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The Cranial Morphometric and Morphologic Characteristics of Mehraban Sheep in Western Iran

[1]Isaac Karimi, [2]Vedat Onar, [2]Gülsün Pazvant, [1]Mohammadmehdi Hadipour and [3]Yazdan Mazaheri

[1]Department of Basic Sciences, School of Veterinary Medicine, Razi University, Kermanshah, Iran
[2]Department of Anatomy, Faculty of Veterinary Medicine, Istanbul University, Avcilar, Istanbul, Turkey
[3]Department of Basic Sciences, Faculty of Veterinary Medicine, Shahid Chamran University of Ahvaz, Iran

Abstract: The morphology and morphometry of eight skulls of adult Mehraban, a native Iranian breed sheep, were examined. All morphometric data were expressed as mean ± SEM. In this breed, a skull weight of 214.29 ± 22.47 g, a skull length of 20.06 ± 1.71 cm, a cranial length of 11.98 ± 0.24 cm, a skull index of 53.57 ± 3.26, a cranial index of 52.76 ± 1.13, a facial index of 85.44 ± 1.89, an orbital index of 21.46 ± 0.68 and a cranial volume of 130.86 ± 11.55 ml were measured. In order to determine the likely relationship, if any, between the indices and skull length and skull width, correlation coefficients were computed. Cephalic index was negatively correlated with both length and width of the skull in Mehraban sheep. The neurocranium capacity was negatively correlated with skull length. The results were discussed in terms of the usage of morphologic and morphometric characteristics of skulls in several basic and clinical applications in Mehraban sheep industry.

Key words: Mehraban sheep · Skull · Morphology · Morphometry

INTRODUCTION

The morphological and morphometrical studies of the skull are not only reflect contributions of genetic and environmental components to individual development and describe genetic and ecophenotypic variation, but also are foundations of the clinical, surgical and stereotaxic practices [1]. It enables the surgeon to visualize details of structures relevant to the case at hand [2]. Similarly, the different foramina of the skull are of clinical importance in regional anesthesia around the head [3].

As a result of the large population of the Mehraban sheep breed - about three million heads- there has been an increasing interest and necessity to have more information concerning the neuroanatomy and neurophysiology of this breed. This fat-tailed carpet-wool native breed is mostly adapted to the poor range conditions of mountainous areas in western parts of the country [4]. There is currently no published information on the morphometric and morphological characteristics of this breed. The aim of this study was to evaluate morphology and morphometry of skulls of Mehraban, a native breed sheep of Hamedan province of Iran.

MATERIALS AND METHODS

Eight heads of adult, local breed (Mehraban) sheep were obtained from the local abattoir, the sheep body weights and sexes were not considered. The heads were macerated according to the usual techniques that have been reported elsewhere [5, 6]. Subsequently, skulls were used to study their morphological features. Different craniometrical parameters were recorded with the help of measuring scale, thread and digital Vernier callipers using the methods described elsewhere [6 -9]. Data were entered into a standard format, which was transferred to the computer for analysis as appropriate.

Skull Parameters:

- Length: Distance between the highest points of the parietals to the middle of the rostral margin of the incisive bone.
- Width: Maximum breadth between two zygomatic arches.
- Skull basal length: Distance between the midpoint of the ventral margin of the foramen magnum and the level of the middle point on the rostral margin of the incisive bone.

Corresponding Author: Isaac Karimi, Department of Basic Sciences, School of Veterinary Medicine, Razi University, Kermanshah, Iran, Tel: +98-831-8322599-8329540, E-mail: isaac_karimi2000@yahoo.com.

- Skull weight: It was measured by using a digital scale (excluding the mandible).
- Skull index= (Skull width × 100)/ Skull length [10].

Cranial Parameters:

- Cranial length (Medial frontal length): Distance from the junction on the median plane of the right and left nasofrontal sutures to the middle point of the nuchal crest.
- Cranial width: Maximum breadth between the bases of the hornal buds.
- Cranial index= (Cranial width × 100)/ Cranial length [10].
- Cranial height: Distance from the central point of the dorsal rim of foramen magnum to the point of the origin of interfrontal suture.
- Length of the cranial cavity (Length of braincase): Distance between the cribriform plate and the central point of dorsal rim of the foramen magnum.
- Neurocranium capacity (Capacity of braincase): Foramina of the cranial cavity were plugged with fresh plasticine and then this cavity was filled with fine quality rice grains through the foramen magnum upto its brim. The contents were emptied and measured in a measuring cylinder (ml).

Foramen Magnum:

- Height (Height of the foramen magnum): Distance between the midpoints of the dorsal and ventral rims of the foramen magnum.
- Width (Greatest breadth of the foramen magnum): Maximum breadth between two occipital condyles.
- Area (cm^2) = 1/4 WH, where W = width and H = height of the foramen magnum [6].
- Circumference: Length of the entire boundary of the foramen magnum.

Orbital Parameters:

- Orbital length: The vertical distance between the supraorbital and infraorbital borders of the orbit.
- Orbital width: The horizontal distance between the rostral and caudal borders of the orbital rim.
- Orbital index = (Orbital width × 100)/ Orbital length [10].
- Orbital depth: Distance between optic foramen and centre of the orbital rim.
- Orbital area = 22/7 AB, where A and B are the halves of orbital length and width, respectively [6].
- Interorbital distance (Measurements were done according to three different levels):
- At cranial level: Distance between the junction of fronto-lacrimal sutures of either side at the rostral margin of the orbit.
- At middle level: Distance between the supraorbital borders of orbit on either sides.
- At caudal level: Distance between the junctions of the zygomatic bone at the caudal margin of the orbit on either sides.
- Length of the frontal: Distance from the tip of the zygomatic process of the frontal bone to the fronto-lacrimal sutures.
- Length of the lacrimal: Distance from fronto-lacrimal sutures to the junction between the lacrimal and malar bones.
- Length of the zygomatic: Distance from the junction between the lacrimal and zygomatic bones and the tip of the frontal process of zygomatic bones [6].

Facial Parameters:

- Facial length: Distance from the frontonasal suture to the centre of the incisive bone.
- Facial width: Distance between the caudal extent of the orbital rims.
- Facial index = (Facial width × 100)/ Facial length [10].

Nasal Parameters:

- Length of nasal bone: Distance from the central point of the fronto-nasal suture to the rostral end of the internasal suture.
- Width across nasal bone: Maximum distance between the naso-maxillary sutures.

Statistical Analysis: Mean, standard error of the mean (SEM) and coefficient of variation (CV) were computed for each skull measurement using the SPSS (ver. 16) software. The data recorded were subsequently analyzed statistically for ANOVA and Regression equations.

RESULTS AND DISCUSSION

Results were expressed as mean, standard error of the mean and coefficient of variation for each linear measurement.

Morphology: Macroanatomical study was conducted on the skulls of eight adult Mehraban sheep. The skull could be divided into 4 surfaces: frontal, lateral, nuchal and

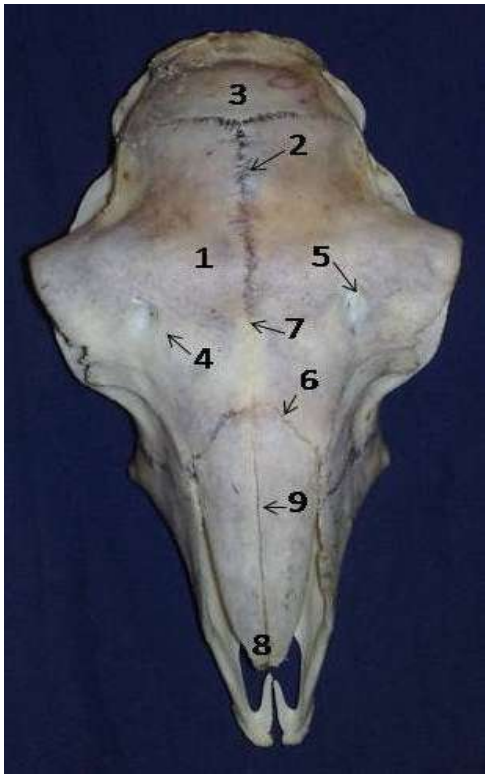

Fig. 1: Photograph of the skull of Mehraban sheep showing: 1. Frontal bone; 2. More zigzag interfrontal suture; 3. Parietal bone; 4. Area containing supraorbital foramina; 5. Supraorbital foramina; 6. Frontonasal suture; 7. Less zigzag interfrontal suture; 8. Sharp rostral end of the nasal bone; 9. Internasal suture.

basal surfaces. The nasal bone was much convex as compared to the frontal and parietal bones. The temporal fossa was shallow and the facial crest was very prominent. The orbits were directed more rostrally towards the median plane. The paracondylar processes were very sharp. The tympanic bulla was large and oriented caudomedially, on the other hand, petrous temporal bone was very small. The minor palatine foramina were found to be absent.

Frontal Surface: This surface comprised frontal, parietal, nasal and incisive bones. The frontal bone extended upto the caudal extent of the skull as reported in cattle [7], goat [11], mithun [12] and Dum pig [13]. However, in Kagani goat [6], the frontal bone did not constitute the caudal extent of the frontal surface; rather it was formed by the parietal bone.

The frontal eminence was present on the median line of the frontals. The interfrontal suture was more serrated at the caudal part rather than rostral part of the frontal bone and fronto-nasal suture was "U" shaped while it was reported "V" shaped in Kagani goat [6] (Fig. 1).

The number and location of the supraorbital foramina are dependent to the species and possibly breeds. Borthakur *et al*. [12] reported presence of two numbers of supraorbital foramina in the skull of local goat of Assam, while Sarma [6] reported presence of the single supraorbital foramina in Kagani goats. In Mehraban sheep, the supraorbital foramina were single on either side. May [14] also has reported single supraorbital foramina on both the sides in sheep. These foramina were located equidistant from the interfrontal suture, approximately 2.15 ± 0.08 cm away from the dorsal rim of the bony orbit in Mehraban sheep.

The supraorbital foramina have been lying at the dorso-lateral aspect of a roughly quadrilateral depression in goats [6] while this type of depression was not seen in Mehraban sheep. In mithun, the supraorbital foramina were placed on an obliquely oriented supra-orbital groove [12]. The maximum width of the frontal surface was noticed at the level of the dorso-caudal margin of the orbits in Mehraban sheep.

The nasal bones were convex at its dorsal surface, which terminated into a sharp rostral end. The nasal bones are more convex in Mehraban rams (data not shown). Both the nasal bones were divided longitudinally into two halves by deep notches upto the middle part, starting from its rostral end. The internasal suture was straight. Similar findings were also reported in ox [15] and goat [6]. The rostral end of the incisive bone was blunt, with two long and narrow palatine fissures. The linkage of palatine process of incisive bone to vomer bone possibly is age-dependent and is reduced by increasing of age (data not shown). The corneal buds of this hornless breed are located in caudodorsal surface of orbits on the frontal bone.

Lateral Surface: The temporal crest ended into a sharp narrow tubercle caudo-lateral to the external auditory meatus while it ended to blunt tubercle in cattle [16] and in goat [6]. The temporal fossa in Mehraban sheep was deep and extensive as in Kagani goat [6], whereas it was reported to be deep but short in buffalo [17], wider in ox [7], shallow and elongated in Assam goat [11] and deep in yak [18].

Sarma [6] reported presence of one foramen on the right and two foramina on the left side on the floor of the caudomedial aspect of the temporal fossa in the skull of Kagani goat, while these foramina were 4-5 in numbers connecting the temporal canal in mithun [12].

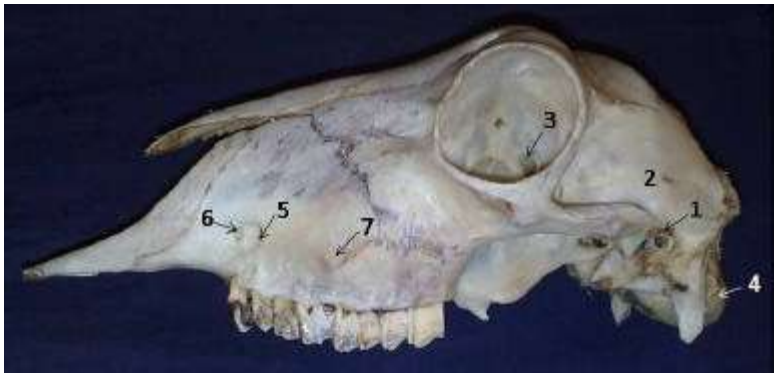

Fig. 2: Photograph of the skull of Mehraban sheep showing: 1. External auditory meatus; 2. Temporal fossa; 3. Optic foramen; 4. Tympanic bullae; 5. Infraorbital foramen; 6. Deep fossa containing 4 Foramina; 7. Facial tuberosity.

In the present study, two foramina on either side on the floor of the caudomedial aspect of the temporal fossa were observed in the skull of Mehraban sheep.

The prominent facial tuberosity was placed at the level of 5th cheek tooth as other sheep breed [14], but the same was placed at the junction of the 4th and 5th cheek teeth in Kagani goat [6], dorsal to the 4th cheek tooth in Assam goat [11], above the 3rd cheek tooth in ox [7], yak [18] and mithun [12]. The facial tuberosity was 1.33 ± 0.08 cm away from the dorsal rim of the maxilla bone in Mehraban sheep.

The infraorbital foramen was single on either side, placed on a depression. Cranial to this foramen, a deep fossa was found lodging 4 numbers of foramina as Kagani goat [6] (Fig. 2). The orbits were complete, oval and the rostral end of the rim was serrated. The frontal bones contributed much more in the formation of the bony orbit of Mehraban sheep that followed by zygomatic and lacrimals. The orbits were directed laterally as in dog, ox, horse, Assam goat, Kagani goat, yak and Dum pig [6, 7, 10, 11, 13, 18, respectively]. The orbital surface of the lacrimal bone was flat and marked off from the facial surface by a dentated orbito-facial crest. A shallow lacrimal fossa leading to a lacrimal canal was recorded just behind this crest as in goat [6]. The foramen ovale was positioned in the caudal part of the pterygoid bone.

Basal Surface: In Mehraban sheep, mean length of the cranial, choanal and palatine parts of basal surface of skulls were recorded as 5.50 ± 0.16, 3.97 ± 0.18 and 11.54 ± 0.55cm, respectively. The basisphenoid bone had a sharp median ridge on its body. The basilar part of the occipital bone was straight and surrounded by two pairs of muscular tubercles, out of which the rostral pair were larger while the caudal pair were larger in Kagani goat [6] (Fig. 3).

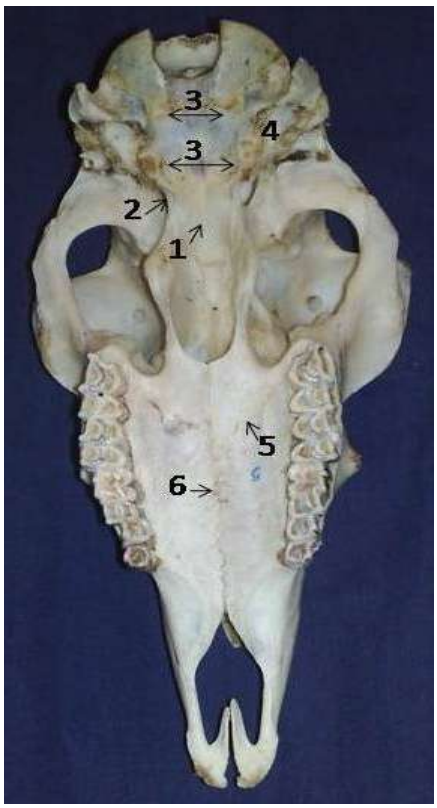

Fig. 3: Photograph of the skull of Mehraban sheep showing: 1. Sharp ridge on the basisphenoid bone; 2. Foramen ovale; 3. Muscular tubercles; 4. Tympanic bullae; 5. Transverse palatine suture; 6. Median palatine suture.

The articular areas for the mandibular condyles of Mehraban sheep were roughly quadrilateral in shape similar to Kagani goat [6]. The caudal border (rim) of articular surface (tubercle) of lower jaw is composed of zygomatic process of temporal bone.

The tympanic bullae on the temporal bone were caudo-laterally compressed and small in Kagani goat [6]. However, it was caudo-medially compressed and well developed in Mehraban sheep (Fig. 3).

The palatine portion was "U" shaped with a straight and smooth median palatine suture in caudal portion but it is mildly serrated in rostral maxillary part (Fig. 3). Similar to Kagani goat [6], the transverse palatine suture was "V" shaped and serrated, lying over the greater palatine foramina. The dorsal border of the palatine bone was united by the sphenoid bone and perforated by sphenopalatine foramen. As previously reported in sheep [14], the external occipital protuberance was located on the external lamina of the squamous occipital bone which was wide and blunt in Mehraban sheep while it was reported sharp and pointed in goat [6], pointed in Dum pig [19] and small and double in leopard cat [20].

The lambdoid suture between the parietal bones and the occipital bone was deeply serrated suture in the middle towards the parietal bones. Unlike Kagani goat [6], the coronal suture was rudimentary in the skull of Mehraban sheep (Fig. 1). The basisphenpoid bone had a sharp median ridge on its body as also reported in small ruminants [6, 21].

Craniometry: To our knowledge, there is no information on the measurements of the skulls of adult sheep in the literature. For this purpose, the variations in the values obtained for the skulls of sheep in this study were compared to those of other (pseudo)ruminants and even carnivores such as dogs.

The data as mean, standard error of the mean and coefficient of variation recorded in the present investigation on skulls of Mehraban sheep were shown in Table 1. The mean length and width of the skulls in

Table 1: The various craniometrical measurements of the skull of the Mehraban sheep

Parameters	Mean	S.E.M.	CV%
Skull parameters			
1. Skull length	20.06	1.71	22.58
2. Skull width	10.44	0.29	7.37
3. Skull index	53.57	3.26	16.10
4. Skull base length	21.48	0.82	10.10
5. Weight of the skull (g)	214.29	22.47	28.70
Cranial parameters			
6. Cranial length	11.98	0.24	5.34
7. Cranial width	6.33	0.23	9.63
8. Cranial index	52.76	1.13	5.70
9. Cranial height	6.86	0.20	7.87
10. Length of cranial cavity	9.80	0.29	7.85
11. Capacity of cranial cavity	130.86	11.55	23.35
Foramen magnum			
12. height	1.92	0.04	6.25
13. width	1.97	0.04	6.59
14. Area	0.94	0.01	4.25
15. Circumference	8.31	1.22	38.98
Orbital parameters			
16. Orbital length	3.64	0.05	5.76
17. Orbital width	5.11	0.13	9.98
18. Orbital index/ Orbital depth	21.46	0.68	11.83
19. Interorbital distance at caudal level	10.52	0.33	8.26
20. Interorbital distance at middle level	9.40	0.35	10.00
21. Interorbital distance at cranial level	7.56	0.33	11.64
22. Length of the frontal bone forming orbital rim	3.65	0.05	5.75
23. Length of the lacrimal bone forming orbital rim	1.97	0.05	10.15
24. Length of the zygomatic bone forming orbital rim	3.53	0.06	7.08
25. Percentage of frontal bone forming orbital rim	39.66	0.26	2.47
26. Percentage of lacrimal bone forming orbital rim	21.48	0.44	7.68
27. Percentage of zygomatic bone forming orbital rim	38.57	0.38	3.75
Facial parameters			
28. Facial length	12.54	0.47	9.88
29. Facial width	10.68	0.29	7.20
30. Facial index	85.44	1.89	5.86
Nasal parameters			
31. Length of nasal bone	8.08	0.35	11.75
32. Width across the nasal bone	2.88	0.14	13.54

Table 2: Showing measurements of various orbital parameters of the skull of Mehraban sheep

						Overall			
Parameter (mm)	Side	Mean	S.E.M	CV%	Range	Mean	S.E.M	CV%	Range
Orbital length	Right	3.44	0.08	6.10	3.24-3.64	3.64	0.05	5.76	3.34-3.58
	Left	3.48	0.08	6.32	3.27-3.69				
Orbital width	Right	3.73	0.09	6.70	3.49-3.96	5.11	0.13	9.98	3.62-3.90
	Left	3.80	0.08	5.78	3.59-4.00				
Orbital index	Right	108.38	1.15	2.81	105.55-111.20	108.72	0.73	2.51	107.14-110.30
	Left	109.07	0.92	2.35	106.68-111.44				
Orbital depth	Right	5.15	0.19	9.90	4.68-5.63	5.11	0.13	9.98	4.82-5.41
	Left	5.07	0.20	10.65	4.57-5.58				
Orbital circumference	Right	11.84	0.30	6.84	11.09-12.59	12.16	0.26	8.22	11.58-12.74
	Left	12.48	0.42	8.97	11.44-13.52				
Orbital area	Right	10.46	0.45	11.56	9.34-11.58	10.49	0.31	11.24	9.80-11.17
	Left	10.51	0.46	11.79	9.36-11.66				

Table 3: Showing simple regression equations for the prediction of different unknown parameters (Y) of the skull of Mehraban sheep

	Known parameters X= Skull width		Known parameters X= Skull length	
Predicted parameters (Y)	Correlation coefficient	Regression equation	Correlation coefficient	Regression equation
Cephalic index	-0.076	Y=-0.839X+62.338*	-0.913	Y=-1.737X+88.41*
Skull base length	0.806	Y=2.252X-2.036	0.624	Y=0.299X+15.482
Cranial index	0.363	Y=1.406X+38.073	0.063	Y=0.042X+51.926
Orbital depth	0.958	Y=635X-1.470	0.567	Y=0.064X+3.867
Orbital index	-0.001	Y=-0.005X+108.426*	0.048	Y=0.032X+107.736*
Interorbital distance (caudal)	0.936	Y=1.057X-0.517	0.623	Y=0.121X+8.104
Interorbital distance (middle)	0.948	Y=1.151X-2.618	0.481	Y=0.100X+7.397
Interorbital distance (rostral)	0.935	Y=1.065X-3.554	0.602	Y=0.117X+5.211
Cranial capacity	0.379	Y=14.907X-24.834	-0.062	Y=-0.414X+139.173*
Cranial length	0.827	Y=683X+4.848	0.359	Y=0.051X+10.966

Mehraban sheep were found to be 20.06 ± 1.71 and 10.44 0.29 cm, respectively. The cephalic index was reported 41.95 in goat [6], 58.45 in 45-60 days old puppies and 51.73 in 61-105 days old puppies [9], while in Mehraban sheep 53.57 was recorded. As previously reported in goat [6], the facial length is longer than the cranial part of the skull in Mehraban sheep (Table 1).

The contributions of the frontal, lacrimal and zygomatic bones in the formation of the bony orbit of Mehraban sheep were 39.66, 21.48 and 38.57 percent, respectively. The frontal bone has the highest contribution in Mehraban sheep as reported in cattle [15], yak [18] and goat [6]. Different orbital parameters have been summarized in table 2. All orbital parameters were larger in left orbits except orbital depth. This bilateral variation among the orbits of both the sides was also reported in yak [18], goat [6], bovine [22] and equine [17].

The correlation analyses of the features examined in this study are presented in table 3. A strong negative correlation between the cephalic index and the length and width of the skull was determined in Mehraban sheep. A very strong negative correlation was found between Orbital index and length of the Skull, while a very weak positive correlation was found between Orbital index and width of the Skull in Mehraban sheep (Table 3). In Kagani goat, the skull width was positively correlated with the cephalic index, while the skull length had no such correlation [6]. Although, skull base length varied positively with both skull length and skull width like Kagani goat [6], these correlations were not significant in Mehraban sheep. The skull width only was positively correlated with the orbital depth in the Kagani goat [6] however; such correlation was not recorded in buffalo [23] and in Mehraban sheep. The skull length showed no correlation with the orbital depth in both Kagani goat [6] and Mehraban sheep.

In Mehraban sheep, no correlation was found between interorbital distances at the all levels- caudal, middle and rostral- with skull length and skull width, while the interorbital distance at the caudal and middle levels

was highly correlated with skull length and correlated with skull width in goat [6]. The neurocranium capacity in Mehraban sheep was collinearly varied with the skull width as also observed in yak [18] and goat [6].

In conclusion, the morphologic and morphometric data of Mehraban sheep are comparable to other ruminants and the present results provide basic information on the skull of sheep to develop a package for this prolific sheep breed.

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