

# Morphology of the Bones of the Skull in the Sahel Ecotypes of Goats(*Capra hircus*)in Nigeria

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With 5 figures

Received March, accepted for publication June 2011

## Abstract

The study was designed to investigate some morphological characteristics of the skull of the Ecotypes of Sahel goats in Nigeria. The approach involved morphological description of all the bones in the skull and observing the abnormalities among ecotypes. Morphologically, sexual dimorphism was evident in the frontal and occipital bones with the females having slightly straight frontal plain. The longitudinal convexity of the frontal bone in the male was accentuated between the horns in all ecotypes than the females making the former to possess more of the frontal and cornual sinuses dorsal to the cranium and the distance from the muzzle to the occipital bone shorter. The Basic Brown ecotype skulls had the highest evidences of dental abnormalities, most prominent facial and mandibular tuberosities and mandibular symphyseal rugae. Accessory foramina were

seen in mental, infraorbital and supraorbital foramina in all ecotypes. The occurrences of incisive-nasomaxillo-lacrimar relationship in the all the ecotypes clearly differentiated this species from other small ruminants.

## Keywords

Morphology, Skull, Mandible, Sahel goat, Ecotypes.

## Introduction

Skull typology involves the extensive morphological and osteometric studies of skulls of animal species. Work was done in relation to agein goats (Borthakur, 1990; Borthakuret. *al.*, 1998). Also works leading to the determination of skull shape have been carried out (Onaret. *al.*, 2001), aiding the estimation of landmarks and metric values for regional anaesthesia of the head (Olopade and Onwuka, 2005a) and for sexual dimorphism (de Paiva and Segre, 2003) among others.

There is a relatively little information on the skull typology of the Sahel ecotypes of goat despite the fact that the Sahel goat is one of the largest goat breed in Nigeria (Gall, 1996).

The aim of this work therefore is to study the bones of the skulls and mandible of the Sahel ecotypes of goats in Nigeria.

## Materials and Methods

A total of 144 goat heads comprising of 24 Basic White, 20 each of Basic Brown, Basic Black, Black and White, Brown and White, Black and Brown and Mixed colours of the three, Sahel ecotypes were used for this study.

The goats were obtained from Maiduguri Abattoir and Environs in the northeastern Nigeria. All the goats were physically examined and those found without apparent osteological deformities were slaughtered at the atlanto-occipital joint through decapitation and rapid bleeding and the heads were frozen at 20°C. The heads were then processed and skulls were prepared according to the hot water maceration technique described by Onar(1999), Olopade*et. al.*,(2006). The form (shape, size and position) of the bones of the skulls of the

seven different ecotypes were studied and compared using the information of May (1970); Dyce *et. al.*, (2002) and Olopade and Onwuka (2005a) as guide.

## Results and Discussion

### I. Cranial bones

#### Occipital bones

The condyles, jugular processes and the basi-occipital in all ecotypes resembled that of the ox as reported by Sisson and Grossman (1975). However, the muscular tubercles were situated more caudally and farther apart from the median plane as described by McFadyean (1953) in sheep. The external occipital protuberance was very obvious in female ecotypes than the male (fig. 2).

#### Sphenoid bones

In the cranial cavity, the hypophyseal fossa (sellaturcica) of the sphenoid bones was long and deeply concave, unlike in the sheep where the increased depth of the hypophyseal fossa accommodates the relatively large hypophyseal gland (Sisson and Grossman, 1975). This could mean that the hypophyseal gland in the Sahel ecotypes is larger than in other small ruminants such as the

Sheep. The oval foramen was formed completely by the sphenoid bone similar to that reported in the sheep by Sisson and Grossman (1975), and slightly rostral in comparison to the position in the ox (May, 1970).

### **Ethmoid bone**

The crista galli of the ethmoid basically showed some size differences between ecotypes being thick and large in the Basic White ecotype, but are relatively thin in the Black and White ecotype. The elongated cribriform plates in all ecotypes were most likely a direct correlation with the morphology and size of the olfactory bulbs.

### **Parietal bones**

The prominence of the interparietal suture in the Basic Black ecotypes could be an indication that such breed is prone to cranial fracture in this region. The supramastoid foramen was a direct continuation of the external mastoid foramen. This opening was ventral to the internal opening of the temporal meatus (fig 1). This foramen could provide direct access to the brain in experimental procedures for the delivery of pharmacological substances. In all the ecotypes studied, a median ridge was observed to join the parietal bone at the transverse plane

from the occipital bone. This ridge (external occipital protuberance) is thicker and more developed in the female than the male. This is probable that the ligament of the neck (*ligamentum nuchae*) in the female is robust or well developed than in the male. The differences observed in this study also agree with the report of König and Liebich (2004) which stated that skull bones of the same breed could differ in morphology.

### **Frontal bones**

Sexual dimorphism was prominent in the concavity of the frontal bones. These concur with the information reported by Shawulu et al. (2008a). The accentuated longitudinal convexity of the frontal bones between the horns in the male is probable that it corresponds to the location of the cranium (*Cavum cranii*) and frontal sinuses in the buck (fig 1). This coupled with the fact that males usually have stronger and larger horns than females (Dyce et al., 2002) demand that careful consideration be given to frontal bone morphology in captive-bolt stunning of male goats (Sivachelvan et al., 1995). The ethmoid foramen was completely formed by the frontal bone within the orbit. The occurrence of accessory supraorbital foramina (fig 4) on the dorsofrontal surface of the skull was observed in

over 40% of Black and the black and White ecotype skulls, over 70% of Basic White and Basic Brown ecotypes. Such accessory foramina were seen in the Asam goats (Borthakur, 1990), not reported in Kagani breeds (Sarma, 2006), depicting variation within a specie. The accessory foramina open into large foramen in most cases and in others into a blind end. The numerous supraorbital and accessory foramina are indications of numerous nerve exits that innervate this region and the robust corneal processes in these ecotypes. This is important in regional anaesthesia and dehorning procedures in these ecotypes. The architecture, shapes and sizes of the cornual processes generally revealed a breed polymorphism but generally placed far apart in both sexes and closest in the Basic Brown ecotypes (figs 2 & 3). Clinically, considering the accentuated frontal sinus in the males and the architecture of the corneal processes, the captive-bolt stunning procedures in the goat could be done in between the horns at the back of the head at the position of the interparietal and parietal bones unlike that of the cow and pig where it is done on the frontal bone between the eyes (Dyce *et. al.*, 2002).

## **Temporal bones**

The squamous part of the temporal bone extended less rostral than that of the sheep (Sisson and Grossman, 1975). The retroarticular foramina in all ecotypes were closer to the external acoustic meatus as reported in the Ox (Sisson and Grossman, 1975). The perforation seen in the axis of the ventral end, the zygomatic process of the temporal bone, and the squamous part of temporal bone concur with that found in the ox (Sisson and Grossman, 1975) and in sheep (Popesco, 1975). The petrous part of the temporal bone was relatively small in all ecotypes studied and was completely within the cerebral cavity similar to the sheep as reported by Sisson and Grossman, (1975). The tympanic bulla was compressed with blunt edges seen ventral to the squamous part and rostral to the large jugular processes of the occipital bone as reported by Sisson and Grossman (1975) in the sheep. The muscular processes are very small and almost absent in all the ecotypes. This is unlike to the report of Kahn and Line (2000) in the sheep and goat.

## **II. Facial bones**

### Maxillae

The maxillary bones were less convex than described in the Ox while the facial tuberosity is more prominent than that of the sheep and placed dorsal to a point between the third to fourth cheek tooth as similar to that of the ox (Sisson and Grossman, 1975) while that of the Basic Brown and Basic Black ecotypes of goats were situated dorsal to the fourth to fifth cheek tooth as seen in the sheep. The facial tuberosity was more prominent in the Basic Brown and less in the Basic White goats. This could probably be as a result of greater grinding force exerted by the cheek teeth in response to chewing of tougher roughages, or due to the presence of dental abnormalities in the skulls studied. The infraorbital foramen was generally placed between first and second premolars. However like in the sheep, it was vertical to the second premolar in the Basic Brown and the Basic Black ecotypes of goats. The occurrence of accessory infraorbital foramina had been reported in man (Cananet. *al.*, 1999; Elias *et. al.*, 2004). The foramina seen in this study were single in most cases. In case of double foramina, a tiny plate is found dividing the foramen into two, similar to that reported in man (Elias *et. al.*, 2004). The position of the infraorbital foramen, relative to the premolar

tooth is crucial in the regional anaesthesia during dental extraction (Hall *et. al.*, 2000). Cranial and dorsal to the opening of the infraorbital-foramen is the presence of minute bony perforations. These features were reported in the sheep (May, 1970) and in Kagani goats (Sarma, 2006). The maxillae had short communications with the nasal bones, the incisive, and the lacrimal bones. The premaxillae unit medially forming the palatine fissure similar to that described in the ox and sheep by Sisson and Grossman (1975). The pterygopalatine fossa was seen, formed by the pterygoid, perpendicular part of the palatine bones and the maxillae in all the ecotypes studied. This concurs with the report of May (1970) in sheep.

### Incisive bones

The incisive bones made contact caudodorsally with the nasal bones (fig. 4). The nasal opening was constricted in the Basic White and the White and Brown ecotypes with the palatine processes unified caudally and with the premaxillae in these ecotypes. This arrangement may confer a mechanical strength to the dental pad of the Basic White goats which may aid prehensile ability and prevent injuries to the rostral part of the face and hard palate.

### **Nasal bones**

The nasal bones were not separable from the incisive bone thus laterally, the nasal bone communicates with the incisive, maxillary and lacrimal bones. However except in the Basic White ecotypes, this communications were accompanied by a firm union. The Basic Brown ecotype had in addition bilateral openings on the dorsal surface inward (fig. 4). These openings were observed by Olopadeet. *al.*, (2006). The nasal bone ends into blunt edge prongs rostrally (fig.4) and concurs with the ox reported by Sisson and Grossman (1975). The Basic Brown, Basic Black, Black and White ecotypes (fig. 3), may thus be more prone to cranial fractures in this region than the Basic White ecotypes.

### **Nasal conchae**

Three separate nasal conchae were observed with no sex oreotypic differences in these bones. These conchae were seen like shelves with spaces between them. These concur with that of the ox reported by Sisson and Grossman (1975).

### **Lacrimal bones**

The lacrimal bulla was not extensive but compressed as that reported in sheep by Sisson and Grossman, (1975).The opening of

the naso-lacrimal duct in the goat was also smaller than in sheep as reported by May (1970). The lacrimal bone in all ecotypes presents weak naso-lacrimal junction and fossae, limiting the margin of the orbital circumference; the external lacrimal fossa (fig. 3).

### **Zygomatic bones**

There was no ecotypic difference observed in the lacrimo-zygomatic junction (fig 3). However, a sharp demarcation between the bones was more obvious in the Basic Brown, White and Brown and the Black and Brown ecotypes forming the zygomatic arch of the orbit. This is similar to the ox reported by Sisson and Grossman (1975).

### **Sphenoid bones**

The hypophyseal fossa (sellatucica) of the sphenoid bones was long and deep in concavity; unlike in the sheep where the increased depth of the hypophyseal fossa accommodates the relatively large hypophyseal gland (Sisson and Grossman, 1975).This could mean that the hypophyseal gland in the Sahel ecotypes is larger than in other small ruminants such as the sheep. The oval foramen was formed completely by the sphenoid bone similar to that reported in the sheep by Sisson and Grossman (1975).

### **Ethmoid bone**

The crista galli of the ethmoid basically showed some size differences between ecotypes being thick and large in the Basic White ecotype, but are relatively thin in the Black and White ecotype. The elongated cribriform plates in all ecotypes were most likely a direct correlation with the morphology and size of the olfactory bulbs. This is in agreement with the findings of Reece (2005), which stated that the size of the olfactory region is directly related to the degree of development of the sense of smell which varies among species. It is probable also that the larger olfactory region allows for the degree of the detection of odorous substances reported in dogs by Reece, (2005).

### **Palatine bones**

A set of foramina was seen on the horizontal plate of the maxilla-palatine junction. This feature was also reported in the Kagani goats (Sarma, 2006). Majority of these foramina were seen as large foramina on the palatine bone (fig. 4).

### **Pterygoid bones**

The hamulus of the pterygoid bone was sharp and distinct in all the ecotypes examined. This may present a similar positional mor-

phology of the tensor veli palatini muscle which inserts on this structure in all the ecotypes of goats. The function of this muscle is to flatten a part of the soft palate (in live animal) and to enable the opening of the auditory tubes reported by Himmelreich, (1964).

### **Vomer bones**

The vomer bone was observed in all ecotypes to be a single median bone having double and thin dorsal margins for the articulation with the nasal septum, similar to those found in the ox reported by Sisson and Grossman, (1975).

### **Mandible**

The double opening of the mental foramen seen above the alveolar spaces of some specimens may suggest the occurrence of accessory mental nerve from the smaller foramen. These occurrences are of great importance since accessory foramina in the mandible have been known to transmit nerve branches supplying the roots of the teeth. Local nerve block techniques might fail if any of these nerves or their branches pass through these foramina and escape nerve block. The sources of these foramina might also be an alternate route for tumor spread (Das and Suri, 2004). Lieberman and Crompton (2000) reported that animals that have un-fused man-

dibles, like the goat, does not only have a ratio of working to balancing side adductor muscle force of 1:1 and that they have mandibles that rotate independently during occlusion and have a vertical tooth movements during power stroke of mastication. Such independent rotatory movement is expected to be pronounced in the goats where the two halves of the mandibles do not fuse completely at the symphysis in both young and old animals. The presence of an extremely rough symphyseal surface (fig 6) and marked reciprocal projections (rug-gae) and cavities in the Basic Brown ecotypes compared to the Basic Black and Basic White ecotypes of goats could be an adaptational feature that hold the symphyseal joint in the former which is not only loosed but subjected to pronounced independent rotatory movements than the ecotypes and breeds. Prominent tuberosities were observed at the caudo-ventral portions of the lateral surfaces of the mandibles in Basic Brown ecotypes of goats and less so in the White and the White and Brown goats.

In conclusion, the Basic Brown Sahel ecotype of goat was believed to have evolved from the red Sokoto breed reported by Shawulu *et. al.*, 2008a and therefore had similar trend in skull strength and abnormalities reported by Olopade *et.*

*al.*,(2010). Due to prominent facial and mandibular tuberosities, prominent symphyseal ruggae of the mandible and Cranial sinuses might be prone to fracture easily.

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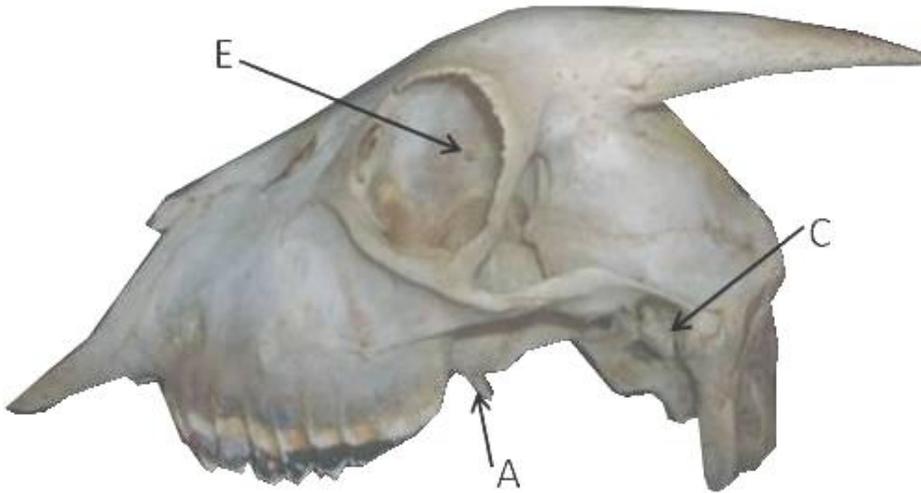
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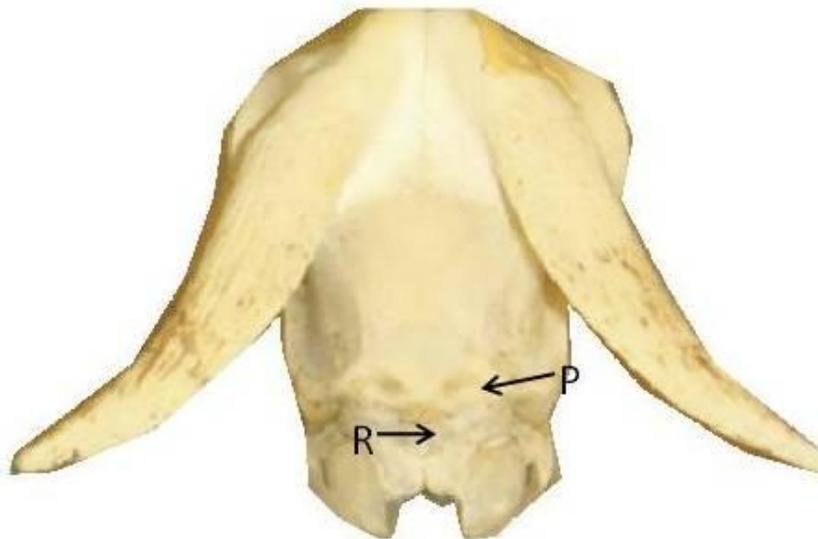
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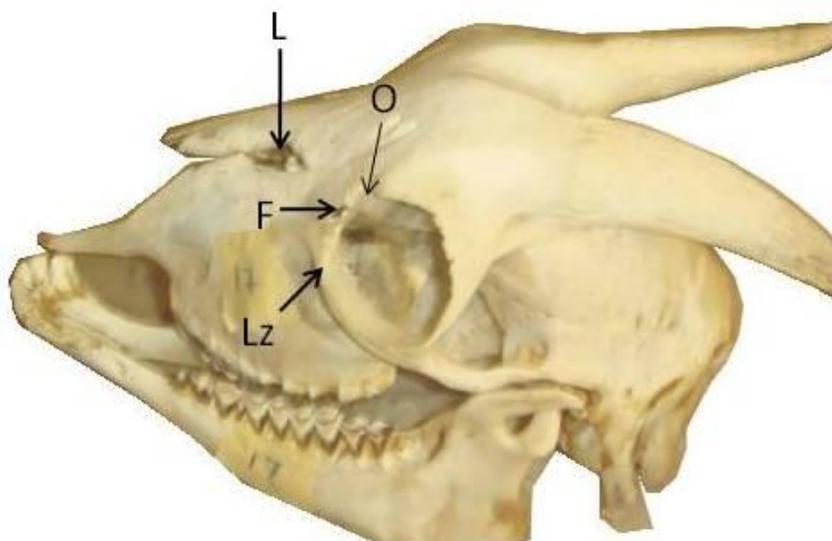
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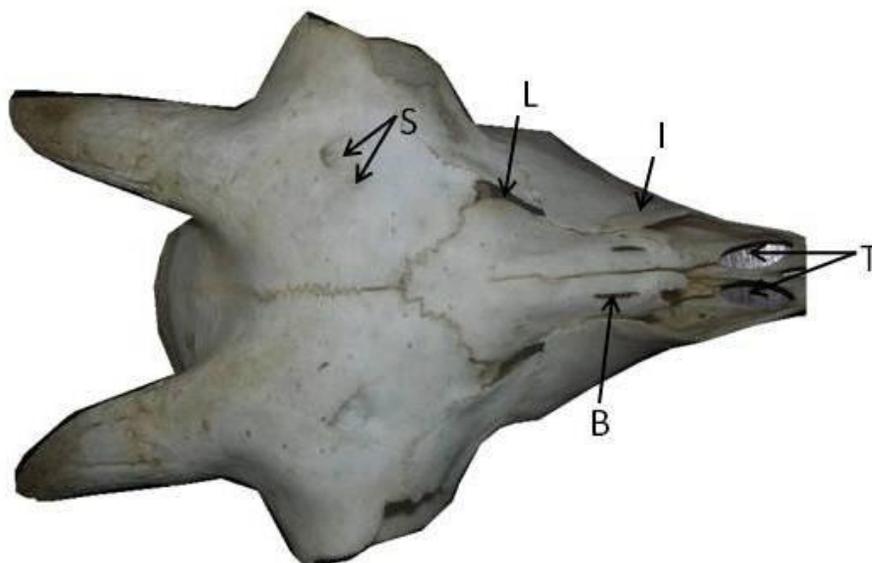
**Fig (1):** Skull of the Sahel ecotypes goat (Lateral view) showing the well developed and pointed pterygoid hamulus (A), ethmoid foramen (E) and the cerebral opening of the temporal meatus (C).



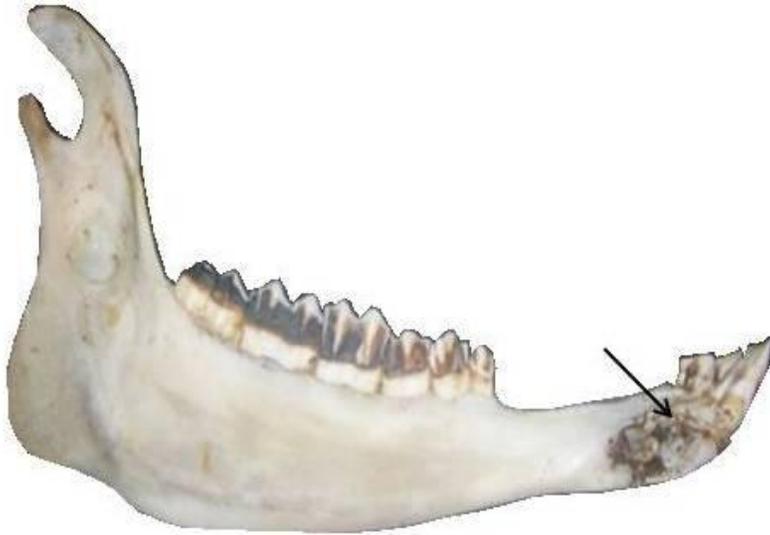
**Fig (2):**Skull of female Sahel ecotypes of goat (Dorsocaudal view) showing the degree of cornual divergence and the thick median ridge (R) and the transverse parietal sutures (P).



**Fig (3):**Skull of female Sahel ecotypes goat (Dorsolateral view) showing a lacrimal fossa (F), weak lacrimo-nasal suture (L), lacrimo-zygomatic suture (Lz) and the limitation of the orbital circumference (O).



**Fig (4):**Skull of the Sahel ecotypes of goat (Dorsal view) with multiple Supraorbital foramina (S), Bilateral openings (B), palatine fissures (T), incisive bone (I) and lacrimo-frontal suture (L).



**Fig (5):**Mandible of the Sahel ecotypes of goat (medial view) showing abnormal and loosed mandibular symphysis (arrow).