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A study on morphological and morphometrical parameters on the skull of the Konya Merino Sheep

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ABSTRACT

Objective: In this study, it was aimed to determine the craniometric measurements of the skull of the Konya Merino breed and to reveal the differences between it and other sheep breeds.

Material-Method: For this study, ten Konya merino heads were used and craniometric measurements were made from 46 points on the skull.

Result: In the study, the skull length of the Konya merino was 274.03±5.23, the frontal width (ectorbitale – ectorbitale) which is the widest region of the skull was 123.47 ± 2.60, zygomatic width (the distance between two zygomatic arches) was 110.30±1.96 and the distance between the foramen supraorbitales was 49.06 ± 2.38.. It was determined that both the fronto-nasal and palato-maxillar sutures resembled the letter "V" in Konya merino, while the pariato-frontal suture was in the form of a straight line. When the correlation between index values was examined, it was seen that there was a statistically significant strong positive correlation between I1 (Nasal index) and I2 (Facial Index), but the relationship between other examined features was insignificant. When the statistically significant correlation values of the skull measurements were examined, it was seen that there was a strong negative or positive correlation between the features. While the highest positive correlation was between L5 (premolare – prosthion) and L39 (greatest palatal breadth (measured across the outer borders of the alveoli) features (0.943), the highest negative correlation was L33 (greatest neurocranium breadth-greatest breadth of the alveoli). Braincase (euryon - euryon) and L46 (supraorbital foramina distance) features were found to be (-0.908).

Conclusion: As a result, in this study, it is thought that the difference in the craniometric values of Konya merino, which is accepted as the native breed of Turkey, with other sheep breeds, depending on the skull morphology, may be caused by the breed of sheep.

Keywords: *Konya merino sheep, Morphology, Craniometrics, Skull*

INTRODUCTION

The skull is a structure consisting of a series of fused flat and mostly double bones. This structure includes the brain as well as the sense organs such as vision, smell, balance and taste. The upper respiratory and digestive tracts are also located in here. It is divided into two parts as neurocranium and viscerocranium. Neurocranium consists of cavum cranii and viscerocranium consists of bones that make up the facial skeleton (König and Liebich, 2020).

Taking craniometric measurements depending on skull morphology is a preferred method in

zooarchaeological studies, osteological evaluations, to reveal shape differences due to internal and external factors and differences between sexes (Cakir et al., 2012).

Konya Merino, also called Central Anatolian Merino, is one of Turkey's domestic sheep breeds, obtained by crossing the German fleece meat merino and Akkaraman sheep. It is a breed developed by crossbreeding studies carried out in Konya stud farm since 1950. Konya Merino breed carries an average of 80% German fleece meat merino and 20% Akkaraman genotype. The sheep, which has a large, deep, wide and long body structure, has a medium head length and width, and thick lips. The face and legs of the sheep are bare, the fleece is thin and uniform, with a white fleece. The tail is lean, thin and long. Sheep and rams are hornless (Akcapinar, 1994).

To this date, some studies on Konya merino (Ozudogru et al., 2019; 2021) and craniometric measurements have been carried out in Xisqueta sheep (Parés-Casanova et al., 2010), Tuj and Morkaraman sheep (Ozcan et al., 2010), Mehraban sheep (Karimi et al., 2011), Iranian domestic sheep (Monfared, 2013), Barbados Black Belly sheep (Mohamed et al., 2016), Sharri sheep (Jashari et al., 2022), Hasmer and Hasak sheep (Can et al., 2022) and South Karaman sheep (Ozudogru et al., 2022) no craniometric studies were found in Konya merino. This study is especially important because it is the first study on the head structure of Turkey's native sheep breed, which is common in the Central Anatolian region.

MATERIALS and METHODS

Supply of Materials

In the study, 10 Konya merino skulls with a weight varying between 44-79 kg obtained from Bahri Dağdaş 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 Konya Merino skull. The anatomical terms used were based on Nomina Anatomica Veterinaria (NAV, 2017).

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.

This study was approved by the Experimental Animals Ethics Committee of Atatürk University (Ethical number: 23.10.2015, 8/148).

Measuring points on the skull;

Akrokranion (A): the most aboral point on the vertex of the cranium in the median plane,

Basion (B): the orobasal border of the foramen magnum in the median plane,

Bregma (Br): the median point of the parieto-frontal suture,

Ectorbitale (Ect): the most lateral point of the frontal bone on the occipital side of the orbit,

Entorbitale (Ent): the naso-medial indentation of the orbit that corresponds with the inner angle of the eye in the living animal,

Euryon (Eu): the most lateral point of the braincase,

Infraorbitale (If): the (dorso) aboral point of the foramen infraorbitale,

Nasion (N): the median point of the naso-frontal suture,

Nasointermaxillare (Ni): the most aboral point of the premaxilla on the facial surface,

Opisthion (O): the nuchodorsal border of the foramen magnum in the median plane,

Otion (Ot): the most lateral point of the mastoid region,

Prosthion (P): the median point of the line joining the most oral points of the premaxillae,

Postdentale (Pd): the median point of the line joining the aboral points of the alveoli of the hindmost cheekteeth,

Premolare (Pm): the median point of the line joining the oral points of the alveoli of the foremost cheekteeth,

Palatinoorale (Po): the median point of the palatine-maxillary suture,

Rhinion (Rh): the median point of the line joining the most oral points of the nasals, Supraorbitale (Sp): the median point of the line joining the aboral borders of the supraorbital foramina (Von den Drisch, 1976).

The following measurements by using definitions of measuring points (Onar and Pazvant, 2001; Ozcan et al., 2010; Dalga et al., 2018; Ozkan et al., 2019; Gundemir et al., 2020) on the cranium were made:

L1. profile length (akrokranion - prosthion),

L2. condylobasal length (aboral border of occipital condyles - prosthion),

L3. basal length (basion - prosthion),

L4. short skull length (basion premolare),

L5. premolare - prosthion,

L6. neurocranium length (basion - nasion),

L7. viscerocranium length (nasion prosthion),

L8. median frontal length (akrokranion - nasion),

L9. akrokranion - bregma,

L10. frontal length (bregma - nasion),

L11. upper neurocranium 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 neurocranium 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 the 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 the root of the 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 (Ozcan et al., 2010; Gundemir et al., 2020)**:**

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. Neurocranium index: maximum width of the neurocranium x 100/neurocranium length

I4. Basal index: maximum width of neurocranium 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.

RESULTS

In the study, 46 morphometric measurements of Konya Merino were made. The reference points for these measurements are given in Figure 1-6, the morphometric values obtained are presented in Table 1, and the calculated index values are presented in Table 2.

As seen in Table 1, the skull length of the Konya merino was 274.03±5.23, the frontal width (ectorbitale – ectorbitale) which is the widest part of the skull was 123.47 ± 2.60, the distance between the

foramen supraorbitales was 49.06±2.38 and the distance between arcus zygomaticus was 110.30 ± 1.96.

Table 1. The mean and standard deviations values of Merino sheep.

Length	Mean ± Std Deviation	Length	Mean ± Std Deviation
L1	274.03 ± 5.230	L24	110.30 ± 1.957
L2	255.76 ± 3.030	L25	43.69 ± 1.756
L3	237.27 ± 2.336	L26	38.34 ± 1.950
L4	170.15 ± 3.310	L27	74.62 ± 2.252
L5	70.14 ± 2.429	L28	48.89 ± 0.957
L6	124.82 ± 3.958	L29	70.33 ± 2.218
L7	149.04 ± 5.136	L30	22.87 ± 1.807
L8	133.03 ± 1.910	L31	20.03 ± 0.728
L9	52.46 ± 3.200	L32	50.62 ± 0.994
L10	90.58 ± 2.839	L33	68.89 ± 1.215
L11	105.06 ± 2.499	L34	88.59 ± 0.948
L12	134.38 ± 4.498	L35	123.47 ± 2.605
L13	200.07 ± 4.461	L36	89.99 ± 2.015
L14	45.73 ± 2.909	L37	37.53 ± 1.187
L15	98.41 ± 4.878	L38	46.53 ± 1.818
L16	156.08 ± 4.827	L39	79.86 ± 2.488
L17	180.97 ± 1.362	L40	30.35 ± 1.940
L18	136.01 ± 2.799	L41	14.34 ± 0.947
L19	110.49 ± 2.972	L42	31.77 ± 1.176
L20	88.08 ± 1.929	L43	42.97 ± 1.069
L21	75.43 ± 4.116	L44	50.29 ± 2.087
L22	51.98 ± 3.351	L45	104.42 ± 1.996
L23	24.78 ± 2.057	L46	49.06 ± 2.384

Table 2. The mean and standard deviation values of craniofacial indices of Merino sheep.

Craniofacial index	Mean ± Std Deviation
I1 Nasal index	74.08 ± 2.804
I2 Facial index	38.22 ± 2.263
I3 Neurocranium index	55.25 ± 2.354
I4 Basal index	29.04 ± 0.560
I5 Skull index	40.26 ± 0.992
I6 Ortibal Index	114.16 ± 6.873
I7 For. Mag. Index	88.03 ± 7.135

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 I1 (Nasal index) and I2 (Facial Index), but the relationship between other examined features is insignificant. Although the correlation between I3 and I4 index values was high (r=0.721), the correlation was found to be statistically insignificant (P=0.058). A similar situation was seen in I1 and I7 features (P=0.094).

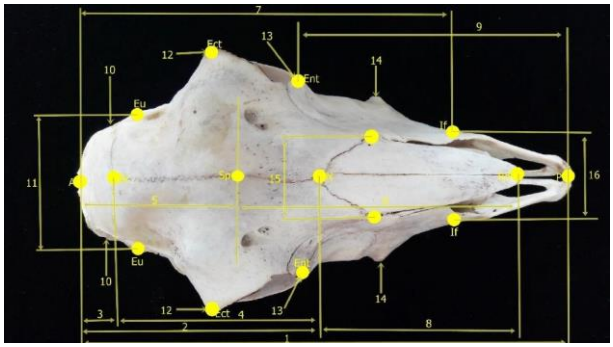

Figure 1. Measurements of the skull of the Konya merino sheep (dorsal view).

1. profile length (akrokranion - prosthion), **2.** median frontal length (akrokranion - nasion), **3.** akrokranion-bregma, **4.** frontal length (bregma - nasion), **5.** upper neurocranium length (Akrokranion – supraorbitale), **6.** facial length (supraorbitale - prosthion),**7.** akrokranion-infraorbitale of one side, **8.** greatest length of the nasals (nasion-rhinion), **9.** short lateral facial length (entorbitale - prosthion), **10.** least breadth of parietal: Least breadth between the temporal lines, **11.** greatest neurocranium breadth-Greatest breadth of the braincase (euryon - euryon),**12.** greatest breadth across the orbit-greatest frontal breadth-greatest breadth of skull (ectorbitale - ctorbitale),**13.** least breadth between the orbits (entorbitale - entorbitale),**14.** facial breadth (breadth across the facial tuberosities),**15.** greatest breadth across the nasals,**16.** greatest breadth across the premaxillae.

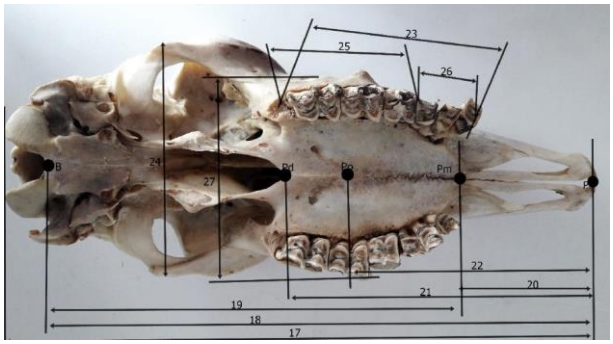

Figure 2. Measurements of the skull of the Konya merino sheep (ventral view).

17. condylobasal length (aboral border of occipital condyles - prosthion), **18.** basal length basion - prosthion), **19.** short skull length (basion premolare), **20.** premolare-prosthion, **21.** dental length (postdentale - prosthion), **22.** oral palatal length (palatinoorale - prosthion), **23.** Length of the cheektooth row (measured along alveoli), **24.** zygomatic width (the distance between two zygomatic arches), **25.** Length of the molar row (measured along the alveoli on the buccal side), **26.** Length of the premolar row (measured along the alveoli on the buccal side), **27.** greatest palatal breadth (measured across the outer borders of the alveoli).

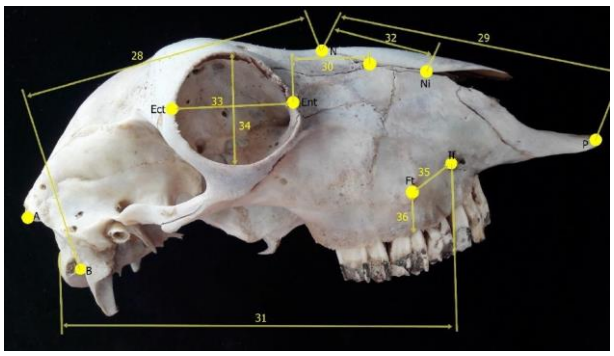

Figure 3. Measurements of the skull of the Konya merino sheep (lateral view).

28. neurocranium length (basion - nasion), **29.** viscerocranium length (nasion-prosthion), **30.** greatest length of the lacrimal (most lateral point of the lacrimal - the most oral point of the lacrimo-maxillary suture, **31.** from the aboral border of one occipital condyle to the infraorbitale of the same side, **32.** lateral length of the premaxilla (nasointermaxillare - prosthion), **33.** greatest inner length of the orbit (ectorbitale - entorbitale),**34.** greatest inner height of the orbit (measured in the same way as measurement), 35**.** the distance from infraorbital foramen to facial tuberosity**, 36.** the distance from facial tuberosity to root of alveolar tooth,

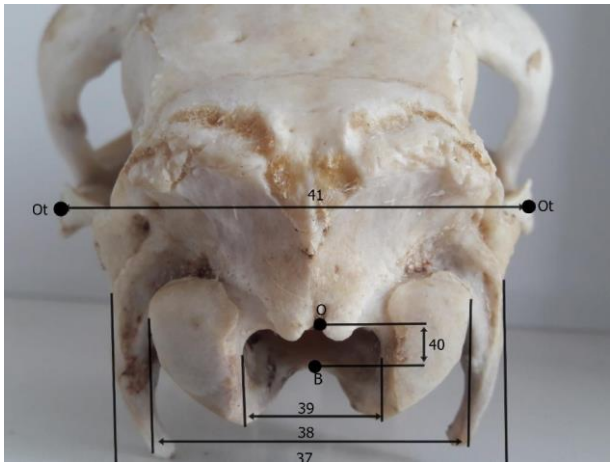

Figure 4. Measurements of the skull of the Konya merino sheep (occipital view)

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 (basion - opisthion),

41. greatest mastoid breadth (otion - otion).

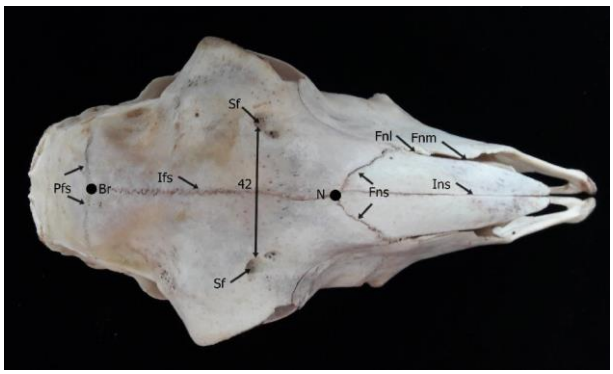

Figure 5. Morphological feature of the skull of Konya merino (frontal surface).

42. Supraorbital foramina distance; **Nfs.** Naso-frontal suture like "U" shape; **Pfs.** Parieto-frontal suture like "V" shape; **Ins.** Internasal suture (caudal quarter part is serrated); **Sf.** supraorbital foramen; **Fnm.** fissura nasomaxillaris; **Fnl.** fissura nasolacrimalis; **Ifs.** Interfrontal sutura.

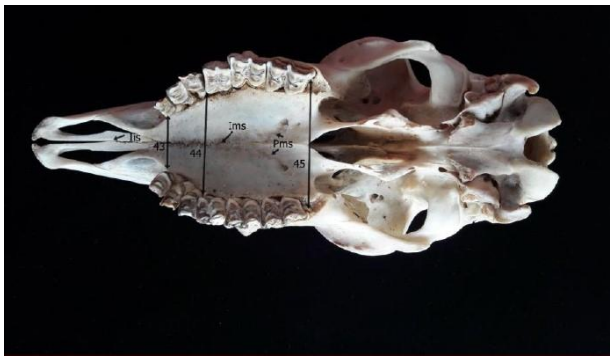

Figure 6. Morphological feature of the skull of Konya merino (basal surface).

43. distance between first premolar teeth, **44.** distance between first molar teeth, **45.** Distance between the last molar teeth, **Pms.** Palato-maxillar sutura ("V" shape of the palatine bone with maxilla's palatine processes); **Ims**. Intermaxillar sutura; **Iis.** Interincisiv sutura.

Table 3. Correlation of craniofacial index.

	I1	I2	I3	I4	I5	I6
I2	0.796*					
I3	0.177	0.396				
I4	0.248	0.231	0.721			
I5	0.348	0.403	-0.236	-0.250		
I6	-0.123	-0.085	0.138	-0.278	0.461	
I7	0.678	0.203	-0.439	0.004	0.164	-0.304

*: 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. While the highest positive correlation was between L5 and L39 features (0.943), the highest negative correlation was between L33 and L46 features (-0.908).

Table 4. The correlation values of skull Merino sheep.

	L1	L2	L3	L4	L5	L6	L7	L8	L10	L12	L13	L14	L15	L16
L5		0.876**												
L8						0.779*								
L9					0.809*									
L10					0.872*									
L11								0.797*						
L12			0.786*				0.775*							
L13	0.900**	0.867*												
L14	-0.758*	0.790*									0.856*			
L15							0.936**			0.857*				
L16							0.868*						0.831*	
L18		0.845*			0.836*					0.845*		0.862*		0.824*
L25									0.828*					
L26				-0.783*										
L28							0.776*							
L33				0.787*										
L34						0.773*								
L36										0.886**		0.759*		
L38							0.917**			0.849*			0.933**	0.935**
L39		0.788*			0.943**				0.872**					
L42							-0.810*							-0.796*
L43	-0.808*	0.882**									0.869*	0.845*		
L44									-0.858*					

*: p<0.05; **: p<0.01

DISCUSSION

In the study, the skull length was determined as 274.03 ± 5.23 in Konya merino. This value is 209±4.77 in Iranian domestic sheep (Monfared 2013), 200.6±0.6 in Mehraban sheep (Karimi et al., 2011), 246.5±2.16 in Barbados Black Belly sheep (Mohamed et al., 2016), 198.08±7.69 in Tuj sheep and 204.49±9.71 in Morkaraman sheep (Ozcan et al. 2010), 241.20±25.17 in Hemsin sheep (Dalga et al., 2018), Suffolk Down Sheep (Barra et al., 2020) 238.3±2.07, Kosova in Barkhoka sheep (Gundemir et al., 2020) 245.25±10.24, Zell sheep (Marzban Abbasabadi et al., 2020) 196.73±0.60 in Yankasa sheep (Shehu et al., 2019) 325±0.99 in Awassi sheep (Yilmaz and Demircioğlu, 2020) was reported to be 241.30±14.01, in Xisqueta sheep (Parés-Casanova et al., 2010) 265.51± 22.24 and in Sharri sheep (Jashari et al., 2022) 247.47 ± 13.12. According to these reported values, it was observed that the skull length of the Konya merino was longer than all of the other reported species except for the skull length of the Yankasa sheep.

The skull index value in Morkaraman sheep (Ozcan et al. 2010) is 51.36±0.69, Tuj sheep (Ozcan et al. 2010) 50.42±0.78, Mehraban sheep (Karimi et al., 2011) 53.57±3.26, Awassi sheep (Yılmaz and Demircioğlu, 2020) 47.77±3.23, Xisqueta sheep (Parés-Casanova et al., 2010) 44.69± 4.29, Barkhoka sheep of Kosova (Gundemir et al., 2020) 41.69±1.74, Saanen goat (Wang et al., 2021), hasmer sheep (Can et al., 2022) 46.36, South Karaman sheep (Ozudogru et al., 2022) 42.16 ± 1.06 was measured as 53.45±1.55. This value was measured as 40.26 ± 0.992 in Konya merino sheep.

In dogs (Onar and Pazvant, 2001), camels (Al-Sagair and Al-Mougy, 2002) and Kagani goats (Sarma, 2006), the distance between the two arcus zygomaticus has been reported as the widest region of the skull. Yılmaz and Demircioğlu (2020) and Ozcan et al. (2010) 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 (Ozcan et al. 2010), 101.66±1.69 mm in Tuj sheep (Ozcan et al. 2010), and 115.07±7.74 mm in Awassi sheep (Yilmaz and Demircioğlu, 2020). In this study, the distance between two arcus zygomaticus in Konya merino was 110.30 ± 1.96 and the frontal width (ectorbitale – ectorbitale) was measured as 123.47 ± 2.60. According to these values, it was determined that

the widest region of the skull was the frontal width (ectorbitale – ectorbitale) in Konya merino.

From a clinical point of view, since the nervus infraorbitalis innervates the lateral and upper parts of the nose, upper lip and facial skin, it is important to determine the location of the foramen infraorbitale in the blockade of this nerve (Getty, 1975). To locate the foramen infraorbitale, it is necessary to know the distance from the infraorbital foramen to facial tuberosity. This distance has been reported as 18.7 ± 0.09 in Iranian domestic sheep (Monfared, 2013), 31.6±0.70 in Barbados Black Belly sheep (Mohamed et al., 2016) and 12.82±0.18 in female Zell sheep skull (Marzban Abbasabadi et al., 2020). In Konya merino, this distance was measured as 30.35±1.94. Since the orbital region consists of a complex bone structure, it plays a fundamental role in the evaluation and recognition of the craniofacial complex.

Parés-Casanova et al. (2010), 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 the Awassi sheep (Yilmaz and Demircioglu, 2020) and 93.46± 3.48 in the Barkhoka sheep of Kosova (Gundemir et al., 2020). In the study, it was determined that the value measured as 114.16 ± 6.87 in Konya merino was greater than all of the mentioned sheep species.

Although it was stated that the fronto-nasal sutura was in the form of the letter "V" in Sharri sheep (Jashari et al., 2022), in Bardhoka sheep of Kosovo (Gundemir et al., 2020), Kagani goat (Sarma, 2006), and Hemsin sheep (Dalga et al., 2018) it 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 "V" in Konya merino.

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 (Karimi et al., 2011), and in the shape of the letter "V" in Bardhoka sheep of Kosovo (Gundemir et al., 2020) has been done. In the study, it was determined that the palato-maxillar sutura in Konya merino resembles the letter "V" as in Bardhoka sheep. In addition, in the study, it was determined that the pariato-frontal sutura was in the form of a straight line, and this finding is consistent with the reports of Sharri sheep (Jashari et al. 2022) that the sutura can be in the form of a straight line or the letter "V".

When the correlation between the index values of Konya merino is examined in the study, it is seen that there is a statistically significant strong positive correlation between I1 (Nasal index) and I2 (Facial Index), while the relationship between other examined features is insignificant. Although the correlation between I3 (Neurocranium index) and I4 (Basal index) index values was high (r=0.721), the correlation was found to be statistically insignificant (p=0.058).

In their study on Hemsin sheep skull index values, Dalga et al. (2018) found that there was a statistically significant and strong positive correlation between the Neurocranium index and Basal index.

According to the statistical values of Konya Merino skull measurements, it is seen that there is a strong negative or positive correlation between the features. The highest negative correlation was found between L33 (greatest neurocranium breadth-greatest breadth of the braincase (euryon - euryon) and L46 (supraorbital foramina distance) features (-0.908).

There is a positive strong correlation between the basal length and the short skull length of the hemsin sheep (Dalga et al., 2018), while the length 25 (The greatest inner height of the orbit) and the length 27 (between the breadth of the occipital condyles) 26 (the greatest mastoid breadth (Otion-Otion)) there was a strong negative correlation.

CONCLUSION

As a result; This study is important because it is the first study on the head structure of one of Turkey's domestic sheep breeds. It is thought that the difference between the skulls of Konya merino and other sheep may be due to the breed of 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.

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