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Topography of the Nasal Conchae of Sahel Goat (*Capra hircus*)

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ABSTRACT

A total of five heads of adult Sahel goat obtained from slaughterhouse was examined to elucidate the topography of the nasal conchae. The heads were fixed in 10% formalin and mid-sagittal and cross-sections were performed to examine the shape, form, and explore the internal configuration of the conchae. The cylindrical shaped nasal cavity was divided into two equal halves by a median nasal septum and further reduces into sequence of clefts and meatus by the nasal conchae. The dorsal nasal concha was spindle shaped with tapered rostral ends that blends into the straight fold. The cone shaped middle nasal concha was situated caudo-ventral to both the dorsal and ventral nasal conchae and was bounded by the caudal ethmoidal labyrinth. The ventral nasal concha was the largest and extends rostral into dorsal alar fold and ventral basal fold. These conchae are formed by delicate lamellae that presented distinct structural pattern, depending on the levels of cross-sectional planes. The dorsal, middle, and ventral nasal meatuses which defined the nasal conchae, connects with the common meatus that lie parallel to the median nasal septum.

Keywords: Ecotype; Nasal Cavity; Nasal Turbinate; Sahel Goat; Topography

INTRODUCTION

The nasal cavity plays an important role in conditioning of inspired air to a specific range of temperature, humidity and olfaction, and removal of suspended particles and droplets (Kumar *et al*., 2000). Larger part of the nasal cavity is covered by thin cartilaginous or ossified scrolls of nasal conchae (Konig and Liebich, 2004), a distinctive features of class Mammalia (Van Valkenburgh *et al*., 2004) presenting a complicated and species-specific arrangement (Dyce *et al*., 2010). The anatomy of the nasal conchae has been described in rabbit (Pereira et al., 2011), pig (Parkash *et al*., 2016), camel (Gewaily *et al*., 2019) and sheep (Alsafy *et al*., 2021; Girgiri *et al*., 2022). While reports on craniofacial anatomy (Shawulu *et al*., 2008) and skull typology (Shawulu *et al*., 2011) of different ecotype of Sahel goats are available, to the best of our knowledge there is no reported study on the topography of the nasal conchae. The nasal conchae provide an extensive surface area for heat and water exchange (Valkenburgh *et al*., 2004), whereas the topographical presentation of the fragile conchal structures varies with species adapted to diverse location. Furthermore, gross sectional images of the nasal cavity structures are essential for preliminary interpretation of CT and MRI images of the region, and for inhalation and intranasal safety assessment studies. The Sahel goat is reputed as the dominant breed within the Sudano-Sahel region, found within the Sahel belt of Nigeria (Gall, 1996). They are range goats kept mainly as a source of meat, milk and skin by transhuman pastoralist (Chibuzo *et al*., 1997). The aim of the current study is to describe the normal topography and anatomy of the nasal conchae within the nasal cavity chamber in Sahel goat (*Capra hircus*).

MATERIALS AND METHOD

The heads of five adult Sahel goats (Borno ecotype) were procured from Maiduguri central abattoir immediately after slaughter. The heads were washed with tap water and fixed in 10% formalin for approximately 48 hours. Age was estimated from the decapitated heads using dentition described by Constantinescu (2001). Two heads were sectioned at mid-sagittal plane whereas, the remaining three were serially sectioned transversely at one inch interval using electric band saw. The landmarks for the transverse sections are;

i. Incisive Papilla
ii. Third palatine ridge
iii. Sixth palatine ridge
iv. First premolar
v. Third premolar
vi. First molar

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vii. Medial canthus of the eye

The obtained sections were gently cleansed with tap water to remove debris and photographed immediately with the caudal surface of each section facing the camera. Anatomy of the nasal conchae including topographical relations with adjacent structures in all the five heads were examined and documented.

Ethical Statement

This study utilized decapitated heads obtained from abattoir following routine slaughter thus, requirement for ethical approval was not obligatory.

RESULTS AND DISCUSSION

The nasal cavity of Borno ecotype goat was cylindrical shaped and extends from the transverse bony plate of the ethmoidal bone to nasal vestibule. It was bounded dorsally by fronto-nasal bones, ventrally by the palatine bone and Laterally by the maxilla and lacrimal bone. The cavity was lined by nasal mucous membrane and divided by the median septum into two equal halves. The median nasal septum continued caudal into the perpendicular plate of the ethmoid bone, whereas the rostral end of the median nasal cartilage extended bilateral as the dorsal and ventral lateral nasal cartilages. Majority of the nasal cavity was occupied by the nasal conchae projecting from its lateral wall. These include the dorsal, middle and ventral nasal conchae, delineated by nasal meatus (Figure 1).

The nasal conchae are shell-like structures, including the inner and outer mucous membrane, cavernous venous plexus, and middle lamina of thin cribriform plate (Habel, 1989), considered as one of the key diagnostic mammalian features (Matthew *et al*., 2020). These conchae formed the osseous base of endoturbinates (Konig and Liebich, 2007) that have complicated and variable pattern (Dyce *et al*., 2010). These endoturbinates are attached to the dorsal and lateral wall of the skull and the cribriform ethmoidal plate (Nickel *et al*., 1979). According to the Habel (1989), the bones of the ethmoidal conchae which include the dorsal and middle conchae are referred to as turbinates, while the bones of ventral nasal conchae remained unchanged. However, in classical text, the nasoturbinates form the dorsal nasal conchae, whereas the ethmoturbinates and maxilloturbinates form the osseous structure of the middle and ventral nasal conchae (Konig and Liebich, 2007).

Dorsal Nasal Conchae DNC

The DNC was comparatively the longest, surrounded by the dorsal and ventral nasal meatus. It occupied the dorsal portion of the nasal cavity and extends from the caudal cribriform plate of the ethmoid bone to the rostral end of the cavity. It was spindle shaped, slightly wider at the caudal half and tappers toward the rostral end, where it blends with the straight fold. It passes between dorsal and middle meatus. The wide caudal portion enclosed the dorsal conchal sinus (Figure 1). On a transverse plane, the DNC progressively ascend from the lateral wall of the cavity toward the median septum from the level of third palatine ridge, reaching its maximum lateral dimension at the level of third premolar (Figure 2A-B).

Figure 4B). The rostral frontal sinus was medial to the orbital cavity and dorsal to lacrimal bulla. It flanked the

In Sahel goat, the dorsal nasal conchae (endoturbinate I) enclosed a caudal conchal sinus and a rostral lamella as reported in pig (Parkash *et al*., 2016) and camel (Gewaily *et al*., 2019). It is the smallest of the conchae and simplest in structure as observed by Mathew *et al*. (2020). The caudal part of the dorsal conchal sinus in sheep and goat, is associated with the only medial frontal sinus (Habel, 1989). According to Constantinescu (2001), there exists a clinically important vulnerable open space in the skull of goat between the lacrimal, frontal, nasal and maxillary bones exposing part of the dorsal nasal conche. The main role of dorsal conchae is directing airflow to the olfactory region at the caudal part of the nasal cavity (Van Valkenburgh *et al*., 2014).

Middle Nasal Concha MNC

The MNC was the smallest of the conchae and presented pyramidal outlined on a sagittal section. It was situated caudal, occupying a space between caudal ends of the dorsal and ventral nasal conchae (Figure 1). The middle portion of the middle concha enclosed the middle conchal sinus. Caudally, the middle concha ends into the ethmoidal labyrinths (Figure 1).

The middle nasal concha was the smallest in our study, while in camel (Gewaily *et al*., 2019) the average length was the same as the dorsal nasal concha. It is well developed in the dog, formed by the dorsal and ventral spiral leaf of the long second endoturbinate (Konig and Liebich, 2007). Functionally, the middle nasal concha is primarily if not entirely covered with olfactory epithelium and therefore involved in the sense of smell (VanValkenburgh *et al*., 2014). Because of the formation of intricate recesses and complexity within the olfactory region, they are collectively termed olfactory turbinates (Matthew *et al*., 2020). In camel, the characterized brown coloration of the middle concha represents the olfactory region (Gewaily *et al*., 2019).

Ventral Nasal Concha (VNC)

The VNC was the widest of the conchae. It extends from the level of the last molar tooth and ends dorso-rostral into the alar fold and ventrally to the basal fold. This concha on midsagittal section presented a cylindrical outlined and approximate the length of the dorsal nasal concha (Figure 1). In a cross-sectional plane, the ventral concha presented a basal lamella that projects from the lateral wall of the nasal cavity, splitting into two spiral lamellae that rolled up in opposite direction, given rise to the dorsal and ventral plates (Figure3 and 4A-B). The dorsal plate (scroll) is approximately larger than the ventral plate. Both the dorsal and ventral plates, makes one-and-half turn of spiral lamellae at third palatine ridge (Figure 3B), and two-turns at the level of first and third premolar teeth respectively (Figure 4A-B). The spiral lamella further reduces these plates into circular recesses. The caudal portion of the ventral plate was lined by a membrane enclosing the conchal bulla (Figure4A). The maxillary sinus was divided into large medial and narrow lateral chambers by the infraorbital canal at the level of first premolar (Figure 4A). these chambers open caudally into the lacrimal bulla (

ethmoidal labyrinth and was divided dorsally by septae into medial and intermediate compartments (Figure 4B).

The nasal septum was deficient at this level presenting the wide choana that lead into the nasopharynx (Figure 4B)

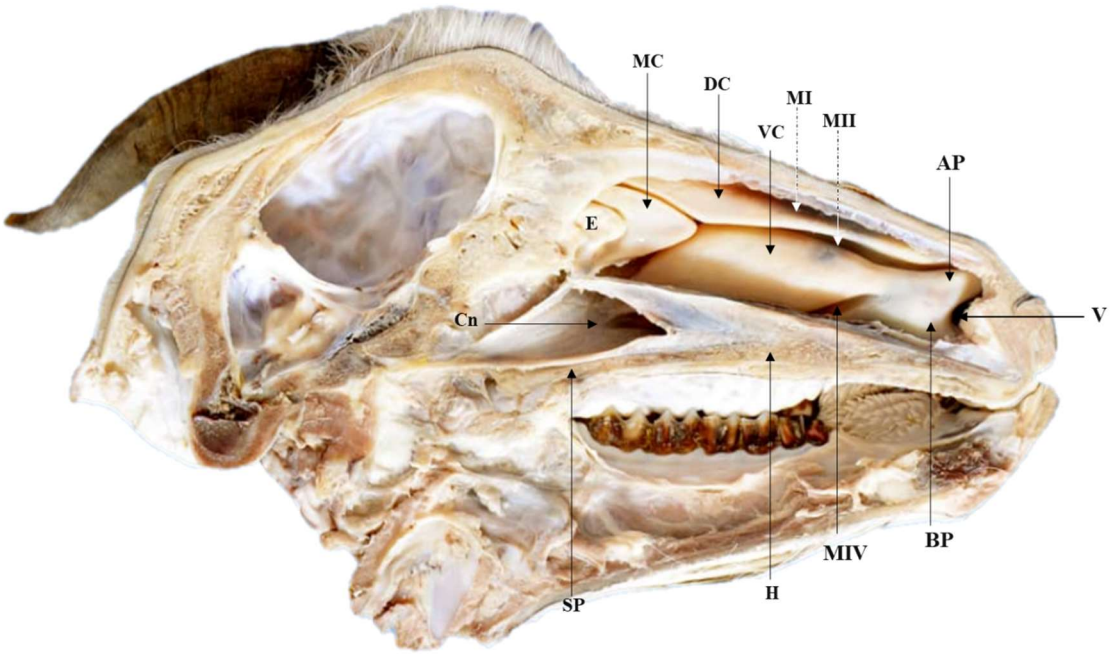

Figure 1: Photograph of mid-sagittal section of Sahel goat head showing dorsal nasal concha DC, ventral nasal concha VC, middle nasal concha MC, ethmoidal labyrinth E, dorsal meatus MI, middle meatus MII, ventral meatus MIV, alar fold AP, basal fold BP, choana Cn, soft palate SP, hard palate H, vestibule V.

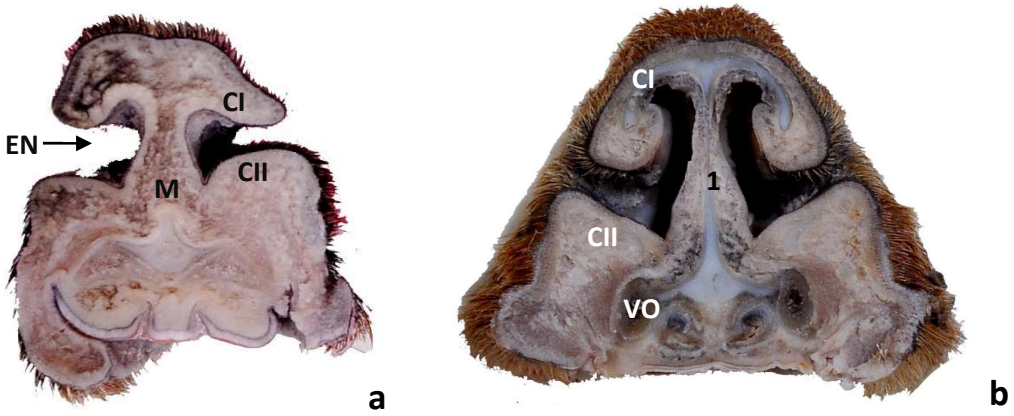

Figure 2.A-B. **A**. photograph of transverse section of nasal cavity of goat at the level of incisive papilla showing; external nare EN, dorsolateral nasal cartilage CI, ventrolateral nasal cartilage CII, rostral end of median septum M. **B**. At the level of 3rd palatine ridge showing; median nasal cartilage 1, bilateral vomeronasal Organ VO.

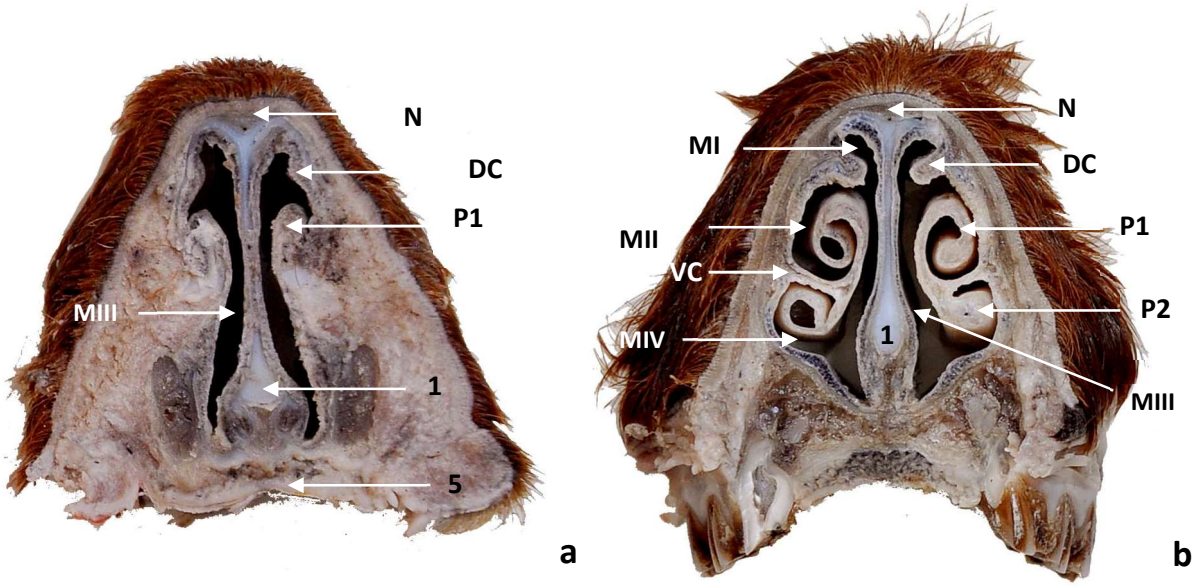

Figure 3: A-B. **A**. photograph of transverse section of nasal cavity of Sahel goat at the level of 6th palatine ridge showing; nasal bone N, dorsal nasal concha DC, dorsal plate of ventral nasal concha P1, common nasal meatus (MIII), median nasal cartilage 1, hard palate 5. **B**. At the level of 3rd molar tooth showing; nasal bone N, dorsal nasal concha DC, dorsal scroll of ventral nasal concha P1, ventral scroll of ventral nasal concha P2, dorsal meatus MI, middle meatus MII, common meatus MIII, ventral meatus MIV, median nasal cartilage 1.

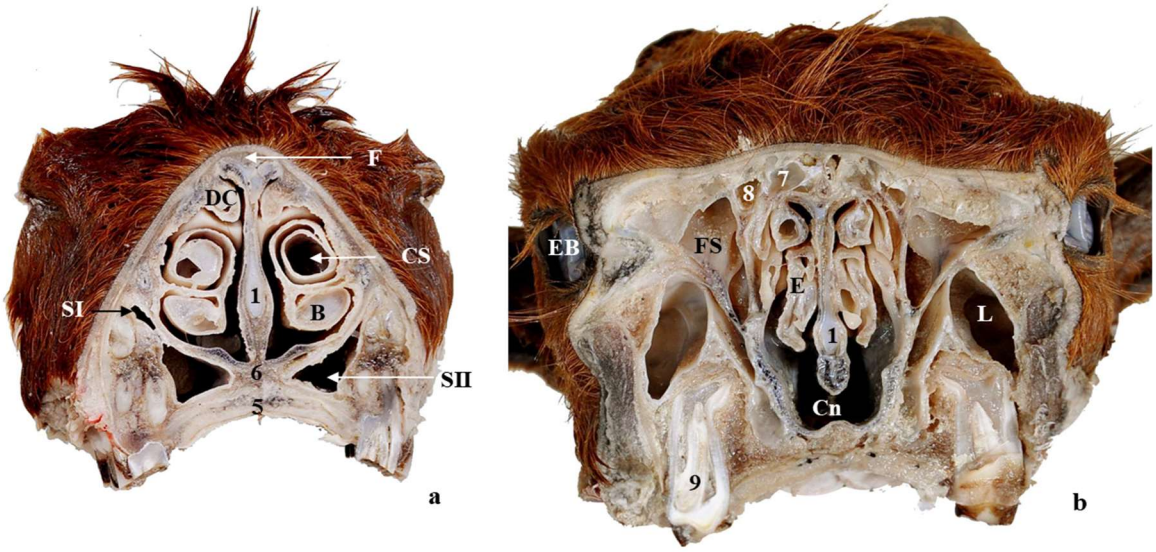

Figure 4: A-B. **A**. photograph of transverse section the nasal cavity of Sahel goat at the level of first molar tooth showing; frontal bone F, dorsal concha DC, conchal sinus of ventral nasal concha CS, conchal bulla B, lateral chamber of maxillary sinus SI, medial chamber of maxillary chamber SII, nasal septum 1, hard palate 5, palatine process of maxilla 6. **B**. At the level of medial canthus of the eye showing; eyeball EB, ethmoidal labyrinth E, choana Cn, lacrimal bulla L, compartment of rostral frontal sinus FS, medial compartment 7, and intermediate compartment of frontal sinus 8, molar teeth 9.

The ventral nasal conchae was the largest in Sahel goat, whereas it was shorter, broader and fusiform in pig (Parkash *et al*., 2016). The rostral portion of this concha bifurcated into the dorsal alar and ventral basal fold as seen in Yankasa sheep (Girgiri *et al*., 2022) and red fox (Mahdy and Zayad, 2020). It appeared nearly S-shape along its length in camel (Gewaily *et al*., 2019). Because of their ventral position, they lie along the pathway taken by air from nares to nasopharynx (Van Valkenburgh, 2004), constituting the largest functional respiratory turbinates

(Matthew *et al*., 2020). In addition, the ventral concha is used for heat and water exchange which is particularly important in endothermic mammals (Matthew *et al*., 2020). All the four nasal meatuses in Sahel goat. It has been observed that the dorsal nasal meatus directs air to the olfactory region (Konig and Liebich, 2007), while the middle nasal meatus communicate with the paranasal sinuses (Awaad *et al*., 2019). The ventral nasal meatus being the main pathway of airflow leading to the pharynx and the only pathway through which stomach tube can be passed (Habel, 1989) whereas the dorsal and middle meatuses are dead end (Constantinescu, 2001). The common meatus is parallel to the nasal septum and connects the other three meatuses as observed in Yankasa sheep (Girgiri *et al*., 2022).

Nasal Meatuses

The projections of the dorsal and middle nasal conchae divided the nasal cavity into dorsal, middle and ventral meatuses, while the median nasal septum contributes to the formation of the common nasal meatus medially (Figure 1-4). The dorsal meatus was the passage between the roof of the nasal cavity and dorsal nasal concha. The middle nasal meatus was situated between the dorsal and ventral nasal conchae. The caudal part of the middle meatus further divided into dorsal and ventral meatuses by the rostral portion of the middle nasal concha (Figure 1). The ventral nasal meatus is situated between the ventral nasal concha and the floor of the nasal cavity (Figure 1). The common nasal meatus was a parallel space on either side of the nasal septum. It communicates with the dorsal, middle and ventral meatuses (Figure1-4). The dorsal and plates of the ventral nasal concha communicates with the middle meatus, whereas the ventral plates open into the ventral meatus (Figure 2-4).

We concluded that sectional images generated in the present study, has provided insight of the nasal conche, nasal meatuses and their functional relation on the head of Sahel goat. This is essential in developing skill of veterinary researchers and clinician in diagnosis and accurate interpretation of radiological, computed tomography CT and magnetic-resonance MR images of these structures.

Conflıct of Interest

The authors declare that they have no conflict of interest.

Author's Contrıbutıon

Concept and results interpretation-IAG; Sample collection and processing UAM, manuscript writing -IA, MHT; Literature search-MHT, MMK.

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