mootoo.** Clinical anatomy of the scull of the Barbados Black Belly sheep in Trinidad. – *Int. J. Curr. Res. Med. Sci.*, **2**, 2016, 8-19.
15. **Monfared, A. L.** Clinical anatomy of the skull of Iranian Native sheep. – *Global Veternaria*, **10**, 2013, 271- 275.
16. **NAV.** Nomina anatomica veterinaria, international committee on veterinary gross anatomical nomenclature. 5th Edition, Hannover, Columbia, Gent, Sapparo, USA, 2005.
17. **Onar, V., G. Pazvant.** Skull typology of adult male Kangal dogs. – *Anat. Histol. Embryol.,* **30**, 2001, 41–48.
18. **Ozdemir, D., Z. Ozudogru.** Macroanatomical investigations on renal arteries of southern Karaman Sheep. – *Turkish Journal of Agriculture - Food Science and Technology*, **8**, 2020, 1878-1881.
19. **Ozcan, S., G. Aksoy, I. Kurtul, I., K. Aslan. Z. Ozudogru.** A comparative morphometric study on the skull of the Tuj and Morkaraman sheep. – *Kafkas Universitesi Vet. Fak. Derg.*, **16**, 2010, 111-114.
20. **Ozkan, E., A. B. Siddiq, O. Kahvecioglu, M. Ozturk, V. Onar.** Morphometric analysis of the skulls of domestic cattle (*Bos taurus* L.) and water buffalo (*Bubalus bubalis* L.) in Turkey. – *Turkish J. Vet. Anim. Sci.,* **43**, 2019, 532–539.
21. **Ozudogru, Z., D. Ozdemir.** A Morphological study on sinus interdigitalis in south Karaman Sheep. – *Atatürk University J. Vet. Sci.,* **16**, 2021, 228-235.
22. **Parés-Casanova, P. M., S. Kamal, J. Jordana.** On biometrical aspects of the cephalic anatomy of Xisqueta sheep (Catalunya, Spain). – *Int. J. Morpol.*, **28**, 2010, 347-351.
23. **Sarma, K.** Morphological and craniometrical studies on the skull of Kagani goat (*Capra hircus*) of Jammu region. – *Int. J. Morphol.*, **24**, 2006, 449-455.
24. **Shehu, S., A. Bello, A. Danmaigiro, et al.** Osteometrical study on age related changes of the skull of Yankasa ram. – *J. Human Anat.,* **3**, 2019, 136.
25. **Von Den Driesch, A.** A guide to the measurement of animal bones from archaeological sites. Peabody Museum Bulletin 1. Cambridge, MA, Harvard University, 1976.
26. **Wang, X., A. Lıu, J. Zhao, F.M. Elshaer, D. Massoud.** Anatomy of the skull of Saanen goat. An anesthesiology and stereology approach. – *Int. J. Morphol.,* **39**, 2021, 423-429.
27. **Yalcin, H., M.A. Kaya.** Anadolu yaban koyunu ve akkaraman koyununun kafa kemikleri üzerinde karşılaştırmalı geometrik morfometri. – *Atatürk Univ. Vet. Bil. Derg.*, **4**, 2009, 105-116. [In Turkish].
28. **Yılmaz, B., I. Demircioglu.** Morphometric analysis of the skull in the Awassi Sheep (*Ovis aries*). – *Fırat* Üniv. *Sag. Bil. Vet. Derg.,* **34**, 2020, 1-6.