RESEARCH ARTICLE

Craniometrical characteristics of the Uda and Yankasa breeds of sheep (*Ovis aries*)

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ABSTRACT

This study aimed to examine and compare the osteometric characteristics of the skulls of Uda and Yankasa sheep breeds. A total of 10 skulls of indigenous sheep breeds, comprising five Uda and five Yankasa rams aged between 12 and 18 months, were used for this study. The samples were obtained from Bauchi Metropolis, Bauchi State, Nigeria and transported to the Gross Anatomy laboratory, Department of Veterinary Anatomy, University of Maiduguri, Borno State, for bone processing. The bones were processed using hot water maceration and soft tissue removal techniques. About 39 cranial and mandibular measurements were identified. Comparative analysis of dorsal, caudal, ventral, lateral, and mandibular parameters revealed no statistically significant differences ($p > 0.05$) between Uda and Yankasa breeds across most measurements. Osteometric findings revealed that viscerocranial length-related parameters such as INL, VCrL, NL, IOL, MDL, and IISL were slightly higher in Yankasa than in Uda. However, neurocranial length-related parameters such as NCrL, ChL and HPL were slightly higher in Uda than in Yankasa. Yankasa also exhibited wider skull profiles, as reflected in IZW, HPW, ChW, IMDAW, NW and NCWLB, although the differences were not statistically significant. This study provides valuable osteometric data on Uda and Yankasa sheep breeds for taxonomic classification, evolutionary studies, and veterinary clinical applications such as regional anesthesia and surgical procedures involving the head.

Keywords: Craniometrics, osteometry, sheep, Uda, Yankasa

INTRODUCTION

There are generally four recognized indigenous sheep breeds in Nigeria (Popoola and Oseni, 2018), among which Uda and Yankasa account for approximately 70% of the estimated 39 million sheep population (Ramalan, 2022). These two breeds exhibit distinct physical features, particularly in their coat color, tail configuration, and growth characteristics (Madikadike and Tyasi, 2024).

The skull serves as a protective framework for the brain and sense organs while supporting the masticatory system. Its shape and dimensions therefore reflect both evolutionary divergence and adaptive responses to diet, climate, and management conditions (Dyce et al., 2010). Studies in craniomorphology and craniometry have proven useful in identifying taxonomic relationships and adaptive modifications resulting from natural selection (Popoola and Oseni,

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2018). Several researchers have used craniometric parameters to distinguish between different sheep breeds (Atabo et al., 2022; de la Barra et al., 2020). Using multivariate statistical methods, Popoola and Oseni (2018) successfully characterized the Balami, Uda, and Yankasa breeds indigenous to Nigeria. In some breeds of sheep such as Uda and Yankasa, these measurements are invaluable for distinguishing breeds, supporting taxonomic classification, and informing breeding, production, and conservation programs (Hailu, 2022). Although several studies have explored skull development in sheep (Olopade and Onwuka, 2005; Reda et al., 2016; Shehu et al., 2019), there is still limited information on the morphometric and craniometric characteristics of Uda and Yankasa rams native to Nigeria.

Numerous studies have investigated developmental changes in the sheep skull, including those of Olopade and Onwuka (2005), Avdić et al. (2013), Muhamed et al. (2016), Shehu et al. (2019), Dalga and Aslan (2021), Dalga et al. (2022), and Duro et al. (2025). However, there is a paucity of information on morphometric and craniometric variations of the skull, particularly in Uda and Yankasa rams from Nigeria. Therefore, this study aims to examine and compare the skull morphometry and craniometry of Uda and Yankasa rams to generate anatomical data that may facilitate breed identification, classification, and veterinary clinical applications.

MATERIAL AND METHODS

Sample collection

A total of 10 skulls of indigenous sheep breeds, comprising five Uda and five Yankasa rams aged between 12 and 18 months, were employed in this investigation. The samples were obtained from Bauchi Metropolis, Bauchi State, Nigeria, during the *Eid-el-Kabir* festival in June 2025 and transported to the Gross Anatomy laboratory, Department of Veterinary Anatomy, University of Maiduguri, Borno State, Nigeria, for bone processing.

Specimen preparation

Following the procedures described by Salami et al. (2011) and Gambo et al. (2016), all soft tissues adhering to the skulls, including fascia, muscles, ligaments and tendons, were carefully removed using scissors and a scalpel. The skulls were subsequently placed in two separate maceration pots filled with water to allow clear identification and differentiation. The samples were heated to boiling, after which the water was replaced. Polycarboxylate detergents were added to enhance the removal of fat, bone marrow, and any residual soft tissue. The macerated skulls were then immersed in 30% hydrogen peroxide for two days, thoroughly rinsed with water, and air-dried under sunlight. After preparation, the morphology and structural attributes of the cleaned skull bones were examined, and their metric dimensions were measured in centimeters (cm). Photographic documentation of the bones from different anatomical orientations was obtained using a Canon EOS 1300D digital camera.

Landmarks for craniometric measurements

According to the method adopted by Gambo et al. (2016), the following 39 landmarks of the skull (Figure 1-6) were considered.

i. Incisive-Nuchal Length (INL): Distance from the rostral tip of the incisive bone to the external occipital protuberance (nuchal crest).
ii. Viscerocranial Length (VCrL): Measured from the rostral tip of the incisive bone to the naso-frontal suture along the midline.
iii. Neurocranial Length (NCrL): From the frontonasal suture to the lambdoid suture.
iv. Neurocranial Width at Lacrimal Bone (NWLB): Maximum transverse width at the level of the lacrimal bones, just in front of the orbits.
v. Neurocranial Width at Horn Base (NWHB): Maximum distance between the bases of both horn cores on the frontal bone.
vi. Nasal Length at Midline (NLM): From the tip of the nasal bones along the midline to the frontonasal suture.
vii. Nasal Width (NW): Greatest transverse width across the nasal bones.
viii. Inter-Supraorbital Foramen Length (ISOFL): Between the left and right supraorbital foramina, above the orbit (frontal bone).
ix. Distance between the Horn Neck (DHN): Distance between the inner borders of the horn cores where they begin to project from the skull (horn necks).
x. Foramen Magnum Height (FMH): Vertical distance from the dorsal to ventral margin of the foramen magnum.
xi. Foramen Magnum Width (FMW): Horizontal distance from the rostral to caudal margin of the foramen magnum.

xii. Maximum Intercondylar Width (MICW): Widest distance between the occipital condyles (lateral edges).

xiii. Maximum Inter-Paracondylar Width (MIPCW): Maximum distance between the lateral ends of the paracondylar processes.

xiv. Paracondylar Process Length (PCPL): From the base to the tip of the paracondylar process.

xv. Inter-Cornual Protuberance to Foramen Magnum (ICPFM): From the center of the intercornual protuberance to the dorsal margin of the foramen magnum.

xvi. Incisivo-Occipital Length (IOL): Distance from the rostral tip of the incisive bone to the base of the occipital condyle.

xvii. Choana Length (ChL): Measured from the caudal margin of hard palate to basisphenoid bone.

xviii. Choana Width (ChW): Measured transversely between the widest lateral borders of the right and left choanae.

xix. Hard Palate Length (HPL): Measured along the midline from the caudal margin of the hard palate to the rostral tip of the incisive bone.

xx. Palatine Width (HPW): Measured across the widest part of the palatine process, from one lateral edge to the other.

xxi. Inter-incisive Suture Length (IISL): From the rostral tip of the incisive bone to the caudal end of the inter-incisive suture at the maxillary border.

xxii. Incisive Width (IcW): Measured transversely across the most lateral points of the incisive bones.

xxiii. Inter-Zygomatic Width (IZW): Measured from the outermost lateral edge of the right zygomatic arch to the outermost lateral edge of the left zygomatic arch.

xxiv. Orbital Height (ObH): Measured vertically from the dorsal orbital rim to the ventral orbital rim.

xxv. Orbital Width (ObW): Horizontal distance across the widest part of the orbit.

xxvi. Facial Tuberosity to Infraorbital Foramen (FTIOF): From the most prominent point of the facial tuberosity to the mid-caudal margin of the infraorbital foramen.

xxvii. Infraorbital Foramen to Root of Alveolar Tooth (IFRAT): Vertical distance from the infraorbital foramen to the root of the alveolar tooth ventral to it.

xxviii. Mandibular Length (MDL): From the rostral tip of the mandible to the caudal border of the mandibular angle.

xxix. Maximum Height of Mandible (MHMD): Vertical distance from the mandible base to the tip of the coronoid process.

xxx. Base of Mandible to Condyloid Fossa (BMCF): From the ventral border of the mandible to the condyloid fossa.

xxxi. Maximum Height to Condyloid Fossa (MHCF): From the lowest point of the mandible base to the top of the condyloid fossa.

xxxii. Diastemal Length (DL): Distance from the alveolar root of the last incisor to the first premolar.

xxxiii. Lateral Alveolar Root to Mental Foramen (LARMF): From the alveolar root of the lateral incisor to the caudal edge of mental foramen.

xxxiv. Mandibular Symphyseal Length (MSL): From the rostral-most point of the mandibular symphysis to the caudal end of the symphyseal fusion.

xxxv. Base of Mandible to Mandibular Foramen (BMMF): From the lowest point of the base of the mandible to the center of the mandibular foramen (medial side).

xxxvi. Mandibular Foramen to Caudal Border of Mandible (MFCBM): Distance from the mandibular foramen to the posterior edge of the mandible.

xxxvii. Mandibular Body Height (MDBH): From the alveolar margin to the widest part of the base of the mandible.

xxxviii. Intermandibular Angle Width (IMDAW): Between the inner caudal angles of the left and right mandibular halves. This is the transverse width across the mandible at its widest part.

xxxix. Mandibular Foramen to Coronoid Process (MDFCP): From the mandibular foramen to the tip of the coronoid process.

Statistical analysis

The morphometric data generated in this study were analyzed using descriptive statistics and presented as mean ± standard deviation (SD), along with column chart visualizations. Differences between mean values were evaluated using the independent samples t-test. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 20.0.

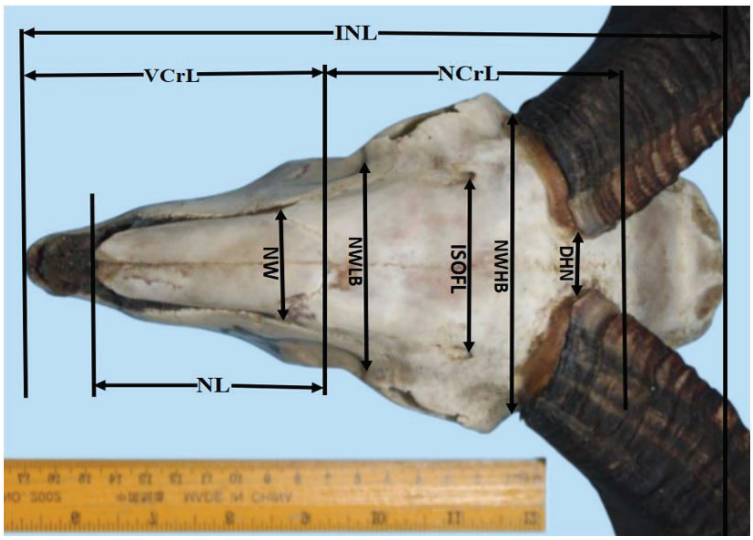

Figure 1 Skull measurements (Dorsal view) showing Incisive-Nuchal Length (INL), Viscerocranial Length (VCrL), Neurocranial Length (NCrL), Neurocranial Width at Lacrimal Bone (NWLB), Neurocranial Width at Horn Base (NWHB), Nasal Length (NL), Nasal Width (NW), Inter-Supra Orbital Foramen Length (ISOFL), Distance between the Horn Neck (DHN)

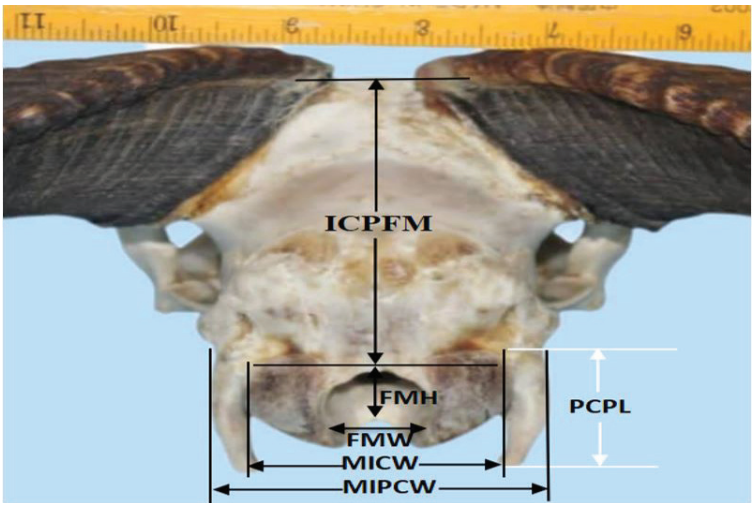

Figure 2 Skull measurements without the mandible (Caudal view) showing Foramen Magnum Height (FMH), Foramen Magnum Width (FMW), Maximum Intercondylar Width (MICW), Maximum Inter-Paracondylar Width (MIPCW), Paracondylar Process Length (PCPL), Inter-Cornual Protuberance to Foramen Magnum (ICPFM)

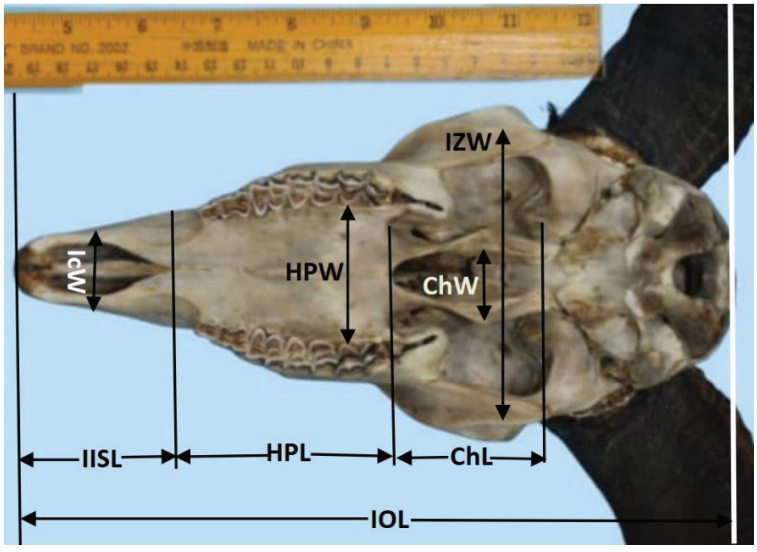

Figure 3 Skull measurements without the mandible (Ventral view) showing Incisivo-Occipital Length (IOL), Choana Length (ChL), Choana Width (ChW), Hard Palate Length (HPL), Palatine Width (HPW), Interincisive Suture Length (IISL), Incisive width (IcW) Inter-Zygomatic Width (IZW)

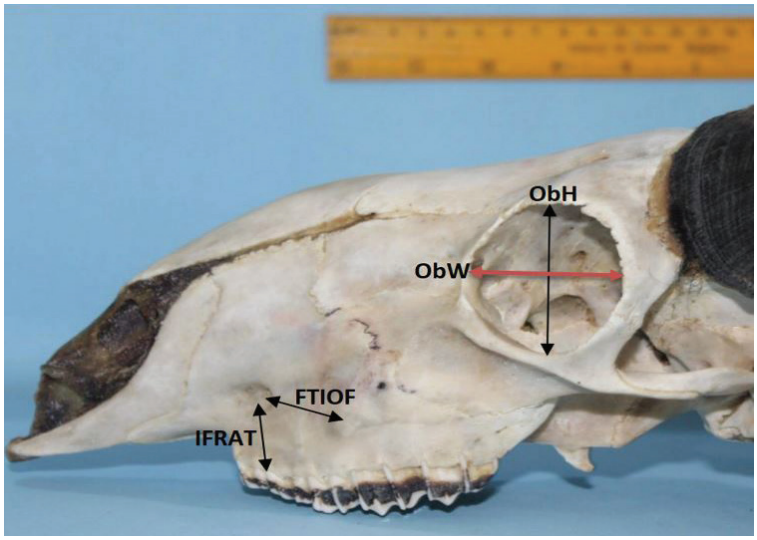

Figure 4 Skull measurements without the mandible (Lateral view) showing Orbital Height (ObH), Orbital Width (ObW), Facial Tuberosity to Infraorbital Foramen (FTIOF), Infraorbital Foramen to Root of Alveolar Tooth (IFRAT)

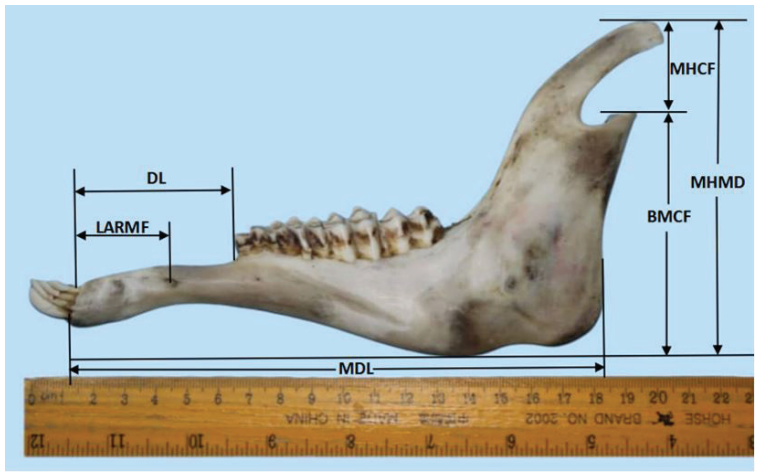

Figure 5 Mandible measurements (Lateral view) showing Mandibular Length (MDL), Maximum Height of Mandible (MHMD), Base of Mandible to Condyloid Fossa (BMCF), Maximum Height to Condyloid Fossa (MHCF), Diastemal Length (DL), Lateral Alveolar Root to Mental Foramen (LARMF)

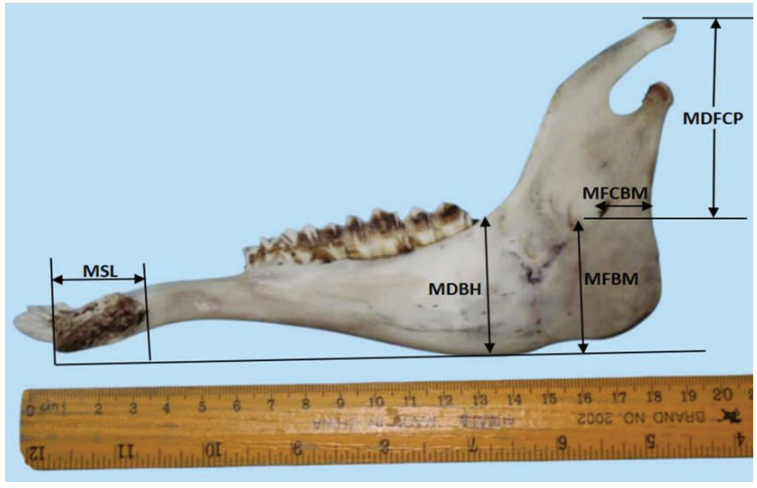

Figure 6 Mandible measurements (medial view) showing Mandibular Symphysis Length (MSL), Mandibular Foramen to Base of Mandible (MFBM), Mandibular Foramen to Caudal Border of Mandible (MFCBM), Mandibular Body Height (MDBH), Mandibular foramen to coronoid process (MDFCP)

RESULTS

Dorsal and Caudal parameters of Yankasa and Uda skulls

Fifteen morphometric parameters were recorded from the dorsal and caudal aspects of the Yankasa and Uda skulls (Table 1). The mean Incisive–Nuchal Length (INL) was 22.08 ± 2.43 cm in Yankasa and 21.08 ± 2.06 cm in Uda. The mean Viscerocranial Length (VCrL) was 9.62 ± 1.62 cm in Yankasa compared to 9.12 ± 1.39 cm in Uda, while the mean Neurocranial Length (NCrL) was 8.36 ± 0.72 cm and 8.66 ± 0.57 cm in Yankasa and Uda, respectively. The mean Neurocranial Width at the Lacrimal Bone (NWLB) was 5.60 ± 0.55 cm in Yankasa and 5.20 ± 0.84 cm in Uda, and the mean Neurocranial Width at the Horn Base (NWHB) was 8.90 ± 0.45 cm in Yankasa versus 8.48 ± 0.66 cm in Uda.

The Nasal Length (NL) averaged 8.04 ± 0.89 cm for Yankasa and 7.98 ± 1.04 cm for Uda, while Nasal Width (NW) measured 3.34 ± 0.70 cm and 3.00 ± 0.42 cm, respectively. The Inter-Supraorbital Foramen Length (ISOFL) was 4.98 ± 0.47 cm in Yankasa and 4.90 ± 0.43 cm in Uda. The Distance between the Horn Necks (DHN) recorded 5.36 ± 1.17 cm in Yankasa and 6.00 ± 0.37 cm in Uda. Mean Foramen Magnum Height (FMH) and Width (FMW) were similar between the breeds. Other parameters, including MICW, MIPCW, PCPL, and ICPF, also showed minimal variation. Overall, none of the 15 dorsal and caudal parameters exhibited statistically significant differences ($p > 0.05$) between Yankasa and Uda skulls.

Ventral and Lateral Parameters of Yankasa and Uda skulls

Twelve morphometric parameters were recorded from the ventral and lateral aspects of the Yankasa and Uda skulls (Table 2). The mean Incisivo-Occipital Length (IOL) was 21.86 ± 2.07 cm in Yankasa and 21.40 ± 2.00 cm in Uda. The Choana Length (ChL) averaged 4.70 ± 0.35 cm in Yankasa compared with 4.76 ± 0.55 cm in Uda, while the Choana Width (ChW) was 1.54 ± 0.13 cm and 1.48 ± 0.08 cm, respectively. The Hard Palate Length (HPL) was similar between the breeds, measuring 6.34 ± 0.84 cm in Yankasa and 6.40 ± 0.85 cm in Uda.

The Palatine Width (HPW) was 4.16 ± 0.29 cm in Yankasa and 3.84 ± 0.34 cm in Uda, whereas the Inter-Incisive Suture Length (IISL) was 5.36 ± 0.87 cm and 5.02 ± 0.47 cm, respectively. Incisive Width (IcW) was 3.72 ± 0.48 cm in Yankasa compared to 3.88 ± 0.97 cm in Uda. The Inter-Zygomatic Width (IZW) was 9.44 ± 0.58 cm in Yankasa and 8.76 ± 0.96 cm in Uda. Orbital Height (ObH) and Orbital Width (ObW) showed minimal variation between the breeds. The Facial Tuberosity to Infraorbital Foramen distance (FTIOF) was 2.14 ± 0.25 cm in Yankasa and 2.20 ± 0.29 cm in Uda, whereas the Infraorbital Foramen to Root of Alveolar Tooth (IFRAT) was 1.64 ± 0.29 cm and 1.52 ± 0.27 cm, respectively.

Overall, none of the twelve measured parameters showed statistically significant differences ($p > 0.05$) between the two breeds. Although several variables, including IOL, ChL, HPL, ObH, and FTIOF, demonstrated only minor variation, others such as HPW, IISL, IZW, and ObW exhibited comparatively greater differences that may indicate subtle breed-related morphological distinctions.

Mandibular Parameters of Yankasa and Uda Skulls

Twelve morphometric parameters were recorded from the lateral and medial surfaces of the mandibular bones of Yankasa and Uda skulls (Table 3). The mean Mandibular Length (MDL) was 15.72 ± 1.05 cm in Yankasa and 15.44 ± 1.68 cm in Uda, while the Maximum Mandibular Height (MMDH) was 10.24 ± 0.40 cm in Yankasa compared with 10.12 ± 1.08 cm in Uda. The Mandibular Body Height (MDBH) averaged 3.86 ± 0.26 cm in Yankasa and 3.98 ± 0.58 cm in Uda. The Base of Mandible to Condyloid Fossa (BMCF) was 7.68 ± 0.23 cm in Yankasa and 7.80 ± 0.90 cm in Uda, whereas the Maximum Height to Condyloid Fossa (MHCF) was 2.54 ± 0.15 cm and 2.28 ± 0.33 cm, respectively.

The Diastemal Length (DL) was 4.48 ± 0.40 cm in Yankasa and 4.18 ± 0.34 cm in Uda, and the Mandibular Symphyseal Length (MSL) was 2.42 ± 0.28 cm and 2.30 ± 0.21 cm, respectively. Measurements from the Mandibular Foramen to the Base of Mandible (MFBM) were 3.96 ± 0.36 cm in Yankasa and 4.00 ± 0.46 cm in Uda, while the distance from the Mandibular Foramen to the Caudal Border of the Mandible (MFCBM) was 1.42 ± 0.11 cm and 1.18 ± 0.49 cm, respectively. The Lateral Alveolar Root to Mental Foramen (LARMF) was 2.44 ± 0.34 cm in Yankasa and 2.44 ± 0.23 cm in Uda. The Inter-Mandibular Angle Width (IMDAW) averaged 5.82 ± 0.61 cm in Yankasa and 4.78 ± 0.41 cm in Uda, and the Mandibular Foramen to Coronoid Process distance (MDFCP) was 6.70 ± 0.75 cm and 6.66 ± 0.86 cm,

respectively. No statistically significant differences ($p > 0.05$) were observed for most mandibular parameters between the two breeds. However, IMDAW showed a statistically significant difference, with Yankasa exhibiting a greater mean value than Uda.

Table 1 Independent sample t-test for osteometric parameters of the dorsal and caudal surfaces of the skull in Yankasa and Uda sheep breeds

	Yankasa (n=5)			Uda (n=5)			
Parameters	**Min.**	**Max.**	**Mean ± SD**	**Min.**	**Max.**	**Mean ± SD**	**p-value**
INL	20.20	25.90	22.08±2.43	19.60	24.20	21.08±2.06	0.502 ^{ns}
VCrL	7.90	12.20	9.62±1.62	7.30	11.10	9.12±1.39	0.615 ^{ns}
NCrL	7.50	9.20	8.36±0.72	8.00	9.20	8.66±0.57	0.484 ^{ns}
NCWLB	5.0	6.0	5.60±0.55	4.00	6.00	5.20±0.84	0.397 ^{ns}
NCWHB	8.30	9.40	8.90±0.45	7.80	9.40	8.48±0.66	0.275 ^{ns}
NL	7.10	9.50	8.04±0.89	6.70	9.10	7.98±1.04	0.925 ^{ns}
NW	2.80	4.50	3.34±0.70	2.60	3.50	3.00±0.42	0.379 ^{ns}
ISOFL	4.40	5.60	4.98±0.47	4.40	5.30	4.90±0.43	0.786 ^{ns}
DHN	3.80	7.00	5.36±1.17	5.40	6.40	6.00±0.37	0.277 ^{ns}
FMH	2.00	2.40	2.22±0.15	2.00	2.50	2.24±0.21	0.865 ^{ns}
FMW	1.60	2.30	2.06±0.28	2.00	2.20	2.14±0.09	0.559 ^{ns}
MICW	4.10	6.10	5.14±0.71	4.90	5.30	5.14±0.17	1.000 ^{ns}
MIPCW	5.40	7.00	6.44±0.61	5.70	6.70	6.24±0.46	0.574 ^{ns}
PCPL	2.10	3.30	2.80±0.45	2.20	3.40	2.68±0.48	0.692 ^{ns}
ICPFM	5.00	6.00	5.62±0.39	5.50	6.00	5.80±0.23	0.402 ^{ns}

INL: Incisive-Nuchal Length; **VCrL**: Viscerocranial Length; **NCrL**: Neurocranial Length; **NCWHB**: Neurocranial Width at Horn Base; **NCWLB**: Neurocranial Width at Lacrimal Bone; **NL**: Nasal Length; **NW**: Nasal Width; **ISOFL**: Inter-Supra Orbital Foramen Length; **DHN**: Distance Between the Horn Neck; **FMH**: Foramen Magnum Height; **FMW**: Foramen Magnum Width; **MICW**: Maximum Intercondylar Width; **MIPCW**: Maximum Inter-Paracondylar Width; **PCPL**: Paracondylar Process Length; **ICPFM**: Inter-Cornual Protuberance to Foramen Magnum.
^{ns} No significant difference ($p > 0.05$).

Table 2 Independent sample t-test for osteometric parameters of the ventral and lateral surfaces of the skull in Yankasa and Uda sheep breeds

	Yankasa (n=5)			Uda (n=5)			
Parameters	**Min.**	**Max.**	**Mean ± SD**	**Min.**	**Max.**	**Mean ± SD**	**p-value**
IOL	20.00	25.00	21.86±2.07	19.10	24.20	21.40±2.00	0.730^{ns}
ChL	4.40	5.30	4.70±0.35	4.30	5.60	4.76±0.55	0.843^{ns}
ChW	1.30	1.60	1.54±0.13	1.40	1.60	1.48±0.08	0.421^{ns}
HPL	5.60	7.30	6.34±0.84	5.60	7.50	6.40±0.85	0.913^{ns}
HPW	3.80	4.60	4.16±0.29	3.40	4.30	3.84±0.34	0.145^{ns}
IISL	4.80	6.90	5.36±0.87	4.30	5.40	5.02±0.47	0.462^{ns}
IcW	3.10	4.40	3.72±0.48	3.00	5.40	3.88±0.97	0.749^{ns}
IZW	8.90	10.40	9.44±0.58	7.40	10.00	8.76±0.96	0.210^{ns}
ObH	3.30	3.80	3.58±0.22	3.30	3.90	3.62±0.24	0.789^{ns}
ObW	3.70	4.00	3.88±0.13	3.50	4.20	3.78±0.28	0.487^{ns}
FTIFOF	1.80	2.50	2.14±0.25	1.90	2.60	2.20±0.29	0.736^{ns}
IFOFAT	1.40	2.00	1.64±0.29	1.30	1.90	1.52±0.27	0.515^{ns}

IOL: Incisivo-Occipital Length; **ChL**: Choana Length; **ChW**: Choana Width; **HPL**: Hard Palate Length; **HPW**: Hard Palatine Width; **IISL**: Inter-incisive Suture Length; **IcW**: Incisive width; **IZW**: Inter-Zygomatic Width; **ObH**: Orbital Height; **ObW**: Orbital Width; **FTIFOF**: Facial Tuberosity to Infraorbital Foramen; **IFOFAT**: Infraorbital Foramen to Root of Alveolar Tooth.
^{ns} No significant difference ($p > 0.05$).

Table 3 Independent sample t-test for osteometric parameters of the mandibles in Yankasa and Uda sheep breeds

	Yankasa (n=5)			Uda (n=5)			
Parameters	**Min.**	**Max.**	**Mean ± SD**	**Min.**	**Max.**	**Mean ± SD**	**p-value**
MDL	14.50	17.10	15.72±1.05	13.70	18.00	15.44±1.68	0.760^{ns}
MMDH	9.70	10.80	10.24±0.40	9.00	11.60	10.12±1.08	0.823^{ns}
MDBH	3.50	4.20	3.86±0.26	3.40	4.70	3.98±0.58	0.684^{ns}
BMCF	7.40	8.00	7.68±0.23	6.90	8.90	7.80±0.90	0.780^{ns}
MHCF	2.30	2.70	2.54±0.15	1.90	2.70	2.28±0.33	0.152^{ns}
DL	3.90	4.90	4.48±0.40	3.70	4.60	4.18±0.34	0.240^{ns}
MSL	2.10	2.80	2.42±0.28	2.00	2.50	2.30±0.21	0.464^{ns}
MDFBM	3.70	4.40	3.96±0.36	3.60	4.50	4.00±0.46	0.882^{ns}
MDFCB	1.30	1.60	1.42±0.11	0.50	1.70	1.18±0.49	0.322^{ns}
LARMF	2.10	3.00	2.44±0.34	2.20	2.80	2.44±0.23	1.000^{ns}
IMDAW	4.90	6.60	5.82±0.61	4.10	5.10	4.78±0.41	0.14 ^{ns}
MDFCP	5.90	7.80	6.70±0.75	5.80	8.00	6.66±0.86	0.940^{ns}

MDL: Mandibular Length; **MMDH**: Maximum Mandibular Height; **MDBH**: Mandibular Body Height; **BMCF**: Base of Mandible to Condyloid Fossa; **MHCF**: Maximum Height to Condyloid Fossa; **DL**: Diastemal Length; **MSL**: Mandibular Symphysis Length; MDFBM: Mandibular Foramen to Base of Mandible; **MDFCB**: Mandibular Foramen to Caudal Border of Mandible; **LARMF**: Lateral Alveolar Root to Mental Foramen; **IMDAW**: Inter Mandibular angle width; **MDFCP**: Mandibular foramen to coronoid process

^{ns} No significant difference ($p > 0.05$).

DISCUSSION AND CONCLUSION

In this study, skull length was recorded as incisive-nuchal length (INL), which is slightly higher in Yankasa (22.08 ± 2.43 cm) compared to Uda (21.08 ± 2.06 cm), but not statistically significant. Shehu et al. (2019) reported a length of 23.90±0.14 cm, similar to the age group in this study, and a longer length of 32.50±0.99 cm in older (three years and above) Yankasa rams from Sokoto. Comparable length (22.9 ± 0.8 cm) in males and (21.7 ± 0.3 cm) in females of Hamdani sheep was reported by Dayan et al., (2022). The skull length of Yankasa and Uda sheep is shorter than many nonindigenous breeds. Yılmaz & Demircioglu (2020) reported 24.13 ± 1.40 cm in İvesi sheep of Turkey. Similarly, higher values were reported by Parés-Casanova et al., (2010), Reda et al., (2016), Dalga et al., (2018), Gündemir et al. (2020), Jashari et al., (2022), and Guzel et al. (2024) in Xisqueta sheep, Barbados Black Belly sheep in Trinidad, Hemşin sheep, Bardhoka rams of Kosovo, Sharri sheep, and Romanov sheep, respectively. Conversely, lower skull length values were equally reported in some nonindigenous breeds. Özcan et al., (2010) reported 20.45 ± 0.97 cm and 19.81 ± 0.77 cm in Morkaraman sheep and Tuj sheep, respectively. Mehraban sheep of Iran were reported to have 20.06 ± 1.71 cm (Karimi et al., 2011).

This study revealed that the Uda breed has a longer neurocranium (8.66 ± 0.57 cm) than the Yankasa (8.36 ± 0.72 cm). Conversely, Yankasa has a longer viscerocranium (9.62 ± 1.62 cm) as compared to Uda (9.12 ± 1.39 cm), though it is statistically not significant. Higher viscerocranial values were reported in Morkaraman sheep and Tuj sheep of Turkey (Ozcan et al., 2010), Akkaraman sheep and Kangal Akkaraman sheep (Hacer et al., 2023), and male Romanov sheep (Guzel et al., 2024).

Yankasa has higher nasal length, and nasal width of 8.04 ± 0.89 cm, and 3.34 ± 0.70 cm, respectively. Conversely, Uda has lower values of 7.98 ± 1.04 cm, and 3.00 ± 0.42 cm, in the respective parameters. Shehu et al. (2019) reported Nasal length value of 8.20 ± 0.42 in Yankasa in Sokoto. Dayan et al. (2022), recorded 8.36± 0.32 cm in males and 8.29 ± 0.31 cm in females of Hamdani sheep of Turkey. Dalga et al. (2018) recorded it as 8.25 ± 0.78 cm in the Hemshin sheep. While it was reported as 7.03 ± 0.67 cm in the Morkaraman sheep breed and 6.86 ± 0.31 cm in the Tuj sheep of Turkey (Ozcan et al., 2010). In Romanov sheep, the length was 7.46 ± 0.12 cm in males and 7.26 ± 0.07 cm in females (Guzel et al., 2024).

The supraorbital foramen, located on the dorsal orbital margin, was also observed to be an important cranial landmark. The mean intersupraorbital foramen length (ISOFL) was higher in Yankasa (4.98 ± 0.47 cm) compared to Uda (4.90 ± 0.43 cm). Reda et al., (2016) reported a length of 5.64 ± 0.84 cm in Barbados Black Belly sheep, and Monfared (2013) reported 9.5 ± 1.44 in the Iranian Native sheep. This foramen transmits the frontal nerve, and its clinical relevance lies in the ability to block this nerve during dehorning, trephination of the frontal sinus, and in the surgical management of horn related injuries (Gambo et al., 2015). Knowing the location across breeds indicates its reliability as a landmark for supraorbital nerve block in sheep.

Foramen magnum shape is an important dimorphic feature (Gapert et al., 2009). In this study, Foramen Magnum Height showed similar values in both breeds, 2.22 ± 0.15 cm in Yankasa and 2.24 ± 0.21 cm in Uda. Shehu et al., (2019) reported foramen magnum height of 2.1 ± 0.10, 1.9 ± 0.10 and 1.8 ± 0.00 in Balami, Uda, and Yankasa, respectively. In Sharri sheep, it was determined as 2.00 ± 0.22 cm (Jashari et al., 2022), whereas Ozcan et al. (2010) reported the same parameter as 1.94 ± 0.11 cm in Morkaraman sheep and 1.78 ± 0.15 cm in Tuj sheep. Guzel et al. (2024) reported 1.72±0.10 cm in Romanov sheep.

Similarly, Foramen Magnum Width is slightly lower in Yankasa (2.06 ± 0.28 cm) compared to Uda (2.14 ± 0.09 cm). However, it was reported as 2.00 ± 0.00 cm in Balami, 2.00 ± 0.00 cm in Uda and 1.90 ± 0.20 cm in Yankasa (Shehu et al., 2019). Dayan et al., (2022) mentioned foramen magnum width in Hamdani sheep as 2.48 ± 0.06 cm, whereas in Romanov ram it was 1.87 ± 0.07 cm (Guzel et al., 2024).

On the ventral and lateral surfaces of the skulls, the results reveal both similarities and differences between the Yankasa and Uda sheep breeds across the twelve parameters analyzed. Skull length related parameters, such as IOL, ChL, HPL, IISL and FTIFOF, show minimal differences between the breeds. However, skull width related parameters such as HPW, IcW, and IZW, exhibit variations, though not statistically significant. Wider skull width profile, such as hard palate width (HPW) and inter-zygomatic width (IZW) in Yankasa sheep, suggest distinct cranial morphology compared to Uda sheep.

In the present study, skull width was regarded as inter-zygomatic width (IZW) representing the maximum cranial width at the zygomatic arches. It was greater in Yankasa (9.44 ± 0.58 cm) compared to (8.76 ± 0.96 cm) in Uda. Comparable values have been reported in Morkaraman and Tuj sheep of Turkey, 10.30 ± 0.25 cm and 10.17 ± 0.17 cm, respectively (Özcan et al., 2010). Karimi et al., (2011) mentioned 10.44 ± 0.29 cm in Iranian Mehraban sheep, and Gündemir et al., (2020) determined it to be 10.70 ± 0.50 cm in Bardhoka sheep of Kosovo. Conversely, in İvesi sheep of Turkey it was recorded as 11.34 ± 0.89 cm in males and 11.68 ± 0.64 cm in females (Yılmaz and Demircioglu, 2020).

In the present study, Incisivo-Occipital Length (condylobasal length), Choana Width, Palatine Width and Inter-Incisive Suture Length presented a higher mean in Yankasa skulls (21.86 ± 2.07 cm, 1.54 ± 0.13 cm, 4.16 ± 0.29 cm and 5.36 ± 0.87 cm) than in Uda skulls (21.40 ± 2.00 cm, 1.48 ± 0.08 cm, 3.84 ± 0.34 cm and 5.02 ± 0.47 cm), respectively. Conversely, Uda skulls showed higher mean values in Choana Length, Hard Palate Length and Incisive Width (4.76 ± 0.55 cm, 6.40 ± 0.85 cm, 3.88 ± 0.97 cm, respectively) compared to Yankasa (4.70 ± 0.35 cm, 6.34 ± 0.84 cm, and 3.72 ± 0.48 cm, respectively).

The mean Orbital Height of Yankasa, 3.58 ± 0.22 cm, was lower compared to that of Uda, 3.62 ± 0.24 cm. Conversely, the mean Orbital Width of Yankasa was higher (3.88 ± 0.13 cm) compared to that of Uda (3.78 ± 0.28 cm). The facial tuberosity was observed to be a prominent landmark in both breeds, positioned laterally on the maxilla. Its proximity to the infraorbital foramen provides a useful guide for identifying this foramen in live animals. To locate the infraorbital foramen, it is necessary to know the distance from the infraorbital foramen to facial tuberosity. The mean Facial Tuberosity to Infraorbital Foramen (FTIOF) of Uda was 2.20 ± 0.29 cm, which is higher than that of Yankasa (2.14 ± 0.25 cm). However, Shehu et al. (2019) reported it as 3.39 ± 0.35 cm in Yankasa rams of Sokoto. Monfared, (2013) mentioned it as 1.87 ± 0.09 cm in Iranian domestic sheep. Similarly, Marzban et al., (2018) reported 1.28 ± 0.18 cm in female Zell sheep skull. It was determined by Gündemir et al., (2020) in Bardhoka sheep of Kosovo as 2.59 ± 0.17 cm in females and 2.58 ± 0.30 cm in males. Özüdoğru et al. (2023) in Konya merino sheep and Reda et al., (2016) in Barbados Black Belly sheep documented it as 3.04 ± 0.19 cm and 3.16 ± 0.70 cm, respectively. The distance between the infraorbital foramen to the alveolar teeth (IFOFAT) was found to be higher in Yankasa 1.64 ± 0.29 cm compared

to 1.52 ± 0.27 cm in Uda. This measurement provides additional guidance for avoiding alveolar injury while inserting needles for infraorbital nerve block.

Clinically, this relationship is significant for blocking the infraorbital nerve to achieve desensitization of the upper lip, nose, and maxillary incisors during dental procedures, rhinoplasty, and suturing of wounds around the muzzle (Gambo et al., 2016).

The mandible is recognized as the largest bone of the skull (Avdić et al., 2013). The mandibular parameters measured (MDL, MDH, MDBH, BMCF, MHCF, DL, MSL, BMMDF, MDFCB, LARMF, MDFCP and IMDAW) did not show any statistically significant differences between the Yankasa and Uda breeds.

Among the mandibles studied, Yankasa exhibited a higher mandibular length (15.72 ± 1.68 cm) than Uda (15.44 ± 1.68 cm). Similar values were reported in Mehraban sheep 15.76 ± 2.25 cm (Karimi et al., 2012), Gurcu goat 15.9 ± 1.04 cm (Dalga, 2021), and Roe deer 15.6 ± 1.22 cm (Avdić et al., 2013), respectively. Higher values were also reported from Sharri sheep, 18.59 ± 1.33 cm (Gündemir et al., 2020), and Barbados Black Belly sheep, 18.16 ± 1.53 cm (Reda et al., 2016). However, lower value of 14.08 ± 0.01 cm was reported in Iranian native sheep (Monfared, 2013), and 14.91 ± 0.48 cm in Norduz sheep (Dalga et al., 2022).

Distance between Base of Mandible to Condyloid Fossa (BMCF) of Yankasa was 7.68 ± 0.23 cm, which is lower compared to Uda (7.80 ± 0.90 cm). Results were comparable to those reported in the Mehraban sheep (7.75 ± 0.96 cm) (Karimi et al., 2011) and higher than those of Barbados Black Belly sheep (7.08 ± 0.73 cm) (Reda et al., 2016), Norduz sheep (6.29 ± 0.23 cm) (Dalga et al., 2022), Iranian Native sheep (6.26 ± 0.17 cm) (Monfared, 2013), Balkan chamois (6.58 ± 0.55 cm) (Duro et al., 2025), Roe deer (5.85 ± 0.21 cm) (Avdić et al., 2013), and Gurcu goat (6.23 ± 0.65 cm) (Dalga, 2021).

The results showed that the distance from mandibular foramen to the caudal border of mandible was higher in Yankasa (1.42 ± 0.11 cm) compared toUda (1.18 ± 0.49 cm). The reported values were comparable to that of Mehraban sheep (1.35 ± 0.29 cm) (Karimi et al., 2011). On the other hand, lower values were recorded in Iranian Native sheep (0.86 ± 0.03 cm) (Monfared, 2013) and Balkan chamois (1.33 ± 0.15 cm) (Duro et al., 2025). This value was higher in Barbados Black Belly sheep (2.3 ± 0.25 cm) (Reda et al., 2016).

The mean mandibular foramen to the base of the mandible was higher in Yankasa (4.00 ± 0.46 cm) than in Uda (3.96 ± 0.36 cm). This value is comparable to that reported in in Mehraban sheep (4.14 ± 0.47 cm) (Karimi et al., 2011), while in Barbados Black Belly sheep 3.75 ± 0.22 cm was reported (Reda et al., 2016). Lower values were reported in the Gurcu goat (3.22 ± 0.28 cm) (Dalga, 2021), Balkan chamois (2.49 ± 0.20 cm) (Duro et al., 2025), and Iranian Native sheep (0.86 ± 0.03 cm) (Monfared, 2013).

This study revealed that the distance between the lateral alveolar root to the mental foramen (LARMF) was nearly similar in both breeds, 2.44 ± 0.34 cm in Yankasa and 2.44 ± 0.23 cm in Uda. Higher figures were reported in the Iranian Native sheep (2.76 ± 0.05 cm) (Monfared, 2013). Value reported in Barbados Black Belly sheep was 2.25 ± 0.31 cm (Reda et al., 2016) and lower value was reported in the Mehraban sheep () (Karimi et al., 2011), Gurcu goat (1.97 ± 0.23 cm) (Dalga, 2021), and Balkan chamois (1.75 ± 0.36 cm) (Duro et al., 2025).

The Mean Inter Mandibular Angle Width of Yankasa was 5.82 ± 0.61 cm, and 4.78 ± 0.41 cm of Uda.. The findings imply that the Yankasa and Uda breeds may share genetic or environmental factors that contribute to their morphological similarities. However, it is important to note that this analysis is limited to the specific parameters measured and does not account for other potential differences, such as physiological, or production-related characteristics.

In conclusion, the comparative osteometric analysis of the skull and mandible in Yankasa and Uda sheep revealed no statistically significant differences across the parameters measured, suggesting that both breeds share a broadly similar cranial morphology. Although slight variations were observed in the dimensions of the neurocranium and viscerocranium, these differences were not statistically significant. The infraorbital foramen was consistently located near the facial tuberosity in both breeds, a clinically important landmark for regional anesthesia. Likewise, mandibular measurements including the location of the mandibular foramen, the base of the mandible to the condyloid fossa, and the distance from the alveolar root to the mental foramen were comparable and aligned with values reported for other sheep breeds. The findings provide baseline osteometric data for Uda and Yankasa sheep and contribute to improved precision in regional anesthetic techniques. Practically, these morphometric landmarks may assist veterinarians working under

field conditions where advanced imaging modalities are unavailable. However, the primary limitation of this study is the small sample size, which may reduce statistical power and limit the detection of subtle morphometric differences. Future studies incorporating larger sample sizes and wider geographic sampling are recommended to enhance statistical robustness and strengthen breed-level anatomical inference.

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CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

CONTRIBUTIONS

BGG–Concept, Design, and Supervision; MK¬–Materials, Data collection and/or processing, Analysis and/or Interpretation of the Data, and Literature review; AMW– Analysis and/or Interpretation of the Data, Literature review, Writing and Critical review; YBM¬–Critical review; IAG– Critical review; WAK– Analysis and/or Interpretation of the Data, Literature review, and Critical review; AY– Supervision

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Kraniometrijske karakteristike ovaca pasmina Uda i Yankasa (*Ovis aries*)

SAŽETAK

Cilj ove studije bio je ispitati i uporediti osteometrijske karakteristike lobanja pasmina ovaca Uda i Yankasa. Za ovu studiju korišteno je ukupno 10 lobanja autohtonih pasmina ovaca, uključujući pet ovnova Uda i pet ovnova Yankasa starosti između 12 i 18 mjeseci. Uzorci su prikupljeni u gradu Bauchi, savezna država Bauchi, Nigerija, te su transportovani u Laboratorij za topografsku anatomiju, Odsjek za veterinarsku anatomiju Univerziteta u Maiduguriju, savezna država Borno, radi obrade kostiju. Kosti su obrađene metodom maceracije u toploj vodi i tehnikama uklanjanja mekih tkiva. Identificirano je oko 39 kranijalnih i mandibularnih parametara. Komparativna analiza dorzalnih, kaudalnih, ventralnih, lateralnih i mandibularnih parametara nije pokazala statistički značajne razlike ($p > 0,05$) između pasmina Uda i Yankasa u većini mjerenja. Osteometrijski nalazi pokazali su da su parametri povezani s dužinom viscerokranijuma, kao što su INL, VCrL, NL, IOL, MDL i IISL, bili nešto veći kod pasmine Yankasa nego kod pasmine Uda. Međutim, parametri povezani s dužinom neurokranijuma, kao što su NCrL, ChL i HPL, bili su nešto veći kod pasmine Uda nego kod pasmine Yankasa. Yankasa je također pokazala širi profil lobanje, što se odražava u vrijednostima IZW, HPW, ChW, IMDAW, NW i NCWLB, iako razlike nisu bile statistički značajne. Ova studija pruža vrijedne osteometrijske podatke o pasminama ovaca Uda i Yankasa, koji mogu biti korisni za taksonomsku klasifikaciju, evolucijska istraživanja, kao i za veterinarsku kliničku primjenu, uključujući regionalnu anesteziju i hirurške zahvate na području glave.

Ključne riječi: Kraniometrija, osteometrija, ovce, Uda, Yankasa