

Foramen Magnum and Dental Osteometry of Balami, Uda, and Yankasa Breeds of Sheep

Shaibu Mohammed Atabo^{1*}, Abubakar Abubakar Umar²,
Sani Abdullahi Shehu^{1,2}, Adamu Abdul Abubakar³, Alhaji Zubair Jaji⁴,
Fatima Oyenike Oyelewo⁵, Tauheed Abubakar Muazu¹, Abdullahi Baso¹,
Tantri Dyah Whidi Palupi⁶, Zulfi Nur Amrina Rosyada⁶

¹Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Bayero University, PMB 3011, Gwarzo Road Kano, Nigeria, ²Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto State, Nigeria, ³Department of Veterinary Surgery and Radiology, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto State, Nigeria, ⁴Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Ilorin, Ilorin, Kwara State, Nigeria, ⁵Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Abuja, Rafin Pa, Federal Capital Territory, Nigeria, ⁶Division of Veterinary Anatomy, Faculty of Veterinary Medicine, Universitas Airlangga, Surabaya, Indonesia.

*Corresponding author: smatabo.van@buk.edu.ng

Abstract

The increasing demand for animal protein, particularly meat, requires a thoughtful approach to selecting the type of meat-producing animal to achieve maximum yields. This is crucial to maintain food security. This study aimed to evaluate and compare some skull osteometries. A total of 60 each of Balami, Uda, and Yankasa sheep (30 adult males and 30 adult females) were used in this study. The skulls were macerated using a hot water technique. Then 7 parameters were measured using a digital Vernier caliper. The obtained data were analyzed using ANOVA ($p < 0.05$). The result of this study was that the mean foramen magnum height (FMH) was highest, medium, and lowest in the Balami (2.1 ± 0.1 cm), Uda (1.9 ± 0.1 cm), and Yankasa (1.8 ± 0.0 cm) breeds, respectively, and vice versa in the foramen magnum index (FMI). The foramen magnum width (FMW) was similar in Balami and Uda but higher than in Yankasa (1.8 ± 0.1 cm). The FMH, FMW, and FMI were similar within sexes of the same breeds in Balami, Uda, and Yankasa. The mean dental length (DL), oral palatal length (OPL), and length of the upper molar row (LUM) were highest and lowest in Balami and Yankasa, respectively, while the mean length of the upper premolar row (LUP) was highest and lowest in Balami and Uda, respectively. The (DL), (OPL), (LUM), and (LUP) were higher in males than females in Balami and vice versa in Uda and Yankasa. In conclusion, craniometric values, including foramen magnum and dental osteometry, of indigenous Nigerian sheep breeds were used to compare them to other breeds and among themselves. It could also guide oral surgery and assist in identifying sheep breeds through comparative study.

Keywords: craniometry, dental, food security, foramen magnum, osteometry

Received: 10 June 2023

Revised: 27 October 2023

Accepted: 27 November 2023

INTRODUCTION

Sheep were among the first animals to be domesticated by humans, and the domestication process led to significant morphological and anatomical changes in the animals' head and body structures over time. These changes gave rise to variations within the same species, with gender being one of the factors influencing these variations (Can, *et al.*, 2022). Different breeds of animals are frequently identified and described using osteometric criteria (Acosta *et al.*, 2018; Hanafi *et al.*, 2021).

The major components of the body and skeletal system are the head and the skull, respectively. Craniomorphology and craniometry have revealed taxonomic affinities and modifications brought on by natural selection in animals (Popoola and Oseni, 2018). Several works of literature (Atabo *et al.*, 2022; Rodrigo *et al.*, 2020) have used the characteristics of the skull's craniometry to describe various sheep breeds. Using multivariate analysis, Popoola and Oseni (2018) identified the indigenous sheep breeds of the Balami, Uda, and Yankasa in Nigeria. However, there is little study on the



morphological variation of the skull, particularly in the sheep breeds from Nigeria.

Therefore, the purpose of the study was to determine the Foramen magnum and dental osteometry of the sheep breeds from Nigeria. The results will be used as a guide for oral surgery and to help comparative studies that can help identify different sheep breeds. On the other hand, to support the health of sheep as beef or dairy sheep and maximize yields in response to the rising demand for animal protein, specifically flesh, a methodical approach is necessary in the selection of meat-producing animals, so, this is essential for ensuring food security.

MATERIALS AND METHODS

Ethical Approval

Usmanu Danfodiyo University in Sokoto's Institutional Animal Care and Use Committee gave their approval for this study under reference number UDUS/FAREC/2019/AUP-RO-17.

Animal and Experimental Design

This study employed a purposive sampling strategy and a cross-sectional design. Balami, Uda, and Yankasa sheep breeds totaled 60 in total; 30 adult males and 30 adult females from each breed were collected from their naturally dominant geographic regions in northern Nigeria. The whole heads of the sheep were collected after slaughtered and transported in a nylon bag containing ice to the Veterinary Anatomy Laboratory, Department of Veterinary Anatomy, Usmanu Danfodiyo University Sokoto for further analysis. The samples of the three breeds were grouped into male and female, the ages of heads were estimated through their dentition (Umar *et al.*, 2018) and sub-grouped into young ($1 \leq$ year) and adult (>1 year).

The heads were weighed and then macerated using the hot water technique to harvest the skull (Atabo *et al.*, 2022). The heads' skin and muscles were removed, as well as those on the eyes, mouth, and nasal cartilage. The brains were expelled by pouring water repeatedly through the foramen magnum until complete evacuation took place while the cerebral cavity was being

disturbed with long forceps or violent shaking. The bones were heated to over 80°C for 1 hour in a metal drum containing a mixture of anionic detergent and crystallized sodium hydrous carbonate. Knives and scalpels were used to extract the remaining flesh from the cooked bones. Following a 48-hour soak in water with detergent and crystallized sodium hydrous carbonate, during which the solution was changed twice every 24 hours, the bones were extracted from their remaining flesh and ligaments using a sponge and knives. The bones were then cleaned under running water from the faucet and left to dry for seven days.

Foramen Magnum Parameter

The following measurements by using definitions of measuring parameters of foramen magnum were made consisted of Foramen Magnum Height (FMH) which is the distance between the midpoints of the dorsal and ventral rims of the foramen magnum; Foramen Magnum Width (FMW) which is measured the maximum width between two occipital condyles; Foramen Magnum Index (FMI) which is measured the foramen magnum height \times 100 per FMW.

Dental Osteometry Parameter

The following measurements by using definitions of measuring parameters of foramen magnum were made consisting of the measured of the mean dental length (DL), oral palatal length (OPL), and length of the upper molar row (LUM).

Data Analysis

The results of the measurement of foramen magnum craniometry and dental craniometry were presented as means \pm SD in Table 1 and Table 2, respectively. The data obtained were analyzed using ANOVA test and Duncan's follow-up test at a 95% confidence level.

RESULTS AND DISCUSSION

Foramen Magnum Craniometry

The mean of FMH was highest, medium, and lowest in the Balami (2.1 ± 0.1 cm), Uda (1.9 ± 0.1 cm), and Yankasa (1.8 ± 0.0 cm) breeds,

respectively. The FMH was similar within the sexes of the same breeds. The FMH only had a significant difference between both sexes of Balami and Yankasa females (1.8 ± 0.1 cm) ($p < 0.05$).

The pattern of FMW, was similar in Balami and Uda and lowest in Yankasa (1.8 ± 0.1 cm). Similarly, the mean of FMW was similar within the sexes of Balami and Uda but lower in females than males in the Yankasa breed. However, a significant difference occurred between Balami females (2.0 ± 0.1 cm) and Yankasa females (1.8 ± 0.1 cm).

The mean of FMI was highest in Uda (105.7 ± 9.8 %), medium in Yankasa (103.8 ± 13.6 %), and lowest in Balami (95.6 ± 6.0 %) breeds respectively. The FMI in the males and females were similar within breeds, and there are no significant differences among the three breeds ($p > 0.05$) (Table 1).

The mean of FMH was the highest, medium, and lowest in Balami, Uda, and Yankasa breeds respectively. The height of the foramen magnum was 2.0 ± 1.2 cm in Bardhoka Kosovo breeds of sheep (Gündemir *et al.*, 2020), 1.69 ± 0.29 cm in Suffolk Down Chilean breed of sheep (Rodrigo *et al.*, 2020), 1.8 ± 0.61 mm in the Zell Iranian breeds of sheep (Abbasabadi *et al.*, 2018), 2.2 ± 2.0 cm in Turkish Hemshin breed sheep (Dalga *et al.*, 2018), 1.4 ± 1.3 cm in Polish Heath breeds of sheep (Baranowski, 2017), 1.9 ± 0.0 cm in Western Iranian Mehraban sheep (Karimi *et al.*, 2011), 1.8 ± 0.0 cm in Spanish Xisqueta breed of sheep (Parés Casanova *et al.*, 2010), and 1.9 ± 1.1 cm in Morkaraman breeds of sheep (Özcan *et al.*, 2010). In this study, the mean height of the foramen magnum was similar within the sexes of the same breeds. This agrees with Gündemir *et al.* (2020) who they reported 2.0 ± 0.8 cm and 2.0 ± 1.2 cm as FMH for male and female Bardhoka Kosovo breeds of sheep respectively. Meanwhile, Abbasabadi *et al.* (2018) reported 1.7 ± 0.9 cm and 1.8 ± 0.6 cm as FMH for male and female Iranian Zell breeds of sheep respectively.

The pattern of FMW was similar in Balami and Uda and lowest in Yankasa. The FMW in adult Western Iran Mehraban sheep was 1.97 ± 0.0 cm (Karimi *et al.*, 2011), in 2.0 ± 0.0 cm

Spanish Xisqueta breed sheep (Parés Casanova *et al.*, 2010), 2.1 ± 1.0 cm and 2.0 ± 1.7 cm in Morkaraman and Tuj breeds of sheep (Özcan *et al.*, 2010), 1.9 ± 0.2 cm in the Iranian Zell breeds of sheep (Abbasabadi *et al.*, 2018). The similarity in the mean FMW within the sexes of Balami and Uda agrees with Abbasabadi *et al.* (2018) who reported 1.9 ± 0.2 cm and 1.9 ± 0.5 cm in male and female Iranian Zell breeds of sheep respectively.

The mean of FMI was highest in Uda, medium in Yankasa, and lowest in Balami breeds respectively. However, the mean FMI reported by Gündemir *et al.* (2020) in the Bardhoka Kosovo breed of sheep was lower than in the three Nigerian breeds of sheep. The FMI in the males and females were similar within breeds which also agrees with Gündemir *et al.* (2020) who reported 94.48 ± 6.8 % and 93.68 ± 9.6 % in female and male Bardhoka Kosovo breeds of sheep respectively.

Dental Craniometry

The mean length from the post-dental to the DL was highest in Balami (14.3 ± 0.8 cm), medium in Uda (11.7 ± 0.9 cm), and lowest in Yankasa (9.2 ± 0.2 cm). The DL was similar within the sexes of Uda and Yankasa breeds, but higher in male than female Balami. The pairwise statistics reveal that the difference in the DL of Uda and Yankasa females was insignificant. However, the Balami male DL differed significantly with both sexes of Uda and Yankasa breeds ($p < 0.05$).

The mean of OPL was highest in Balami (11.3 ± 0.5 cm), medium in Uda (9.4 ± 0.7 cm), and lowest in Yankasa (7.5 ± 0.2 cm). The mean OPL in the females was higher than the males within the Uda and Yankasa breeds, but statistically insignificant ($p > 0.05$). The Balami male had a higher OPL than its female (10.9 ± 0.9 cm) and it differed significantly for both sexes of the Uda and Yankasa breeds ($p < 0.05$).

The mean length of LUM was highest in Balami (4.1 ± 1.2 cm) and lowest in Yankasa (1.6 ± 0.0 cm). It was longer in the females than males within Uda and Yankasa, and vice versa in Balami. The pairwise statistics showed significant

Table 1. Foramen magnum craniometry of the three breeds of sheep

Indices	Balami		Uda		Yankasa	
	Male	Female	Male	Female	Male	Female
FMH (cm)	2.1 ± 0.1 ^b	2.1 ± 0.0 ^a	1.9 ± 0.1	1.9 ± 0.1	1.8 ± 0.0	1.8 ± 0.1 ^{ab}
FMW (cm)	2.0 ± 0.0	2.0 ± 0.1 ^a	2.0 ± 0.0	2.0 ± 0.2	1.9 ± 0.2	1.8 ± 0.1 ^a
FMI (%)	95.6 ± 7.5	95.6 ± 6.0	105.7 ± 9.8	105.9 ± 8.3	103.8 ± 13.6	101.7 ± 5.1

Means with the same superscript across the breeds in the same row differ significantly ($p < 0.05$).

Foramen magnum height (FMH), Foramen magnum width (FMW), and Foramen magnum index (FMI).

Table 2. Dental craniometry of the three breeds of sheep

Indices	Balami		Uda		Yankasa	
	Male	Female	Male	Female	Male	Female
DL	14.3 ± 0.8 ^{fhij}	13.4 ± 0.9 ^{abcd}	11.2 ± 0.4 ^{cik}	11.7 ± 0.9 ^{aefg}	9.2 ± 0.2 ^{djgk}	9.9 ± 0.8 ^{bhe}
OPL	11.3 ± 0.5 ^{fhij}	10.9 ± 0.9 ^{abcd}	9.0 ± 0.3 ^{ci}	9.4 ± 0.7 ^{aefg}	7.5 ± 0.2 ^{dgi}	8.0 ± 0.7 ^{beh}
LUM	4.1 ± 1.2 ^d	3.5 ± 0.7 ^a	3.4 ± 0.5	3.8 ± 1.1 ^b	1.6 ± 0.0 ^{abcd}	3.4 ± 0.5 ^c
LUP	3.4 ± 0.1	2.9 ± 0.4	2.4 ± 0.2 ^a	2.7 ± 0.4	3.5 ± 0.2 ^a	2.9 ± 0.5

Means with the same superscript across the breeds in the same row differ significantly ($p < 0.05$).

Dental length (DL), Oral palatal length (OPL), Length of the upper molar row (LUM), and Length of the upper premolar row (LUP).

difference between the Yankasa males (1.6 ± 0.0 cm) and females (3.4 ± 0.5 cm) ($p < 0.05$), between both sexes of Balami and Yankasa females. No significant difference between the Balami and Uda, ($p > 0.05$).

The mean length of LUP showed that it was longer in Yankasa (3.5 ± 0.2 cm) and shortest in Uda (2.4 ± 0.2 cm). The LUP was longer in males than females in Balami and Yankasa and vice versa in Uda. The pairwise statistics revealed there were no significant differences between and within breed and sex across the three groups except between Uda males (2.4 ± 0.2 cm) and Yankasa males (3.5 ± 0.2 cm) ($p < 0.05$) (Table 2).

The mean length from the post-dental to the DL was highest in Balami, medium in Uda, and lowest in Yankasa. The dental DL reported by Gündemir *et al.* (2020) Bardhoka Kosovo breeds of sheep (12.9 ± 9.7 cm) measured from the tip of an incisive bone to the caudal border of the last molar DL was lower than the DL in Balami but higher than in Uda and Yankasa breeds. The DL by Dalga *et al.* (2018) in Turkish Hemshin breed sheep (12.0 ± 11.4 cm) and Baranowski (2017) in Polish Heath breed sheep (12.1 ± 8.9 cm) were measured from Postdentale-Prosthion similar to this study, although the DL values obtained were lower than the Balami and higher than the Uda

and Yankasa DL. According to Özcan *et al.* (2010), the DL (Postdentale-Prosthion) in Morkaraman (11.965 ± 4.5 cm) and Tuj (11.7 ± 3.8 cm) breeds of sheep were lower, similar, and higher than the DL in Balami, Uda, and Yankasa breeds of sheep respectively. The DL was similar within the sexes of Uda and Yankasa breeds, similar to the work of Gündemir *et al.* (2020), who reported 12.6 ± 6.6 cm and 12.9 ± 9.7 cm in male and female Bardhoka Kosovo breeds of sheep, respectively.

The mean of OPL was highest in Balami, medium in Uda, and lowest in Yankasa. The mean of OPL reported by Dalga *et al.* (2018) in Turkish Hemshin breed of sheep (9.5 ± 7.8 cm), Baranowski (2017) in Polish Heath breeds of sheep (9.6 ± 6.0 cm), Özcan *et al.* (2010) in Morkaraman (8.3 ± 3.7 cm) and Tuj (8.1 ± 3.1 cm) breeds of sheep indicates that the roof of their mouth is shorter, similar, and longer compared to the Balami, Uda, and Yankasa breeds respectively.

The mean length of LUM was highest in Balami and lowest in Yankasa. The LUM reported by Dalga *et al.* (2018) in Turkish Hemshin breed sheep, Baranowski (2017) in the Polish Heath breed of sheep, Özcan *et al.* (2010) in Morkaraman and Tuj breeds of sheep were 4.0 ± 8.4 cm, 3.5 ± 2.7 cm, and 2.8 ± 1.1 cm and 3.0

± 3.1 cm respectively. The LUM was longer in the female than the male within Uda and Yankasa and vice versa in Balami; this could be due to the variations in the age groups and timing of eruption of the molar teeth (Megawati *et al.*, 2020). The mean length of LUP showed that it was longer in Yankasa and shortest in Uda. The LUP were 2.8 ± 1.1 and 3.0 ± 3.1 in Morkaraman and Tuj breeds of sheep, respectively (Özcan *et al.*, 2010); 3.0 ± 4.0 in Polish Heath breeds of sheep (Baranowski, 2017); and 2.1 ± 1.8 Turkish Hemshin breed of sheep (Dalga *et al.*, 2018).

CONCLUSION

The observed dissimilarities in the foramen magnum and dental osteometry of Balami, Uda, and Yankasa breed sheep are hypothesized to be attributed to breed variations. To sustain the health of sheep as beef or dairy sheep and maximize yields in response to increased demand for animal protein, notably flesh, a rigorous approach to meat-producing animal selection is required. This is critical for maintaining food security. Furthermore, this study will provide a valuable contribution to the clinical approach and enhance the current supply of literature on the topic.

ACKNOWLEDGEMENTS

The authors express their gratitude to the Veterinary Anatomy Laboratory, Department of Veterinary Anatomy, Usmanu Danfodiyo University Sokoto.

AUTHORS' CONTRIBUTIONS

All authors contributed to the research and preparation of this manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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