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MORPHOLOGICAL OBSERVATIONS ON THE DEVELOPMENT OF THE VOMERONASAL ORGAN IN THE PRENATAL RED SOKOTO GOATS (CAPRA *HIRCUS*)

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ABSTRACT

The morphological developments of the vomeronasal organ (VNO) in Red Sokoto Goat at prenatal ages of 50 days, 70 days, 90 days, and 130 days, were studied grossly by dissection and light microscopy. The specimens used were obtained from the abattoir and ages were estimated by crown to-rump length. In fetuses aged about 50 days, the vomeronasal epithelium was of stratified cuboidal type with 3-4 layers of undifferentiated cells. Surrounding the epithelium was dense mesenchymal connective tissue that contained venous sinuses and developing crescentic vomeronasal cartilage (VNC), the core of which at this stage contained eosinophilic cells. Mitotic figures were apparent in both the epithelium and cartilage.

In fetuses aged about 70 days, local differences in the epithelium were observed on the lateral wall. The epithelium reduced to 3 layers, while that of the medial wall was up to 5 layers in places. Precursors of glands invaginated into the underlying maturing connective tissue on the lateral wall. These glands were interposed amongst profiles of venous sinuses. The VNC matured further as the perichondrium developed. The underlying connective tissue on the medial wall showed section of nerve bundles.

In fetuses aged about 90 days, the medial and lateral wall maintained the difference in thickness of their epithelium. However at the dorsal and ventral borders, the epithelium was reduced to 2 layers. Glandular ducts were seen to open into the epithelium on this boundary. Profiles of glands and venous were retained in the connective tissue on the lateral wall. The VNC further showed maturation of the perichondrium with clearly differentiated outer fibrous and inner layers. Mitotic figures were not common.

In fetuses aged about 130 days, the epithelium on the medial wall matured into sensory pseudostratified columnar type comprising: bipolar sensory neurons, supporting cells and basal cells, supported by an indistinct basal lamina. The lateral wall became folded and 2-3 layers of pseudostratified columnar cells lined it. Other components of the organ seen in earlier fetuses were present.

KEY WORDS: Histology, Vomeronasal organ, development, Prenatal, Red Sokoto goats.

INTRODUCTION

The vomeronasal organs (VNO) constitute a part of the vomeronasal system, which also includes the accessory olfactory bulb (AOB) and amygdala. The VNO plays important role in chemosensory-mediated pheromonal effects on endocrine regulation, social and sexual behaviour (Halpern and Martinez-Marcos, 2003). It contains the peripheral chemoreceptors for detection of pheromones (Wysocki et al., 1991). The VNO consists of paired cigar-shaped structures that are located medially, usually along the rostral base of the nasal septum (Wysocki and Meredith, 1987). The VNO opens at one and forms a blind sac at the other. The location of this opening is quite variable in mammals, for example in rodents the opening is into the nasal cavity (Vaccarezza, 1981); in cats it is into the nasopalatine canal, which connects the nasal and oral cavities (Salazar et al., 1996); in cows it opens directly into the oral cavity (Adams, 1986). The paired VNO is an isolated area of the olfactory membrane enclosed by a scroll of cartilage, the vomeronasal cartilage (VNC). In almost all groups of mammals, it communicates with the oral cavity or nasal cavity or both cavities (Miller et al., 1964). Dorsal to its origin in the mouth each nasopalatine duct expands considerably and then narrows prior to joining the VNO. In mammals generally, the lumen of the VNO duct is fluid-filled and lined with vomeronasal sensory epithelium on its medial wall, while a nonsensory (respiratory epithelium) lined the lateral wall (Bargmann, 1997; Johnson and Rasmussen, 2002). Typically the epithelium of the VNO is pseudostratified. The sensory receptors on the medial wall are similar to those of main olfactory system, with the exception that they lack cilia and have only microvilli instead. The vomeronasal receptor cells, like the main olfactory receptors, constantly regenerate. The VNO is present in most mammals, reptiles and amphibians, but morphological and functional variations are evident amongst vomeronasal systems of related species and even breeds. There is paucity of information on the development and growth of organs in our local breeds especially goats. There is also little information available on the morphology of the VNO at prenatal stages of development. The report of Ramakrishna and Tiwari (1988) was based only on the study of mid-gestational goat fetus.

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of the VNO at prenatal stages were investigated in attempt to determine whether the anatomical features of the VNO are developed prenatally and perhaps matured to support function. This could contribute to the field of chemosensory studies in our local breeds of domestic animals.

MATERIALS AND METHODS

The heads of 35 Red Sokoto goat fetuses of various ages were used for this study. The fetuses were of abattoir origin. Ages of fetuses were estimated using crown-to-rump length (CRL) and the age calculated using the formula: Age (days) = (CRL+17) 2.1, (Richardson et al., 1976). The fetal age were grouped in the following: 50 days, 70 days, 90 days, 130 days. Following decapitation, the heads were washed with normal saline and their vomeronasal (VNO) was dissected out with the nasal septum and the hard palate for gross observations under a dissecting magnification. Thereafter blocks were fixed in 10% neutral buffered formalin and decalcified for about 1-4 days, depending on the age of the specimen, using formic acid-sodium citrate solution (Bhatnagar and Kallen, 1974; Smith et al., 1997, 1998). The tissues were dehydrated in graded series of ethanol, cleared in xylene and embedded in paraffin wax. The blocks were sectioned in transverse plane at 6-8µm.Every tenth section was mounted on glass slides and stained with Haematoxylin and Eosin..Selected sections were photographed with Leica (Gallen 111) photomicroscope with Moticam digital camera attachment.

RESULTS

The vomeronasal organ was observed to be in direct relationship with the developing vomer, palatine process of maxillary bone and incisive bone. It was laterally encircled by the nasal mucosa and ran along the ventral wall of the nasal septum from the rostral to the caudal part of the nasal cavity. Rudiments of the developing incisive papilla were observed in the fetuses of about 90 days onwards, but the incisive ducts and the openings of the vomeronasdal duct were visible in the fetal samples of about 130days. The vomeronasal cartilage, housing the VNO could not be distinguished from surrounding tissues. The palatal length of the VNO could not be determined and also gross structural differences were not observed between males and females in all fetal specimens available.

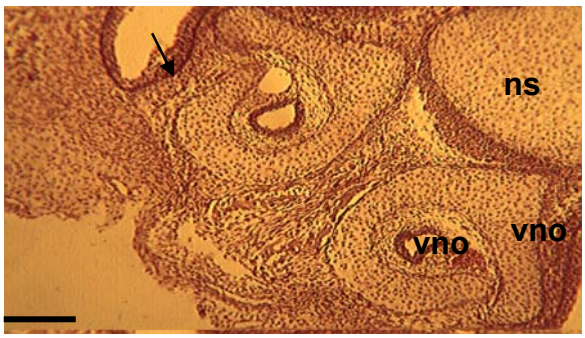

Fig.i:**50**-day fetus, s.b-40µm

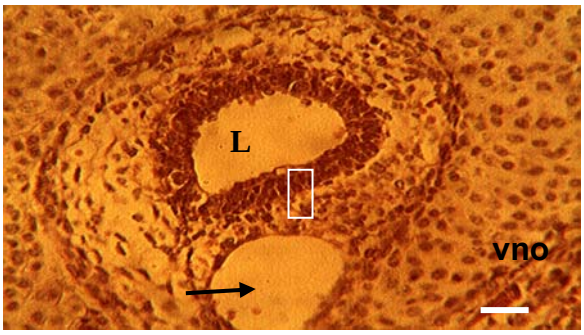

Fig.ii:**50**-day fetus, s.b-20µm

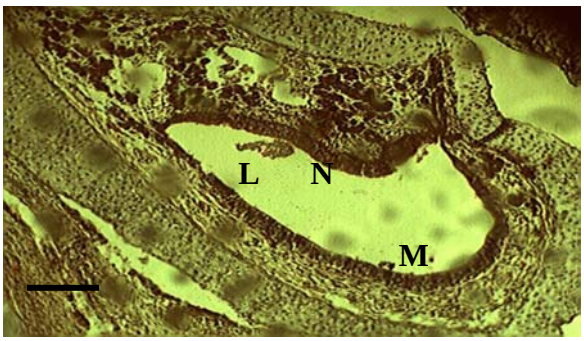

Fig.iii:**70**-day fetus, s.b-40µm

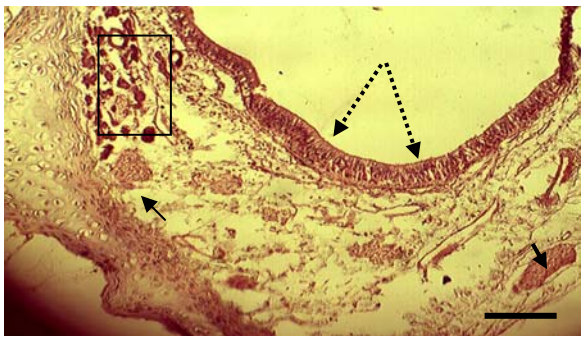

Fig.iv:**70**-day fetus, s.b-40µm

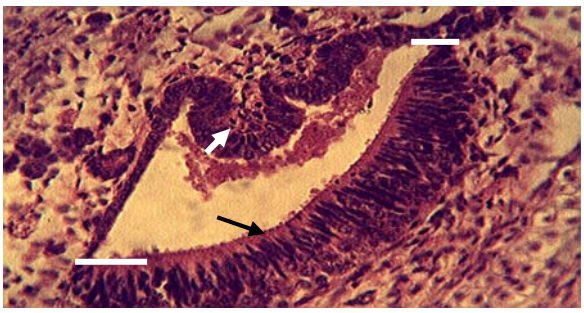

Fig.v:**90**-day fetus, s.b-20µm

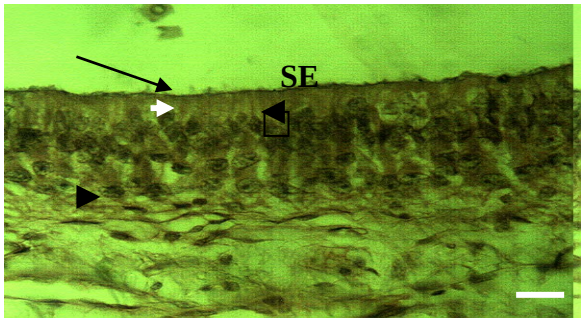

Fig.vi:**90**-day fetus, s.b- 20µm

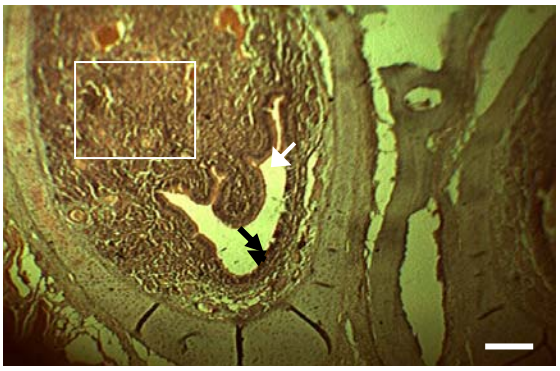

Fig.vii: **130**-day fetus, s.b-30µm

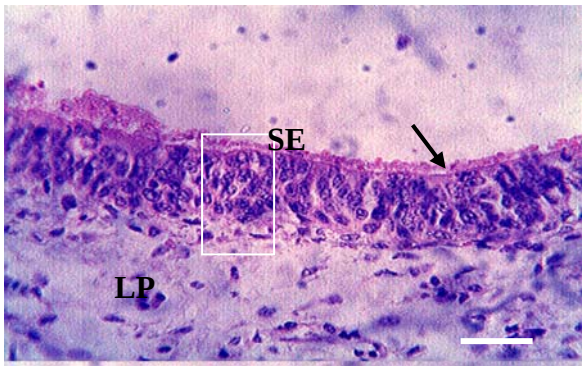

Fig viii: **130**-day fetus s.b-20µm

Fetuses of about 50 days

In fetuses of about 50 days of age, the VNO, under light microscopy was present and clearly distinguished on both sides of the base of the nasal septum as two coma –shaped narrow openings 8 mjenveloped by a complete vomeronasal cartilage (VNC) enclosing a mitotic epithelia lining, scant mesenchymal connective tissue, some blood vessels, precursors of glands and nerves. The organ also communicated with nasal and oral cavities via the incisive duct in the rostral transverse sections of the organ. The vomeronasal epithelia, vomeronasal cartilages and few venous sinuses apparently varied in orientation along the rosto-caudal sections of the organ. The epithelium was of stratified cuboidal type with 3-4 layers of undifferentiated cells. Surrounding the epithelium was dense mesenchymal connective that contained few venous sinuses and developing crescentic VNC, the core of which at this age contained eosinophilic cells. Mitotic figures were apparent in the basal and middle layers of the epithelium. There were also highly evident in the maturing VNC of all the fetal stages. There were no cytological differentiations between the epithelium on the lateral and medial wall of the organ (*Figs i and ii)*. Moreover the basal layers of the stratified cuboidal cells possessed cells that were tightly packed, while the middle and superficial cells were larger, ovoid, with nuclei. In the maturing VNC, the central cells presented round profiles with eosinophilic cytoplasm and high mitotic figures. Few blood sinuses were present. Small vascular sinuses were distinguishable in the lamina propria of the lateral wall of the organ. The lamina propria that underlined the medial wall was also composed of maturing mesenchymal connective tissue with abundant collagen fibers. The submucosa also showed mesenchymal connective tissue with collagen fibers but lacked vascular sinuses. In the middle sections, complete VNC formed complete ring, but in the more caudal sections the VNC was C-shaped, allowing contact with the precursors of the soft tissue structures of the organ (nerves, vessels and glands). It was also observed that fibrous layer of the VNC perichondrium merged with the surrounding mesenchymal tissue. Mitotic cells were common in the VNC and numbers of isogenous group of chondrocytes were less at this age of development and it was observed that isogenous cells increased with the age of fetus. Veins and venules were present and evident by their large lumina and thin walls composed of a thin endothelium and loose surrounding connective tissue with poorly developed tunica media. It was observed that both types of blood vessels retained their characteristics in all fetal ages studied. Spicules of vomer and palatine process of incisive bone were observed. In addition, the adjacent respiratory epithelium lining the nasal cavity had goblet cells at this stage.

Fetuses of about 70 days

In fetuses aged about 70 days, the narrow opening of the VNO was coma to kidney-shaped with its concavity directed laterally. Local differences in the epithelium were observed. On the lateral wall, the epithelium reduced to 3 layers, while the medial wall was up to 5 layers in places. Precursors of glands invaginated into the underlying maturing connective tissue on the lateral wall. These glands were interposed amongst profiles of venous sinuses. The VNC matured as the perichondrium showed differentiation of the outer layer of loose connective tissue from inner cellular layer. Fibroblasts differentiated into chondroblasts, which are round cells, but there were scanty intercellular substance at this stage of the developing VNC *(Fig. iii & iv)*. There was further differentiation occurring between the outer, fibrous layer of the VNC perichondrium and the surrounding maturing mesenchymal tissue unlike the previous age. The nerve bundles were few and occurred mainly on the medial wall close to the maturing VNC. Mitotic figures were also common in this stage of development of chondrocytes. The numbers of isogenous groups of chondrocytes were not different from that of the earlier age. Some blood vessels were also apparent and located in the upper part of the VNO mainly near the lateral epithelium. Glands and their duct were observed in the rostral and middle sections of the organ. These glands occupied more medial positions in the rostralmost sections; the glands were distributed mainly on the lateral wall of the vomeronasal lumen. The connective tissue in the lamina propria and submucosa was apparent but not dense and is made up of collagen and elastic fibers, well organized around the vomeronasal lumen, just beside the VNC. In the rest of the vomeronasal parenchyma, the connective tissue occupied space between the glands and blood vessels. There was apparent increase in the size of nerves

bundle of the vomeronasal nerves and nasocaudal nerves associated with the VNO, located in the medial wall of the organ.

Fetuses of about 90 days

In fetuses of about 90 days, the coma to kidney-shaped profile of the vomeronasal openings (vomeronasal duct) was retained and the concavity located laterally. But there was increase in the size of the lumen of the VNO. The medial and lateral wall maintained the difference in the thickness of their epithelium and was folded *(Fig. v &vi).* However at the dorsal and ventral borders; the epithelium was reduced to 2 layers. Glandular ducts were seen to open into the epithelium on this boundary. Profile of glands and venous sinuses were retained in the connective tissue on the lateral wall. The VNC showed further maturation with clearly differentiated outer fibrous and inner cellular layers. Some mitotic activities were still apparent in the epithelia and the VNC. The VNC size was observed to have increased. The cells on the on the epithelium of the medial wall became more columnar, strongly basophilic cytoplasm with more pale cytoplasmic projections. The soft tissue components (nerves, glands and blood vessels) of the organ persisted without change, except in spatial arrangement from rostral to caudal sections and also different from the other previous ages. Glandular structures were seen readily in the parenchyma of the lateral wall, which regressed in thickness at this age. Mitotic figures were appreciable in both vomeronasal epithelia (medial and lateral), VNC and in the glands. The nervous tissue found mainly on the medial wall showed remarkable growth in sectional size.

Fetuses of about 130 days

In fetal ages of about 130 days the lumen of the VND maintained their oval to kidney-shaped sectional profile. The epithelium on the medial wall was clearly seen to be different from the lateral wall in organization and maturity. It showed 3-4 distinct rows of pseudostratified columnar cells distinguishable by their different set of nucleus: bipolar sensory neurons, supporting cells and basal cells located in the indistinct basal lamina. The oval nuclei of the supporting cells were in upper layer and round nuclei of sensory cells accumulated densely in the middle to the basal region. The lateral wall presented an epithelium that is folded and is about 2-3 layers with ciliated cell surfaces probably filled with mucus secretions. The epithelial surfaces on the medial wall was also pseudostratified columnar with microvillary apical modification (*Figs.vii & viii*). The supporting cells formed a discrete and conspicuous columnar layer in the outer region of the sensory epithelium, extending from the basal membrane to the epithelial surface. The nuclear region is situated in the apical extremity. The lamina propria that underlined the sensory epithelium is composed of loose connective tissue with some collagen; while that under the nonsensory epithelium is also characterized by abundant connective tissue with some collagen fibers. The submucosa showed loose connective tissue with collagen, large blood vessels, vomeronasal glands and bundles of vomeronasal nerves. Large and small vascular sinuses were distributed throughout the submucosa. Both give the appearance of a cavernous tissue to the submucosa. The vomeronasal glands were mainly compound tubuloacinar glands located in the submucosa along the long axis of the dorsal aspect of the VNO. The secretory ducts are lined with simple squamous or cuboidal epithelium. Other components of the organ were more abundant than in the previous ages. There appeared to be more glands than in the preceding stages, and numerous nerves bundle were observed in the submucosa. The VNC showed a perichondrium with clearly differentiated outer fibrous and inner cellular layers. Mitosis of the chondrocytes was rare at this stage, inferring signs of morphological maturity. The numerically predominant vomeronasal cartilage cells at this age are the round, oval, or spindle-shaped chondrocytes. The isogenous groups of cells have also increased at this age. Nerves bundle were abundant in the medial sensory wall.

DISCUSSION

Most data regarding the prenatal development of the VNO among mammals come mainly from rodents (Garrosa et al., 1998) and rabbits (Taniguchi and Mochizuki, 1983). Other2 prenatal studies have reported data on cats (Wohrhman-Repenning and Ciba, 1989).

It was not possible, in the specimens available to determine precisely when the cell proliferation that leads to the formation of VNO started. In this study, the VNO was found to be present in all stages of development studied under light microscopy as bilateral structure located in the part of the nasal cavity and directly related to vomer, palatine process of maxillary bone and incisive bone. The organ extended on either side of the nasal septum from level of incisive papilla to third premolar in the adults. The lumen of the organ varied as the animal matured such that it was indistinct in early fetuses, assumed oval to kidney-shape in cross-sectional profile in late fetuses. The lumen of the vomeronasal duct was also found to be patent in all stages of development with variations in size and shape. The VNO was seen to increase in palatal length as the age of the goats advanced. There was communication between the VNO and the nasal and oral cavities in all stages of development studied.

In fetuses aged about 50 days, the vomeronasal epithelium was of stratified cuboidal type with 3-4 layers of undifferentiated cells. The epithelium on the medial and lateral wall was of the same thickness. Mitotic figures were seen in both the epithelium and cartilage. The differences in the thickness of the sensory and nonsensory epithelia were obvious from the 70-day fetuses (representing the second trimester of pregnancy). Microvillary structures ('brush borders') were found in medial sensory epithelia in fetuses of about 90 days onwards. Microvilli have been considered as the first candidate for site of chemoreception (Miragal et al., 1979). Cilia have not become relevant for chemoreception in the vomeronasal epithelium contrary to what happens in the olfactory epithelium where cilia with their odor receptors (Lowe & Gold, 1991) are used to scan chemicals. In fetuses aged about 90 days, the medial and lateral wall maintained the difference in thickness of their epithelium. The differentiation of the epithelium into pseudostratified

columnar was also apparent at this age and folded of the epithelium were seen. In fetuses of about 130 days the epithelium matured into sensory pseudostratified columnar type comprising, bipolar sensory neurons, supporting cells and basal cells. This epithelium was maintained with further maturation in the neonatal, prepubertal and pubertal goats. Other components of the organ seen in fetuses of about 130 days were present in the other stages of postnatal development.

There is a wide agreement that the vomeronasal duct (VND) in most mammals is lined by 2 different types of epithelium, respiratory and receptor (Wysocki & Meredith, 1987; Meredith,1999). This has been demonstrated at the optical and by other sophisticated methods (Bannister & Dodson, 1992) in a representative selection of animals. Moreover from phylogenetic standpoint, therefore, this is now clearly established. The Red Sokoto Goat is no exception to this rule as seen in the fetal and adult stages in the observations; both Besoluk et al., (2001) and Ramakrishna (1988) have demonstrated the presence of both types of epithelium in adult Angora goats and mid-gestational Korean goats respectively and their findings support our present results.

Also, the present results also show that the development of the VNO in Red Sokoto Goat (RSG) tends to progress rapidly in the latter half of the gestation period; (96 days to birth), this is in agreement with the findings of Takigami et al., (2004) in his studies of the entire vomeronasal system (VNO and accessory olfactory bulb, AOB) in fetal goat, that the maturation is reached during the third trimester of pregnancy and also the studies of Salazar et al., (2003) in sheep supports the results of this work in goat.

The VNO in fetuses of about 50 days already takes the form of two tubular bilateral structures, which appear elliptical in transverse sections surrounded by a vomeronasal cartilage (VNC) and small vomeronasal duct lumen. Cytological differences among cells in the lateral and medial walls of the vomeronasal epithelia were not found in the fetuses of about 50 days, though the differentiation between the two epithelia that form the organ probably begins later in this stage of fetuses. The medial wall shows similar characteristics to those of the olfactory mucosa that covers the roof of the nasal pits (and conchas). Later in fetuses of about 70 days, the lumen of the vomeronasal duct which was small, coma or J-shaped began to show more canalization, becoming wider and oval to round in shape in the later fetal stages. The differences between both epithelia that form the VNO was distinct with advancing age, so that in the age of about 130 days, the epithelia difference between the lateral and medial epithelial, other components of the VNO is similar to that in adult. Consequently, this seems to agree with findings of Salazar et al., (2003), that both VNO and accessory olfactory bulb developed in biological sequence and completed their morphological development at the entry into the last third of gestation.

Moreover, the findings on the morphological feature of the fetuses 70 days (approximately mid-gestation of goats) in their lateral and medial wall epithelial lining and presence of occasional goblet cells, with the presence of tubulo-alveolar glands (lateral wall) agrees with that of Ramakrishna and Tiwari(1988) , in their studies of the histomorphology of the VNO in mid-gestational goat fetuses and that of Takigami et al., (2004) in their studies on the development of the VNO of fetal goat using immunohistochemistry.

Three types of cells as in the adult receptor epithelium were not clearly distinguishable from the morphological point of view until towards the end of intra-uterine life, they were then observed as bipolar cells with spindle nuclei in the upper half of the epithelium, polygonal cells with rounded nuclei located in the deeper half and finally occasional basophilic cells located in the basal layer. These cells will give rise, respectively to the supporting cells, the bipolar sensory neurons and the undifferentiated basal cells. At about birth, a nuclei-free region in the luminal edge of the receptor epithelium became distinguishable. This area is the result of the alignment of the supporting cells nuclei in the upper layers, at a distance from the lumen. The existence of basal cells in the vomeronasal epithelium is of considerable interest, because these cells may give rise to one of the cellular types forming this epithelium. The existence of highly mitotic basal cells in the sensory epithelium of fetal goats in this study is strongly supported by reports of (Ichikawa et al., 1999; Wohrman-Repenning and Barthmuller 1994 and Takigami et al., 2000).

The non-sensory epithelium (lateral wall) is found in only one to 2 layers of cells in the 50-day fetuses, but the clear and dark types of cells constituting this epithelium are found in the fetuses of about 70 days onwards. Meanwhile, a complete differentiation of this epithelium is found in the 90-day fetuses. These two cell types have also been distinguished in sheep (Kratzing, 1971). The presence of occasional goblet cells in the lateral (non-receptor) epithelium has also been reported for sheep (Kratzing, 1971) and rabbits, but it is absent in rat (Briephol et al., 1979).

The present study in Red Sokoto goats is also supported by the reports in pigs (Salazar et al., 2003) rats (Garrosa and Coca, 1991;Garrosa et al., 1992), sheep and several other mammals in forming sensory and non-sensory epithelia divisions during fetal development.The characteristics of the ciliated epithelium (non-sensory) are very peculiar, differing clearly with regard to normal respiratory epithelium. For this reason, its significance and role in the functioning of the organ during the prenatal period requires further investigation. Mitoses disappeared in the vomeronasal epithelium as the fetuses grows older and almost non-existent in neonatal sections and if found are located exclusively in the deeper layers of the epithelial. This finding is consistent with that of Salazar et al., (2003) on the morphogenesis of the VNO in fetal and adult pigs. In the study, many blood capillaries were found beneath the medial sensory epithelium. This was also found by Bakker (1939) in donkey, cattle, sheep, dogs and rabbit and by Salazar et al., (1997) in horses.

The vomeronasal cartilage (VNC) was present in all stages examined with similar C-shaped appearance in the middle segments of the VNO, while in the rostral and caudal segments it was coma-shaped.; it matured into a hyaline cartilage with isogenous groups of chondrocytes in the late fetal stages. Mitotic figures are common in the cartilage of early fetuses, but rare in older and postnatal goats. The VNC envelops and

protects the vomeronasal duct and its associated soft tissue components of the VNO (i.e. the vomeronasal parenchyma comprising the vomeronasal duct, glands, connective tissues, blood vessels and nerves).The vomeronasal cartilage (VNC) which protects the vomeronasal apparatus was apparent in first trimester of intra-uterine life and it had the appearance of immature cartilage with many mitotic chondrocytes. The differences between the young and older fetuses were very clearly shown by presence of isogenous groups of chondrocytes which increased with the age of the fetuses. This is different from the bony cartilage (capsule) in rodents (Wysocki & Meredith, 1987). The VNC is also cartilaginous in carnivores and most ungulates. This variation makes it unwise to extrapolate from one species to another. The cartilage of the vomeronasal organ was clearly visible in all histologic sections and play a role in the pump mechanism (Anggard, 1974).The cartilage partly encircles the lumen of the organ with an area of erectile tissue on the lateral aspect of the cartilaginous tube. Nasal erectile tissue has a dense adrenergic innervations and sympathetic stimulation has shown to cause nasal vasoconstriction (Anggard & Edwall, 1974). Therefore the venous erectile tissue around the organ would be expected to constrict on sympathetic stimulation. Encircling cartilage would prevent any collapse of the lumen of the VNO on constriction of the surrounding erectile tissue and the tension created in surrounding may cause an expansion of the lumen.

Vomeronasal glands appeared early in development near the vomeronasal duct and most opened into the lumen in the areas of the lateral wall, especially close to its boundary with the medial sensory epithelium., but are abundant throughout the parenchyma, further studies are needed to show if they active at this early stages. In the development of the vomeronasal glands, some glandular rudiments can be seen even in 50-day fetus in the lateral epithelium. Vomeronasal glands play important functional role in xenobiotic activity (Ramakrishna et al., 1994), mucous secretion (Cooper & Bhatnagar, 1976), production of possible pheromone-carrier proteins (Ohno et al., 1996) and immunological processes. The secretion from vomeronasal organ may act as a sampling medium for air borne odorants and as a cleansing medium, which continually flushes out the lumen of the organ. Without some sort of cleansing secretion, substances that gained access to the lumen of the organ would remain in contact with the receptor epithelium indefinitely.

Blood vessels which form venous sinuses were evident in the early fetal stages, veins are not only larger but also more numerous than arteries and the veins usually singly but atimes in pairs form venous sinuses very close to the lateral nonsensory epithelium. Both kinds of blood vessels retained their main characteristics throughout development. Several arterioles, venules and large venous sinus make the VNO a highly vascularised structure. At about 50 days intra-uterine life of fetuses, some capillaries can already be distinguished in the lateral zones (wall) of the organ. Capillaries were also present in the 50-day fetuses and the central blood sinus can be seen ostensibly occupying the concavity of the organ. Such a highly irrigated structure as the VNO, with many similarities to the neighboring nasal mucosa made us believe that the VNO consisted of an erectile tissue. Taniguchi et al., (1992) stated that there were no venous sinus in the VNO of marmoset, but Salazar et al., (1996) reported venous sinuses in pigs, cows and horses and in this investigation, it was observed that in addition to the arteries and veins described, groups of vessels comprising very few cells are venous sinuses. Observations of serial sections in the adult goats showed that the distribution of these soft-tissue components varies along the rostrocaudal level.

In transverse sections, at levels where the receptor epithelium is present, several nerves are readily apparent between the vomeronasal duct and medial sheet of the VNC in all stages of development. The nerves bundle were observed throughout the stages of development and these nerves were seen to be located medial and ventral to the vomeronasal duct, also further studies are needed to determine when these nerves become myelinated. But previous authors have tended to report the presence of unmyelinated nerves without providing any photograph or other evidence (Mendoza & Khunel, 1987). But the report of Salazar, (1996) in dogs shows with evidence that these nerve fibers are unmyelinated and myelinated axons and also that these are the vomeronasal nerve and naso- caudal nerve fibers.

In our study the morphological features observed in foetuses of about 130 days (last trimester) was apparently similar to the adult features (Wysocki and Meredith, 1987; Salazar, 1996) and this may suggest that the VNO could support some functions at this age. However, a long period of postnatal development may occur before histological maturity and increased size are achieved.

Some behavioral experiments performed to determine whether the vomeronasal system (VNS) comprising VNO and Accessory olfactory bulb (in brain) is functional at birth in species that posses it at this stage suggest that in snakes it is functional (Holtzmann, 1998; Holtzmann and Halpern, 1990), whereas in rabbits and mice it is not (Coppola et al., 1993), although in some other rodents (e.g. guinea pigs and rats), It might be (Mendoza & Khunel, 1989, Coppola & Miller, 1994). It has even been suggested that in rats it may be functional *in utero* (Pedersen et al., 1983). Some animals that have no functional VNO, even when adult develop them during embryogenesis, they undergo regression afterwards; cases in point include crocodilians, some bats and certain primates (Bhatnagar et al., 2001), possibly man. The functionality of the VNO depends on the development of the accessory olfactory bulb (AOB). The relative early appearance of accessory olfactory bulb (AOB) glomeruli is worth stressing, because the connection of the vomeronasal nerves with the terminal dendritic tree of the mitral/ tufted cells and with the associated periglomerular cells appears to constitute the final link in the information path between the sensory epithelium of the VNO and AOB, as in the main olfactory system (Puche & Shipley, 2001).

In conclusion, this study has shown that the vomeronasal organ (VNO) before birth has already acquired the following characteristics

(i) A VNO that communicates with the nasal cavity and oral cavity through incisive or nasopalatine duct.

(ii) A sensory epithelium (medial epithelium) that are morphologically similar to those of the adult (critical for functional capacity)
(iii) Presence of vomeronasal nerves, vomeronasal glands, vomeronasal cartilage as in adults.

Also, the morphology of the VNO in the Red Sokoto goat like most mammals varies from rostral to caudal end of the organ with different orientation of the soft tissue structures of this organ.

On the basis of these findings, the general conclusion may be drawn that as far as can be judged from morphology, the VNO at late fetal stage or at birth is developed, showed some maturation and may be capable of supporting function.

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