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# Craniometric evaluation of some cranial indices of clinical significance in goats (*Capra Hircus*) from the Middle-Belt Region of Nigeria – case for population surveillance and ecomigration

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## ABSTRACT

*A total of twenty (20) skulls from goats taken around Makurdi, Kwande, Katsina –ala and neighbouring states of Adamawa and Nassarawa in Nigeria were utilized for this investigation. Thirty (30) craniometric parameters were assessed. The measured distance from the facial tuberosity to the infraorbital foramen was 2.33± 0.29cm and 1.80±0.14cm for females and males respectively. In addition, the distance from the medial canthus to the supraorbital foramen, from the lateral alveolar root to the mental foramen and from mandibular foramen to the ventral border of mandible were 3. 27± 0.31cm and 2.83±0.24cm, then 8.05±0.07cm and 5.10±7.28cm and 5. 20± 0.71cm and 3.14± 0.37cm in females and males respectively These values were at variance with those previously reported in some Nigerian goat breeds though the distance from the lateral alveolar margin to the mental foramen in middle belt goats at 8.05± 0.07cm and 5.10±7.28c m in females and male respectively shared similar values with other reported breeds of goats in Nigeria. The statistical evidence revealed that these goats; for most parts do not conform to the previously investigated breeds and can be postulated that the Trans-Saharan and Touareg migrations along with effects of climatic pattern along the route of migrations over time has resulted in these ontogenic variations. Our data shows the basis of its relevance in the regional clinical procedures of the head, comparative anatomy of some salient structures of clinical significance, population studies, identification, and palaeontology as well as eco- migration surveillance. It is further hypothesised that this breed of goat might be a different phenotype of the breeds available in Nigeria.*

**Keywords-** Osteometry, cranial indices, goat breeds, climate change and population surveillance.

## INTRODUCTION

The three recognized major breeds of goat in Nigeria are the West African Dwarf (WAD) [14], Red Sokoto (RS) also called Maradi [9] and the Sahel breed (SH) [11]. These are distributed within the country according to their known route of migrations. The (WAD), goes through trans Saharan route in the deserts from north Africa and is known to inhabit the tropical rain forest (Liberian coast to Congo in the east [2]. [4] described the Sahelian goat migrations to the West African sub region through Egypt Nubian settlers and the borders of Libya. These have been variously characterized by different authors' overtime [11, 14; 23]. Some other goat types available in the minority might not have been described as thoroughly and so present differences which may pose landmark challenges to the clinician with conflicting craniometrical data.

The head, being an entity of identification [6]; serves for distinguishing between breeds, their origin and the environmental conditions to which they may have been exposed at some critical points of their development, this may have modifying effects on their phenotypic appearance [5; 21]. It is therefore imperative to establish standard morphologic descriptions for each established breed of goats and their ecological types.

Previous works on the maxillofacial osteometry of goats includes the works on indigenous goats in Nigeria by [10], [15; 18], [16], on the three major breeds of goat in Nigeria. [22] investigated Kagani goats in India while [25], the Black Bengal goat in Bangladesh. There is no literary information on the skull typology and ecotype of goats found in the middle belt regions of Nigeria.

This work evaluated some cranial features on goats found in Benue, Adamawa and Nassarawa states of Nigeria, and thus seeks to establish the presence of this skull typology exhibiting migratory and climatic variation effects on their phenotypic appearance, and thereby make case for goat breed population surveillance along route of migration and transportation.

## MATERIALS AND METHODS

A total of twenty (20) skulls were used for this study consisting of ten (10) females and males respectively. The goats were bought from various markets in Makurdi, Kwande Katsina-ala areas in Benue and surrounding states of Adamawa and Nassarawa. Ages of these animals were estimated based on dental eruptions and wears [6]. Ante-mortem examinations was carried out on the animals to ascertain health status and were afterwards separated based on gender prior to slaughter. Only apparently healthy goats were used for this enquiry.

### SKULL MACERATION PROCESS

The heads were obtained after restrain and quick decapitation at the atlanto-occipital region. These were then stored at -4ºC in the refrigerator upon each collection and slaughter of the goats. Frozen heads were then thawed out, the skin and other soft tissues were removed with the aid of knives in preparation for maceration process.

The goat heads were processed individually according to the skull maceration process of goat skull as described by [18; 19].

**The measured variables and their acronyms-**

*1.* ***Distance from the facial tuberosity to the infraorbital foramen*** (FT-If). Highest point on the facial tuberosity to the midpoint of infraorbital foramen

*2.* ***Distance from the medial canthus to the supraorbital foramen*** (MC- Sf) produced by caudal diagonal line from the medial canthus along the orbit to the midpoint of the supraorbital foramen on frontal bone.

*3.* ***Supraorbital foramen to the frontal eminence*** (SF-Fe). Vertical line from midpoint of supraorbital foramen to the frontal eminence

*4.* ***Infraorbital foramen to alveolar root of second premolar*** (IF-$AP_2$); Vertical line from infraorbital foramen to the cranial limit of alveolar root of $2^{nd}$ premolar (P2)

*5.* ***Skull length*** (SK-L); from rostral border of incisive bone to occipital crest.

*6.* ***Skull height*** (SK-H); from ventral border of mastoid process to frontal eminence.

*7.* ***Skull breadth*** (SK-B); Distance between the two orbital bony rims

*8.* ***Distance from the lateral alveolar root to the mental foramen*** (LA-M); Horizontal line from the lateral alveolar root of 4th incisor ($I_4$) to the midpoint of mental foramen.

*9.* ***Maximum circumference of the right and left orbital rims*** (MCrO and MClO)

*10.* ***Mental foramen to the alveolar root of the first premolar*** (MF-$AP_1$); Horizontal line from the midpoint of the mental foramen to the cranial limit of lateral alveolar root of the $1^{st}$ premolar ($P_1$)

*11.* ***Mental foramen to the ventral border of the mandible*** (MF-Vb) vertical line from the midpoint of mental foramen to the ventral border.

*12.* ***Mental foramen to the caudal border of mandible*** (MF-Cb)

*13.* ***Mandibular symphyseal length*** (MsL); from the lateral alveolar root of $1^{st}$ incisor ($I_1$) rostral limit of symphysis to caudal limit of symphysis on the ventral aspect.

*14.* ***Mandibular symphyseal breadth*** (MsB); Distance measured across lateral edge of the left $4^{th}$ incisor to the lateral edge of the right incisor no. 4 measured medially.

*15.* ***Length of diastemal gap*** (DGL); from lateral alveolar root of the $4^{th}$ incisor to the cranial limit of $1^{st}$ premolar on the body line

*16.* ***Interdiastemal distance*** (IDd); from the lateral alveolar root of left $1^{st}$ premolar ($P_1$) to lateral alveolar root of the $2^{nd}$ right premolar ($P_2$) on the medial side.

*17.* ***Inter-mental foramina distance*** (IMFd); Midpoint of left mental foramen to midpoint of right mental foramen.

*18.* ***Mandibular thickness*** (Mtk); Width of mandible at 1st molar ($M_1$), second molar ($M_2$) and third molar ($M_3$)

*19.* ***Mandibular length*** (MDL); from the lateral alveolar root of first Incisor ($I_1$) to the most caudal border of the mandible.

*20.* ***Mandibular foramen to ventral border of the mandible*** (MF-Vb); Vertical line from the ventral limit of mandibular foramen to the ventral border of mandible.

*21. **Mandibular foramen to caudal border of mandible*** (MF-Cb); Horizontal line from the vertical aspect of mandibular foramen to caudal border of mandible.
*22. **Length of mandibular condyle*** (McL); Medial to lateral measurement of mandible condyle.
*23. **Length of coronoid process*** (CRL); from the dorsal limit of coronoid process to base of mandibular notch.
*24. **Mandibular notch to ventral border of mandible*** (Mn-Vb); From ventral aspect of mandibular notch to ventral border of mandible
*25. **Height of mandible*** (HM); from dorsal limit of coronoid process to ventral border of mandible.
*26. **Height of mandibular body*** (HMB); from the alveolar root of $M_1$ to ventral border of mandible.
*27. **Inter mandibular distance*** (IMD); Distance between the two mandibles at $M_3$
*28. **Foramen magnum length*** (FML); Rostral to caudal measurement of foramen magnum
*29. **Foramen magnum width*** (FMW); Maximum width of foramen magnum
*30. **Foramen magnum height*** (FMH); Maximum height of foramen magnum

**Skull data collection-** cranial variables were obtained using appropriate metric instruments; digital callipers for linear measurements, cotton threads and metre rule for non-linear landmark assessments, these are outlined below. Some are depicted in Figures 1-4.

The male and female result obtained expressed as mean ± S.D was subjected to paired student-t test statistical software analysis using the Graph pad prism 4. Anslysis of variation (2- Way ANOVA) was performed on female/overall mean.

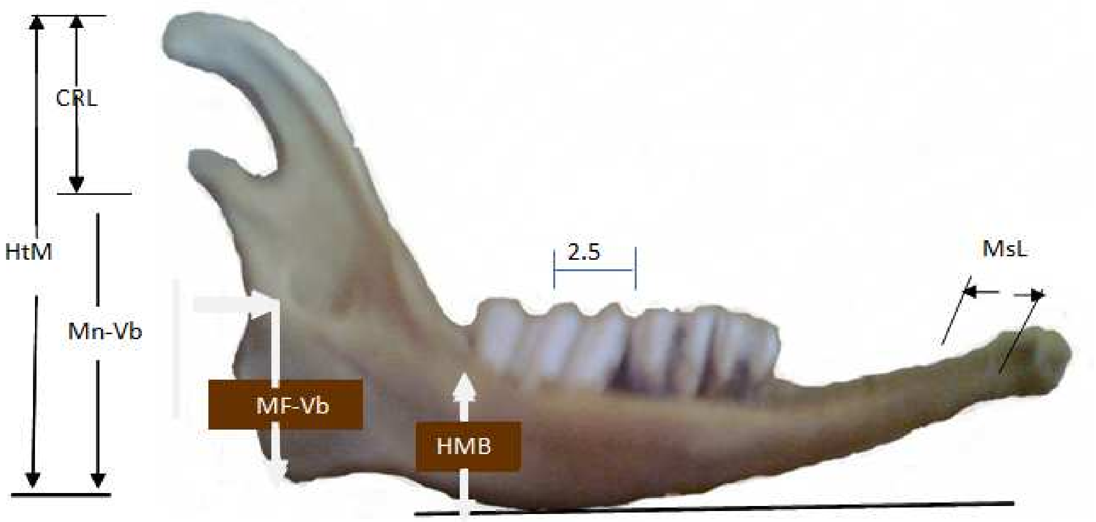


**Fig. 1a. Medial view of the left mandible of goat from the middle belt region of Nigeria showing the following measurements Mandibular foramen to ventral border of mandible (MF-Vb), Height of mandible at molar 1 (HMB), Mandibular symphyseal length (MsL), Mandibular notch to ventral border of mandible (Mn-Vb) and Coronoid process length (CRL).**

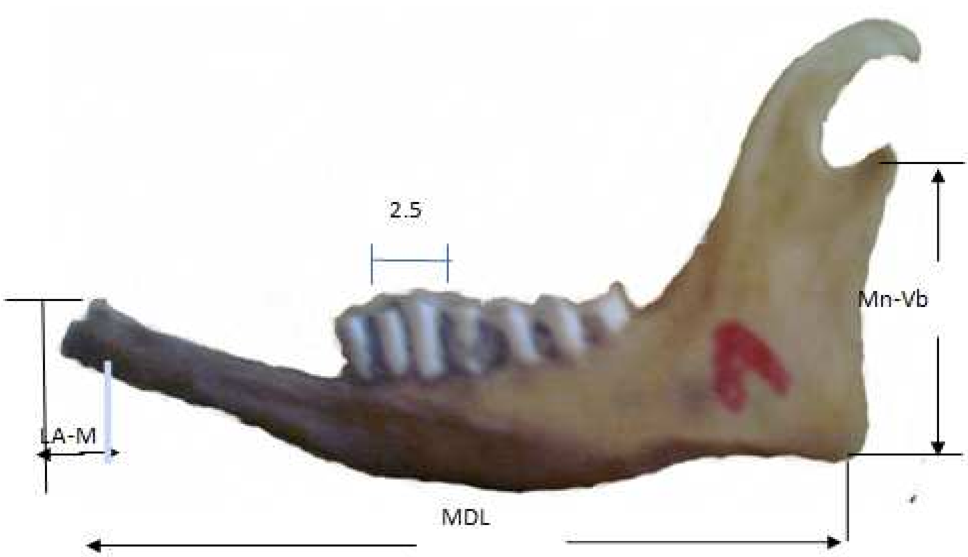


**Fig. 1b Lateral view of the left mandible of goat from the middle belt showing measurements of the mandibular length (MDL),mandibular notch to the ventral border (Mn-Vb)**

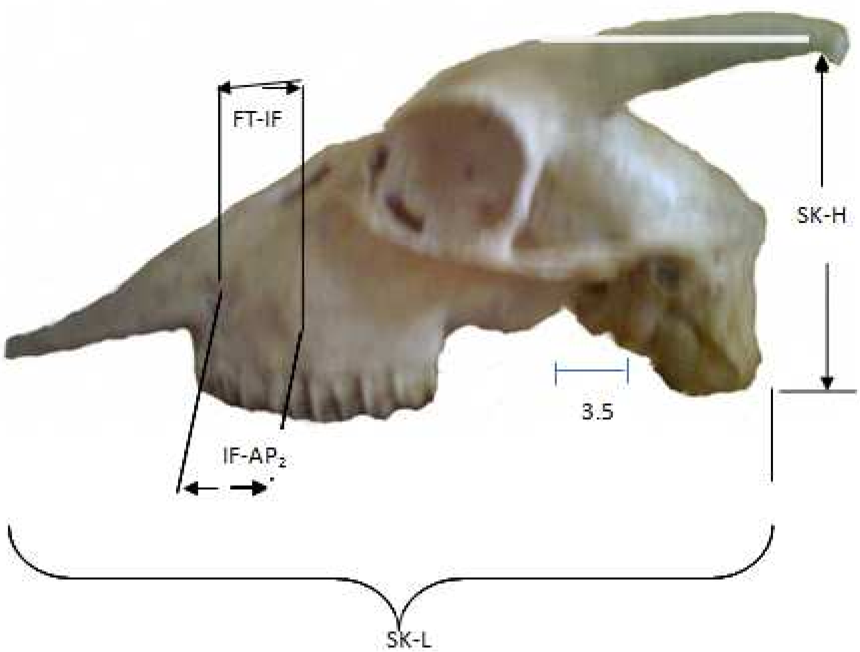


**Fig. 2 Lateral view of the skull of typical middle belt goat without mandibles showing measurements of the skull length (SK-L),height (SK-H),facial tuberosity to infraprbital foramen (FT-IF)and infraorbital foramen to alveolar margin of premolar 2 ($P_2$).**

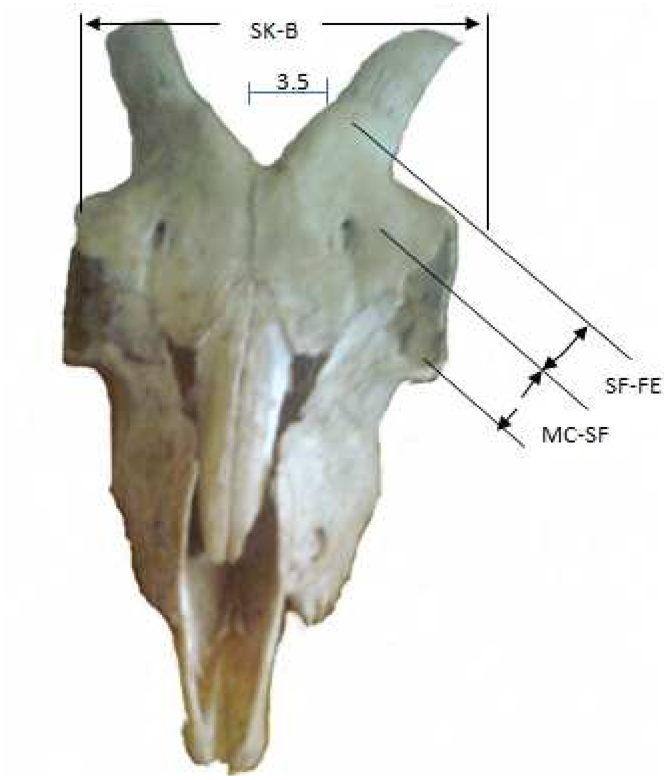


**Fig.3 Rostro-frontal view of the skull of a typical middle belt goat showing the following measurements from the skull breadth (SK-B), from the medial canthus to the supraorbital foramen (MC-SF) and from the supraorbital foramen to the facial eminence (SF-FE)**

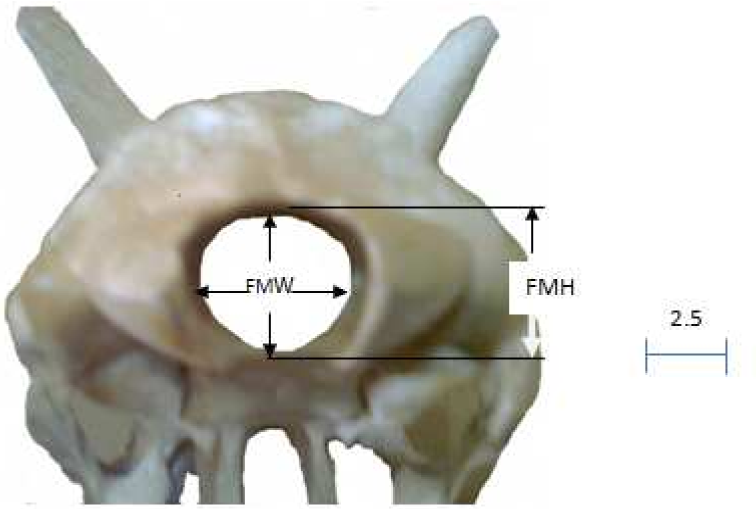


**Fig. 4 Caudo-rostral view of the skull of typical middle-belt zone goat showing the foramen magnum measurements-Foramen magnum width (FMW) and Foramen magnum height (FMH)**

## RESULTS

**Table 1 Measurements of skull parameters based on sex**

| S/N | Parameter (cm) | Male (Mean ± SD) | Female (Mean ± SD | Overall (Male & Female (Mean ± SD) |
|---|---|---|---|---|
| 1 | Ft-If | 1.80± 0.14 | 2.33 ± 0.29 | 2.06±0.20 |
| 2 | MC-Sf | 2.83± 0.24 | 3.27 ± 0.31 | 3.05±0.22 |
| 3 | SF-Fe | 2.65±0.17 | 4.53±0.15 | 3.59±0.94 |
| 4 | IF-$AP_2$ | 2.17±0.35 | 4.63±0.32 | 3.40±1.23 |
| 5 | SKL | 15.23±1.44 | 17.90±1.45 | 16.56±1.33 |
| 6 | SK-H | 8.63±1.15 | 10.07±1.07 | 9.35±0.72 |
| 7 | SK-B | 7.17±0.25 | 9.83±1.15 | 8.50±1.33 |
| 8 | LA-M | 5.10±7.28 | 8.05±0.07 | 6.57±1.47 |
| 9 | MCrO | 12.22±4.09 | 15.58±2.89 | 13.90±1.68 |
| 10 | MTF-$ARP_1$ | 1.40±0.12 | 3.85±0.07 | 2.62±1.22 |
| 11 | MTF-Vb | 0.78±0.05 | 1.95±0.07 | 1.36±0.58 |
| 12 | MTF-Cb | 9.98±0.72 | 12.05±0.49 | 11.01±1.03 |
| 13 | MsL | 1.85±0.13 | 3.25±0.35 | 2.55±0.70 |
| 14 | MDsB | 1.53±0.29 | 3.15±0.49 | 2.34±0.81 |
| 15 | DMGL | 2.95±0.29 | 4.55±0.21 | 3.75±0.80 |
| 16 | IDMd | 1.60±0.24 | 3.95±0.07 | 1.85±1.62 |
| 17 | IMFd | 1.43±0.30 | 2.60±0.42 | 2.01±0.58 |
| 18 | $MDtkM_1$ | 1.13±0.06 | 1.20±0.00 | 1.15±0.03 |
| 19 | MDL | 11.88±0.79 | 15.35±0.78 | 13.61±1.73 |
| 20 | MF-Vb | 3.14±0.37 | 5.20±0.71 | 4.17±1.03 |
| 21 | MF-Cb | 1.98±0.33 | 3.10±0.57 | 2.54±0.56 |
| 22 | McL | 1.63±0.13 | 3.80±0.14 | 2.71±1.08 |
| 23 | CRL | 2.73±0.40 | 4.80±0.14 | 3.76±1.03 |
| 24 | Mn-Vb | 5.48±0.43 | 6.90±0.14 | 6.19±0.71 |
| 25 | HM | 7.98±0.28 | 9.05±0.64 | 8.51±0.53 |
| 26 | HMB | 2.30±0.20 | 3.55±0.35 | 2.41±0.12 |
| 27 | $IMDdM_2$ | 3.70±0.16 | 6.40±0.85 | 5.05±1.35 |
| 28 | FML | 1.85±0.06 | 2.97±0.15 | 2.41±0.56 |
| 29 | FMW | 1.88±0.10 | 3.93±0.12 | 2.90±1.02 |
| 30 | FMH | 1.73±0.10 | 2.80±0.00 | 2.26±0.53 |

**Analysis of results**

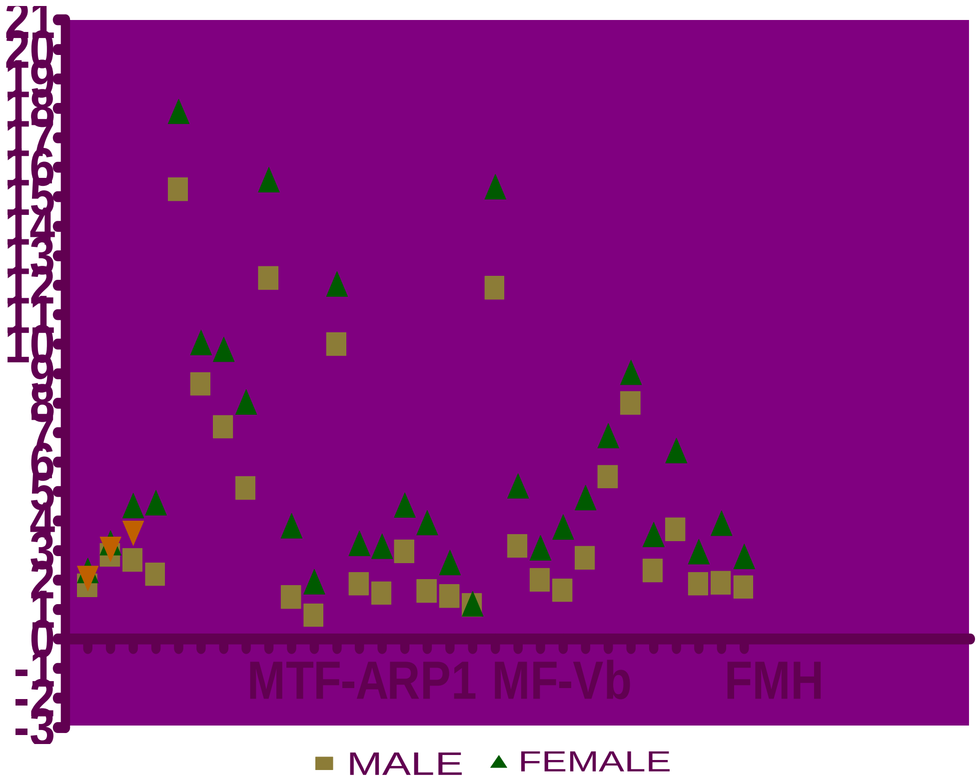


**Fig. 5 Category graph of male/female without error bar showing distribution of parameters measured between the sexes, (parameters significantly higher in females).**

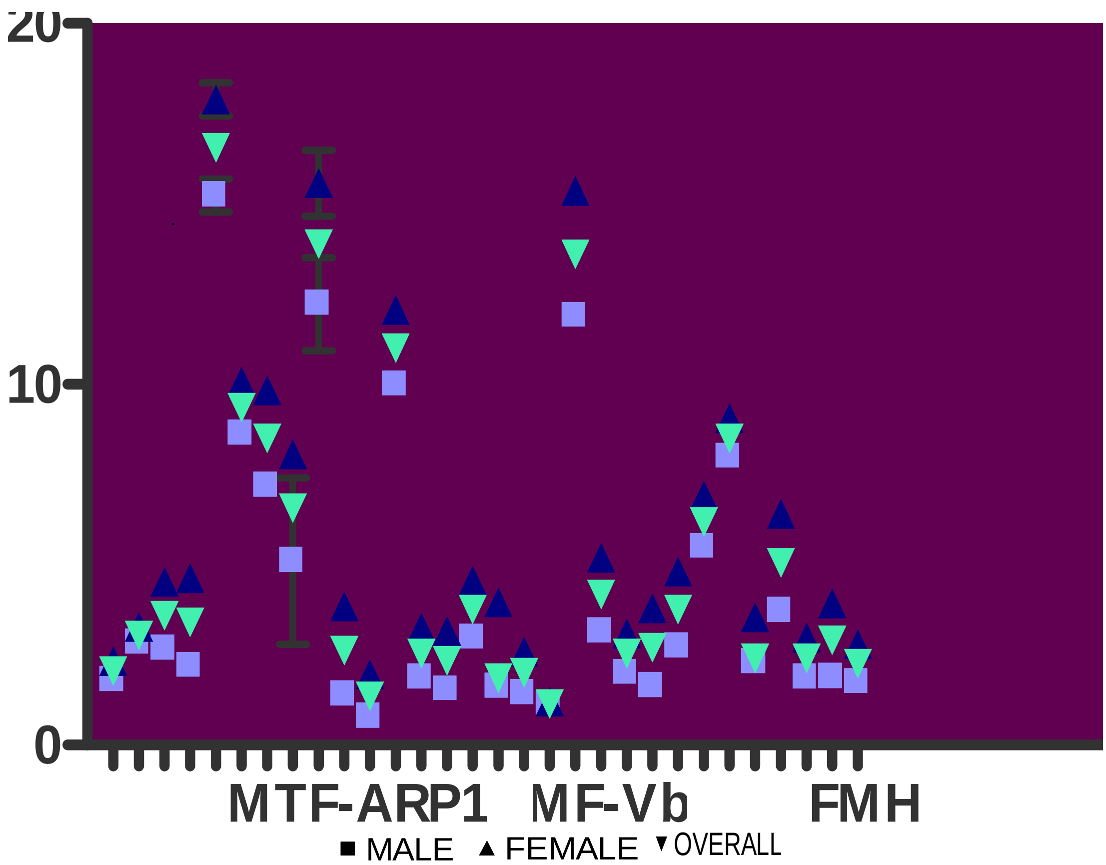


**Fig. 6 Category graph of male/female/overall showing the distribution of parameters within the axes.**
**Paired t test (2-tailed) of this category shows that the means are significantly different ((P < 0.05) at 95% confidence interval.**

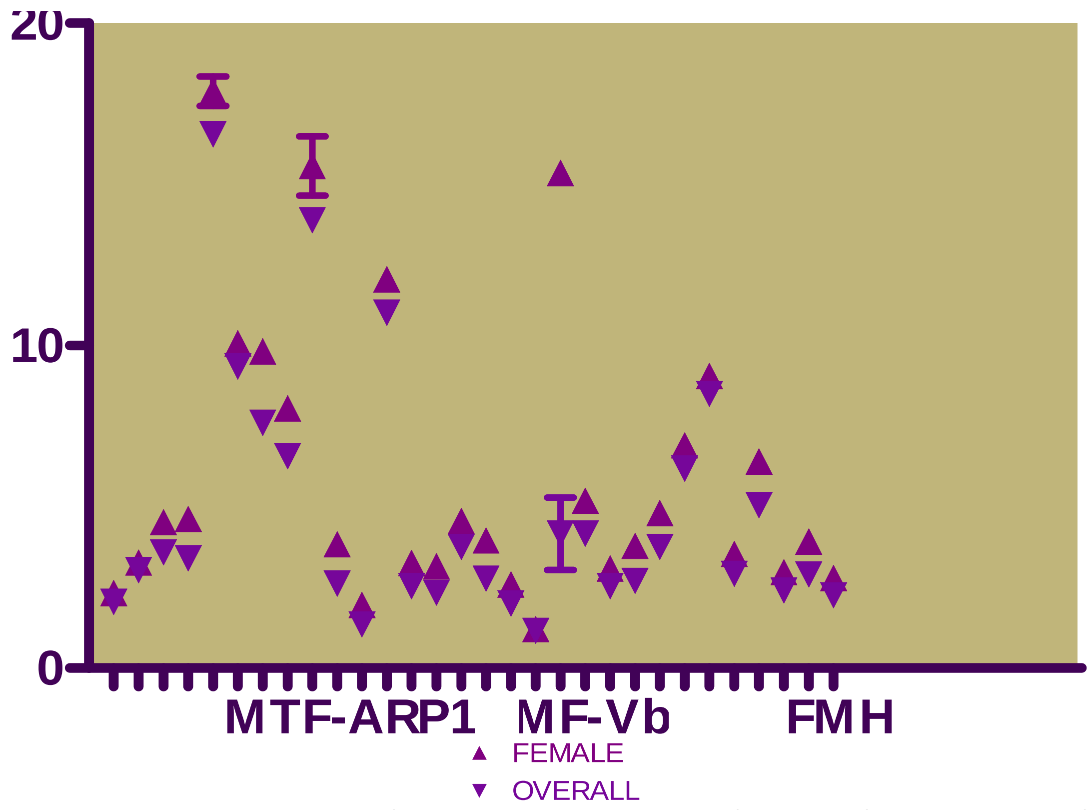


**Fig. 7 Category graph with error bars showing female /overall showing distribution of parameters (female parameters significantly higher than the overall means)**

Two-way analysis of variation (ANOVA) of female and overall parameters revealed that the interaction is highly significant (P<0.0001). The interaction of both column and row factor is extremely significant (P < 0.0001).

## DISCUSSION

The mean distance from the facial tuberosity to the infraorbital foramen was 2.06± 0.20cm in the present goat type being understudied as compared to 1.60±0.01cm of the West African Dwarf (WAD) breed [15; 18], 1.77± 0.11cm in the Sahel breed (SH) [11], 1.82 ±1.20cm in Red Sokoto (RS) and 1.85± 0.14cm in Black Bengal goat [15, 16, 23, and 24] for a similar parameter. The overall mean distance from the medial canthus of the orbit to the supra orbital foramen in our study was 3.05±0.22cm while from the lateral alveolar root to the mental foramen was 6.57±1.47cm is significantly higher when compared to 1.84±0.76cm in the WAD, 1.96±0.02cm in the SH and 1.60±0.34cm for the RS for a similar landmark, these cranial indices are important in regional anaesthesia of the head for rostral dental procedures of the upper jaw and the desensitization of the cornual process for dehorning [7]. The mean distance from the infraorbital foramen to the alveolar root of $P_2$ in the species of our study was 3.40± 1.23cm which is longer than any of the better described WAD between 1.3.-1.6 ±0.21cm in goats taken from the south eastern and south western parts of Nigeria [17], and1.75± 0.19cm in the Black Bengal[25] however, the observed dimensions in the present evaluations are well correlated to the head to body lengths ratio of the goats as reported for the wild boar (*Sus scrufo Leucomyces*) [1]. The middle belt in Nigeria falls within 6ºN and 12ºN of the equator, migrating animals from east Africa pass through northern parts of the Cameroons into Nigeria. Guinea savannah [8] vegetation in these areas begin to dwindle (November-March) as the rains subside, but the daily temperatures remains between 20ºC- 26ºC. The route of migrational grazing by nomadic pastoralists with their cattle and the Sahelian goats is through Niger republic and Sudan as they make their way from Libya [13] through the Sahel savannah and the Sudan savannah. These trade goats to neighbouring states of Borno, Sokoto and Kano. Animals from this route have access to limited water and pasture at such periods, coupled with more prolonged harsh weather per year in comparison to those taken through the northern Cameroons. Exposure of pregnant dams and their young in various stages of development to this climatic stress is hypothesised to have profound effects on their developmental potentialities [5].

The mandibular thickness in all the three breeds at Molar 1 – 3 revealed the mandible had the least thickness at molar 1, (1.15cm in the breed under consideration), 1.05cm in the WAD, 1.03cm RS and 1.13cm in SH, incidentally this is the portion of the mandible that is most accessible during oral examination and other clinical procedures [6], than at molars 2 (1.35) and 3 (1.40). This study suggests_that caution be taken during these procedures because of the relative weakness of the mandible at molar 1. [15].

Moreover the foramen magnum height and width in both the RS and SH goats have a similar values of 1.79cm and 1.85cm [11; 23] but 1.68cm and 1.60cm respectively in the WAD [14], though the subjects of this study has 2.26cm and 2.90cm for the same indices. Suggesting a divergence in morphology [24] though only the foramen magnum width shows a significant variation at p<0.05 in this goat) from the other three breeds. The effects of severe climatic conditions with its attendant shortage of water, scarcity of forage coupled with the long distance of travel is speculated to be an adaptation for surviving in such situations and contribute to the relatively smaller cranial values being reported in goats of the same type but from different regions of Nigeria [12; 20]. These values are significantly higher in the in the subjects being investigated than the same in the others reported in this work. Whereas the Sahel breed of goat travelling through Tchad republic and Northern Cameroons spill into Adamawa, having better access to water in the die seasons from Tchad basins and Benue river. Benue state thus seems to be a rallying point where goats from all the mentioned routes are sold off. The contributions of culture is to the extent that migration of the normads are aimed for both religious and other festive periods (transportation of more goats for sale) which are more often in the later and drier part of the year.

The importance of the anatomic relationships of the structures of the head surpasses the clinical purpose of knowledge of location and localization for surgical procedures [7].

Proper classification of these goats becomes imperative where standardization of breed lines and the anticipated variable limits for different indices in different ecotypes/breeds to be specified. The interplay of altitude, vegetation and rainfall which is bimodal in Nigeria's vegetation zones are major contributory factors which determines the climate in these areas through which grazing migrations occur [8]. Jos area has a higher altitude and therefore enjoys more volume of rains in a year with concomitant period of access to quality pastures, quantity of water as well as lower ambient temperatures during breeding, gestations and nursing seasons. This represents the influence of environment on heredity thereby enhancing ontogenic variations in phenotypic traits [3], different ecotypes may therefore be obtained [11; 26] which needs to be adequately identified and classified.

## CONCLUSION

It is therefore speculated that the present phenotypic type of goat being studied might be one of the minor breeds or an ecotype of goats present in Nigeria on which there are no literary information as to their skull typology, population size, eco-migration, surveillance, palaeontology and other eco-typologic peculiarities such as heat resistance, kidding potentials [9] and milk yield.

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