Research Paper: Investigating the Morphometric Characteristics of Male and Female Zell Sheep Skulls for Sexual Dimorphism

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ABSTRACT

Introduction: The present study aimed to evaluate the morphometric differences of the skull in male and female Zell sheep.

Methods: A total of 30 Zell sheep skulls (15 adult males and 15 adult females) were used in this investigation. The skulls were cleaned by boiling maceration, and the mandibles were disarticulated from the temporomandibular. Then, 19 parameters of the skull and 13 parameters on the mandibles were measured using a digital Vernier caliper. The obtained results were analyzed in SPSS by Independent Samples t-test ($P<0.05$).

Results: The distance of lateral alveolar root to mental foramen was significantly higher in male Zell sheep (accuracy rate: 83.33%); however, no statistically significant difference was observed in other cases. Furthermore, the mandible and the skull of Zell sheep were the smallest among the other studied sheep breeds.

Conclusion: The distance of lateral alveolar root to mental foramen on mandible can be an appropriate landmark in gender estimation in Zell sheep.

1. Introduction

The skull is the major element of the skeleton, indicating taxonomic affiliation, and providing information on selection-induced changes in animals [1]. The craniometry is the foundation of clinical and surgical practices [2]. Similarly, different foramina of the skull are of clinical importance in regional anesthesia around the head [3]. The dimorphism of the skull and the pelvis has been highlighted by many authors. Krogman and Íscan stated that gender and race determination in a collection of 750 human skeletons with the presence of pelvis bone or skull (reliability: 95% and 92%, respectively) are possible. They have also reported that using the skull and pelvis bones could increase the examination reliability to 98%. This demonstrates the importance of these regions in gender determination [4].

Numerous comparative morphological and morphometrical studies have been performed on the skull anatomy in

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many mammalians to detect the distinguishing features of these species [5-8]. Moreover, there are other studies about gender-related characteristics in various animals, including elephants (Asian, Elephas maximus, and African, Loxodonta africana), raccoon dog (Nyctereutes procyonoides), badger (Meles meles), fox (Vulpes vulpes), dog (Canis lupus familiaris), and feline (Felis catus) [9-15]. However, gender identification in the sheep via bone morphometry is limited. Moreover, there is only one publication available on sexual dimorphism in sheep [16].

The Zell breed is the only thin-tailed sheep in Iran with a 10-12 cm long tail. This small sheep has a great ability to walk in the mountains and foothills due to its low body weight (40-45 kg) and fairly tall limbs. Zell sheep greatly impacts sheep production in its home area, north of Iran. In addition, it is the only local breed; i.e. suitable for crossbreeding [17-19]. Therefore, the present study aimed to identify the craniometric traits and sexual dimorphism in these characteristics on the male and female Zell sheep.

2. Material and Methods

In total, 30 skulls (15 adult males and 15 adult females) of Zell sheep were selected from a local slaughterhouse. They were selected based on apparent good health conditions and the lack of skeletal deformities, pathologic lesions, and damages. The skulls were processed by hot water maceration, according to the standard previously reported techniques. Moreover, the mandible was dissociated from temporomandibular joint. All the specimens were coded and documented using a digital camera (Canon PowerShot SD790IS 10MP Digital Camera) [9].

Subsequently, 19 parameters in the skull and 13 parameters in the mandible were calculated based on Onuk (2013) and Pitakarnnop et al. (2017), using digital ruler caliper (Digimatic Caliper, Japan) (Table 1) (Figures 1 & 2) [5, 14]. All measurements and observations were blinded, and each bone was evaluated twice for gender identification. The obtained data were analyzed in SPSS using the Independent Samples t-test. Additionally, the significance level was considered at $P<0.05$. The collected data are presented as Mean±SEM.

Table 1. Description of measurements obtained from the skull & mandible of male & female Zell sheep

Skull Parameters	Mandible Parameters
Total Length (TL)	Condyloid fossa to the height of mandible (TMA)
Nasal Length (NL)	The length between the condyle and canine of the mandible (CCL)
Rostrum Length (RL)	Length of diastema (DL)
Medial Canthus to Supraorbital foramen (MCS)	length of molar and premolar (LTL)
Medial Canthus to Infraorbital foramen (MCI)	The total length of mandible (ML)
Infraorbital Foramen to first Premolar teeth (IFP)	Lateral alveolar root to mental foramen (MI)
Infraorbital Foramen to Nasoincisive notch (IFN)	Mental foramen to first premolar (MM)
Condylobasal Length (CBL)	Condyloid fossa to the base of mandible (MMA)
Zygomatic Breadth (ZIB)	Caudal border of the mandible to beneath of mandibular foramen (CBM)
Neurocranium Breadth (NCB)	Mandibular foramen to the caudal border of the mandible (CM)
Total Breadth (TB)	Mandibular foramen to the Base of mandible (MB)
Basal Length (BL)	Widest part of the mandible (MW)
Upper Tooth Row Length (UTL)	Maximum Height of mandible (MH)
Foramen Magnum Height (FMH)	
Foramen Magnum Width (FMW)	
Orbital Height (OH)	
Orbital Width (OW)	
Distance between two Supraorbital foramen (DS)	
Skull weight	

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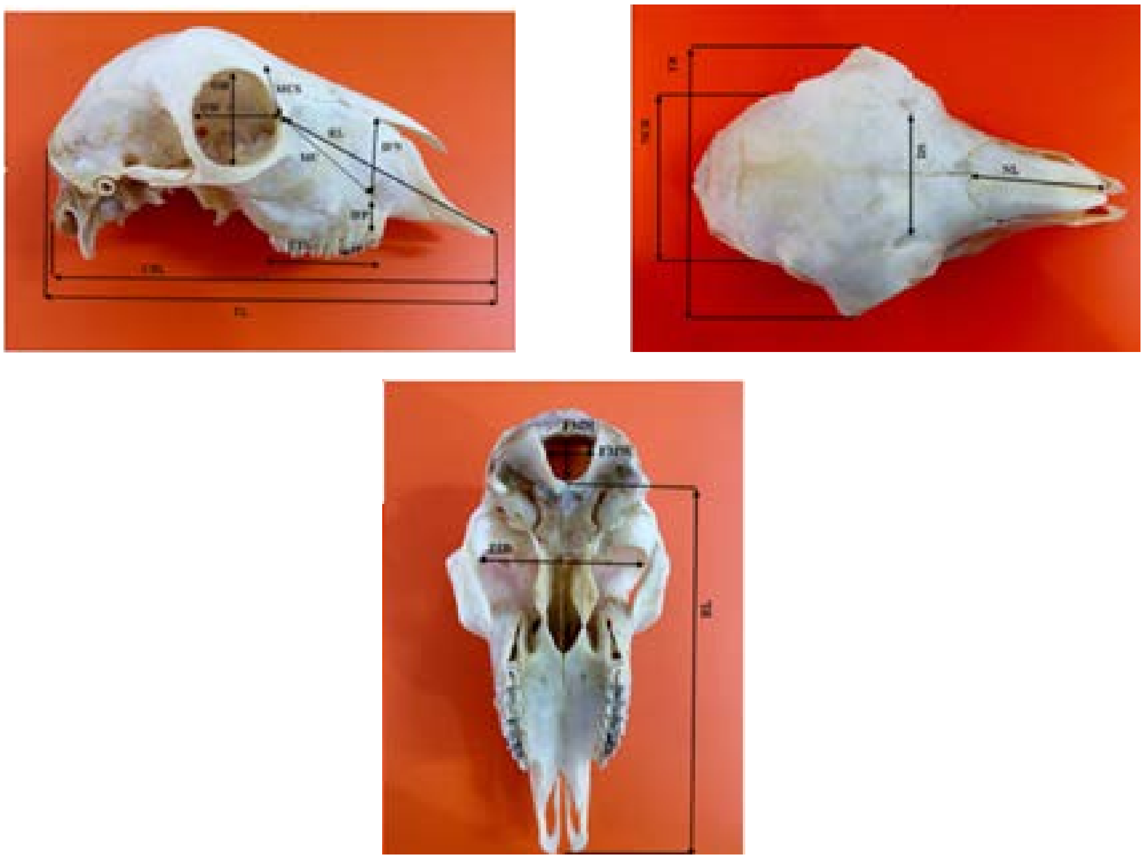

Figure 1. The parameters used in the morphometric measurements of the skull in Zell sheep

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3. Results

The descriptive analysis results (in mm) are presented in Table 2. The skull weight was significantly higher in males. However, no skull-related parameter indicated a significant difference between genders, except for the MI of the mandible; i.e. significantly higher in males, and its accuracy was equal to 83.33%.

4. Discussion

Dimorphism-based gender determination has been performed on most human bones. Reiches stated that applying some study methods occurs through two main approaches, as follows: by the report and description of the bones' morphology, and by the values obtained using morphometry; or in other words, the measurements of these bones [4].

Numerous studies signified the skull as one of the best skeleton parts to determine gender in humans and evaluated its gender differences [4]. In animals, despite many studies on skull gross anatomy, only a few has evaluated the gender-related differences [5, 6, 19-22]. Therefore, we investigated the morphometric characteristics of male and female Zell sheep. As per the obtained data,

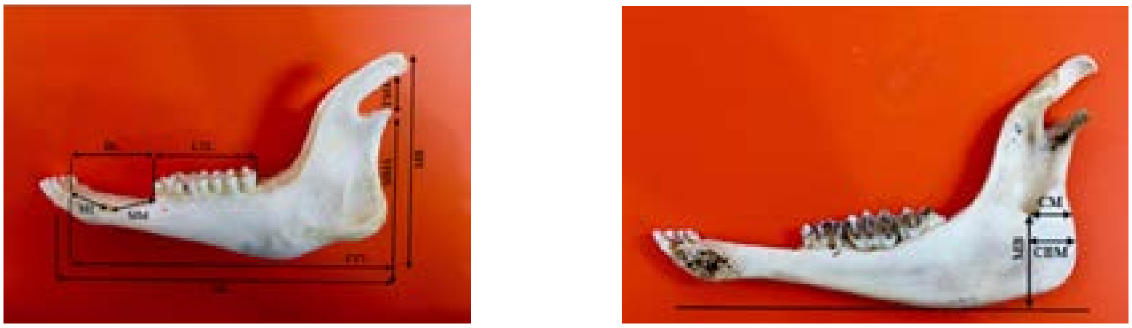

Figure 2. The parameters used in the morphometric measurements of the mandible in Zell sheep

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Table 2. Comparing male and female Zell sheep skull & mandible

Parameter	Mean±SD		P
	Male Zell Sheep (No.= 15)	Female Zell Sheep (No.= 15)	
TL	197.71±1.41	196.73±0.60	0.92
NL	63.22±0.77	60.03±1.06	0.62
RL	96.45±0.88	93.74±0.75	0.58
MCS	14.04±0.18	12.29±0.12	0.24
MCI	43.39±0.24	41.14±0.38	0.21
IFP	12.42±0.21	12.82±0.18	0.3
IFN	2.03±0.30	2.06±0.21	0.81
CBL	188.74±1.56	187.69±1.06	0.71
ZIB	71.17±0.54	68.89±0.16	0.27
NCB	56.19±0.23	56.04±0.18	0.97
TB	101.18±0.81	100.03±0.62	0.72
BL	166.67±1.41	163.38±1.29	0.71
UTL	49.15±0.35	49.10±1.12	0.93
FMH	18.93±0.61	17.65±0.99	0.27
FMW	19.01±0.59	19.88±0.29	0.30
OH	32.80±0.86	32.87±0.30	0.94
OW	37.55±0.67	35.74±0.28	0.07
DS	48.72±1.11	44.62±1.73	0.69
TMA	25.06±2.35	26.11±1.63	0.39
CCL	134.37±7.6	132.02±7.02	0.59
DL	37.08±4.48	36.85±2.72	0.91
LTL	49.43±1.4	49.68±4.2	0.89
ML	142.02±8.62	143.02±7.6	0.89
MI	21±3.06	17.45±1.65	0.03*
MM	16.23±3.25	19.41±2.26	0.07
MMA	69.81±7.19	71.96±4.43	0.54
CBM	18.22±0.02	17.42±0.05	0.61
CM	15.35±0.05	15.71±0.03	0.59
MB	27.43±1.45	28.25±1.32	0.68
MW	71.96±4.43	69.81±7.19	0.56
MH	92.01±2.05	101.60±4.08	0.06

All measurements are in millimeter

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* Significant gender difference level (P<0.05)

there was no significant difference in the parameters as mentioned earlier; however, the distance of lateral alveolar root to Mental Foramen (MI) was significantly higher in male Zell sheep (Table 2). Pares Casanova examined the magnitude of sexual dimorphism in a relict sheep from Catalunya (NE Spain), called Fardasca [16]. Similar to our results, they suggested that the breed was not cranially dimorphic, and gender determination using landmarks such as skull shape and size was likely to yield poor results. In 1989, Jaslow studied the sexual dimorphism of cranial suture complexity in wild sheep. According to their results, most facial sutures were not sexually dimorphic; however, maxillojugal and jugolacrimal, had greater complexity in males, than in females. She suggested horn clashing as the most significant force that might be transmitted through the facial region of rams to develop this complexity. In females, the increased complexity of sutures during ontogeny was pre-

Table 3. Comparing some skull parameters' measurements in the Zell sheep with other sheep breeds

Parameter	Mean±SD			Mehraban Sheep	Xisqueta Sheep	Mean±SD		
	Male Zell Sheep	Female Zel Sheep	Iranian native Sheep			Barbados Black Belly Sheep	Morkaman Sheep	Tuj Sheep
TL	196.73±0.60	197.71±1.41	209.0±4.77	200.6	265.51	246.5±2.16	204.49±9.71	198.09±7.69
NL	60.03±1.06	63.22±0.77		88	92.12	77.7±0.93	70.34±6.77	68.65±3.16
RL	93.74±0.75	96.45±0.88						
MCS	12.29±0.12	14.04±0.18				38.7±1.30		
MCI	41.14±0.38	43.39±0.24				76.8±0.59		
IFP	12.82±0.18	12.42±0.21	16.3±0.04			17.0±0.24		
IFN	2.06±0.21	2.03±0.30				35.8±0.75		
CBL	187.69±1.06	188.74±1.56					199.82±9.39	193.16±7.42
ZIB	68.89±0.16	71.17±0.54		104. 4				
NCB	56.04±0.18	56.19±0.23					60.10±1.20	60.11±1.40
TB	100.03±0.62	101.18±0.81						
BL	163.38 ±1.29	166.67±1.41				181.60±1.53	182.37±8.33	175.59±6.60
UTL	49.10±1.12	49.15±0.35					65.70±1.16	66.17±1.95
FMH	17.65±0.99	18.93±0.61		19.2	18.75		19.41±1.14	17.83±1.54
FMW	19.88±0.29	19.01±0.59		19.7	20.48		21.76±1.06	20.81±1.79
OH	32.87±0.30	32.80±0.86		36.4	36.93			
OW	35.74±0.28	37.55±0.67		51.1	39.07		36.17±0.73	36.63±0.86
DS	44.62±1.73	48.72±1.11	95.1±1.44					

All parameters are presented in mm

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dicted by variables measuring the growth of the skull, brain, or face; while in males, changes in complexity were best predicted by variables representing mechanical loading and frontal bone growth [23].

Abramov and Tumanov (2003) reported that zygomatic breadth and interorbital width were adequate for 96.5% correct classification of European mink Mustela lutreola. The male skull of M. lutreola is characterized by a relatively high neurocranium, widely arranged zygomatic arches, a wide rostrum, and with wider auditory bullae and higher mandibles [24].

Farhadnia et al. (2014) explored the skull of Persian leopard (Panthera pardus saxicolor). They observed significant inter-sexual differences in the samples' skull size. Their study also revealed that inter-sexual differentiation was also remarkable when comparing morphometric body measurements in adults. Their achieved data indicated that males have a larger head mass and longer body; however, there were no gender-specific differences in subadults [25].

Pitakarnnop et al. (2017) reported that no parameters from the skull demonstrated a significant difference between males and females cats. However, one parameter,

Table 4. The comparison of the measurements of some parameters in the mandible of the Zell sheep with other sheep breeds

Parameter	Mean±SD				
	Male Zell Sheep	Female Zell Sheep	Iranian Native Sheep	Mehraban Sheep	Barbados Black Belly Sheep
TMA	26.11±1.63	25.06±2.35	20.3±0.11		
CCL	132.02±7.02	134.3 ±7.6	140.8±0.01		181.6±1.53
DL	36.85±2.72	37.08±4.48	27.6±0.05	39.8±0.48	
LTL	49.68±4.2	49.43±1.4			
ML	143.02±7.6	142.02±8.62		157.6±2.25	
MI	17.45±1.65	21 ±3.06			2.25±0.31
MM	19.41±2.26	16.23±3.25			
MMA	71.96±4.43	69.81±7.19	62.6±0.17	77.5±0.96	70.8±0.73
CBM	17.42±0.05	18.22±0.02			
CM	15.71±0.03	15.35±0.05		13.5±0.29	
MB	28.25±1.32	27.43±1.45		41.4±0.47	
MW	69.81±7.19	71.96± 4.43			
MH	101.60±4.08	92.01±2.05		95.7±2.71	

All parameters are presented in mm

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Masseteric Moment Arm (MMA), was significantly higher in males with an accuracy of 64.9%. Similar to our study, a mandibular parameter was significantly different between males and females; although this parameter was MI (83.33% accuracy) in the present study [14].

Moreover, many data such as TL, NL, MCS, MCI, CBL, ZIB, NCB, BL, UTL, FMH, OH, OW, DS, CCL, and Ml of Zell sheep was less, compared to the other studied sheep breeds, including Iranian breeds Therefore, we consider the Zell sheep breed as the smallest sheep in Iran and among the other studied sheep breeds (Table 3, 4) [3, 23, 24, 26-28].

The current study suggested that the distance of lateral alveolar root to mental foramen on mandible can be an appropriate landmark in gender estimation in Zell sheep. It also identified the skull of Zell sheep as the smallest studied sheep skull.

Ethical Considerations

Compliance with ethical guidelines

There was no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization: Behrokh Marzban Abbasabadi; Methodology: Behrokh Marzban Abbasabadi; Investigation: All authors; Writing-review & editing: All authors; Funding Acquisition: Behrokh Marzban Abbasabadi; Supervision: Behrokh Marzban Abbasabadi.

Conflict of interest

The authors stated no conflicts of interest.

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