HISTOLOGICAL STUDIES OF THE VOMERONASAL ORGAN OF AFRICAN GIANT RAT (*Cricetomys gambianus,* WATERHOUSE)

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ABSTRACT

The vomeronasal organ (VNO), a chemoreceptive organ was studied in African giant rat (Cricetomys gambianus, Waterhouse), a macrosmatic animal, by means of gross dissection and light microscopy. The VNO was located in the rostral part of the base of the nasal septum. It was tubular in shape, about 10.6 mm in length and opened in the rostral region of the nasal cavity, with a blind caudal end that terminated in glandular branches. Its lumen in the middle segment was lined by sensory epithelium on the medial wall and non-sensory epithelium on the lateral wall. The sensory epithelium showed sensory, supporting and basal cells, whereas the non-sensory wall contained psendostratified columnar cells with ciliated epithelium. Vomeronasal glands were present in the lateral wall and on the dorso-lateral region between the sensory and non-sensory epithelia. Intraepithelial blood vessels were observed on the medial sensory epithelium. Nerve bundles were also apparent in the medial sensory wall. The vomeronasal capsule incompletely housed the organ and showed ossified areas. The histological observations suggest that the VNO is an important organ in sexual behaviours as in other rodents and will throw more light on future studies of the vomeronasal organ.

Keywords: African giant rat, Histology, Chemoreception, Vomeronasal organ

INTRODUCTION

It is well established that the mammalian vomeronasal organ (VNO) is involved in the control of sexual behaviour (Estes, 1972; Wysocki, 1979; Meredith and Fernandez-Fewell, 1994). The VNO is a chemoreceptor organ; the receptor cell project their axons to the accessory olfactory bulb and other higher centers of the brain and is involved in detection of con-specific chemical signals (pheromone). The organ has a tubular structure, with a lumen surrounded by two types of epithelium: the vomeronasal epithelium and non-sensory epithelium. Mammalian VNOs has been extensively studied anatomically (Adams and Wiekamp, 1984; Johnson *et al.,* 1985; Salazar *et al.,* 1994; 1995; 1998). The vomeronasal organs of many rodents have also been studied, in rats (Garrosa *et al.,* 1986; Garrosa and Coca, 1991; Zuri *et al.,* 1998; Weiler *et al.,* 1999), in mouse (Addison and Rademake, 1927; Barber and Raisman, 1978), rabbit (Wohrmann-Repenning, 1984; Taniguchi and Mochizuki, 1983), and guinea pig (Sangari *et al*., 2002).

The African giant rat (*Cricetomys gambianus*, Waterhouse), with an average adult mass of 1.4 kg is one of the largest cricetids, occurring in Africa, predominantly confined to moist savannah regions. They are nocturnally active restricting their activity to areas with reasonable vegetational cover (Knight, 1984). It provides supplementary protein diet for rural dwellers. There has been a continuous effort to domesticate it in some parts of Nigeria.

Some aspects of the biology of the African Giant Rat (AGR) have been studied (Ewer, 1967; Ajayi, 1977; Kokkin, 1981; Knight, 1984; Knight and Knight-Eloff, 1987; Ogwuegbu *et al.,* 1983; Oke, 1985; Oke and Aire, 1989; 1997; Olayemi and Adeshina, 2002; Kelani and Durotoye, 2002; Onyeanusi *et al*., 2007). There are no published reports on the vomeronasal organ of the African giant rat. The aim of the present study was to examine the histological structure of the vomeronasal organ in order to shed light on the AGR, which has good potential for use as animal protein and research model.

MATERIALS AND METHODS

Eight adults (5 males and 3 females) over 8 months old from kill-trapping in the fields around the University of Nigeria, Nsukka, were used in this study. Following decapitation, the heads were washed with normal saline and their vomeronasal organ was dissected out with nasal septum and hard palate for

gross observations under dissecting microscope. Some blocks of tissue were sawn with small handsaw after trimming off the palatine and vomer bones. These blocks of tissue containing the VNO was fixed in 10% neutral buffered formalin decalcified using formic acid-sodium citrate solution for 2 – 4 days according to Bhatnagar and Kallen (1974) and Smith *et al*. (1997). 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 7μm thickness. Every tenth section was mounted on glass slides and stained with haematoxylin and eosin. The middle sections of the organ were observed with a Hund Wetzlar 600H light microscope with Moticam 1000 digital camera attachment and images captured into a computer. Ocular and stage micrometer gauge were used to measure the thickness of the sensory and nonsensory epithelium.

RESULTS

Location and Morphology: The vomeronasal organ was a paired bilateral structure located at the base of the nasal septum, with direct relationship with the vomer bone, palatine process of maxillary bone and the incisive bones. Each organ appeared as a hollow cylinder. The average palatal length was 10.6 mm. It communicated with the nasal cavity through the incisive duct rostrally. It was blind caudally. The VNO was enclosed by an incomplete vomeronasal capsule (VNC), which was a matured hyaline cartilage with some ossified areas. The VNC is incomplete in its dorsolateral region. The lumen of the organ was an elongated bean-shaped opening (Figure 1).

The size and internal contour of the vomeronasal duct varied along its longitudinal axis. Rostrally, the lumen of the tube was bounded by a medial and lateral cartiginous wall. Caudally, as the organ increased in size, the lateral wall of the tube was convex and the medial wall concave. The medial wall lay on the nasal septum, while the lateral wall was covered by the nasal mucosa.

Histological Observations: Three segments with different histological features were observed between the rostral and caudal ends of the vomeronasal organ. The rostral segment had the openings of the organ into the nasal cavity. This segment was covered by stratified squamous epithelium and that of the nasal cavity by pseudostriatified columnar epithelium. The middle segment presented different epithelia in each of its walls (Figure 2, 3 and 4). A pseudostratified epithelium about 31.6 μm thick covered the lateral wall.

The vomeronasal epithelium found on the medial wall was about 140.2 μm thick. The sensory vomeronasal epithelium was absent in the caudal extremity of the middle segment and thereafter the pseudostratified epithelium changed to simple columnar cells. The vomeronasal epithelium in the middle segment was made up of a superficial layer formed by extensions of underlying cells, a layer of elongated supporting (sustentacular) with oval nuclei and 8 – 10 layers of bipolar cells with rounded nuclei (Figure 3). The basal cells were interposed amongst lower bipolar cells without forming a distinct layer. Apical 'brush border' were present on the vomeronasal sensory epithelium of the medial wall (Figure 5). A profuse vascularisation of the VNO at the lateral wall was seen and these represented venous sinuses with a prominent large vein amongst smaller arteries, capillaries and venules. The vomeronasal cartilage (vomeronasal capsule) showed ossified points and did not completely enclose the organ but left a dorso-lateral opening for passage of some glands and nerves of the organ. The caudal segment of the VNO terminated in some glandular branches with simple columnar epithelium around its lumen.

Connective tissue spread from the adventitial layer of the venous sinus reached and merged with that of the vomeronasal capsule (Figure 7). Two groups of glands were observed amongst the loose connective tissue, the upper glandular groups were found at the dorsal transition of the epithelia, whereas the other occupied a lateral position on the non-sensory epithelium. Some glands were also visible through openings in the vomeronasal capsule and seem to have reached the lower regions of the nasal septum (Figures 8 and 9). Few nerve plexuses were observed on the lamina propria. Venous sinuses and glands occupied much of the lateral wall of the organ, which was incompletely housed by the ossified capsule. Intraepithelial capillaries were observed amongst the cells of the sensory medial wall (Figures 10, 11 and 12).

DISCUSSION

Histological descriptions of the vomeronasal organ in most mammals frequently show a uniform organization along the longitudinal axis of the tube: The vomeronasal sensory epithelium in the medial wall and the non-sensory (respiratory epithelium) in the lateral wall. Our present histological observations in the medial and lateral walls of the VNO in African giant rat (AGR) is supported by similar findings in very young rat (Kratzing, 1971a); older rat (Vacarezza *et al*., 1981), rabbits (Taniguchi and

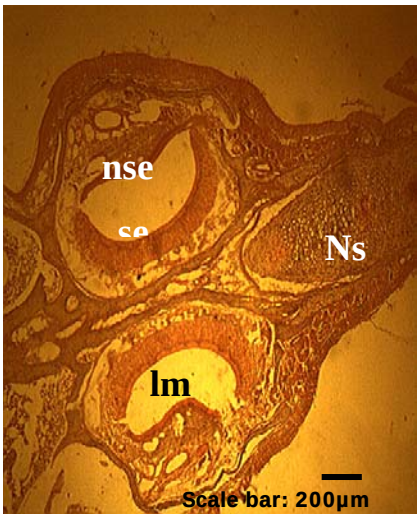

Figure 1: Paired vno sensory (se) and nonsensory (nse) epithelium, lumen of vno (lm), nasal septum (ns)

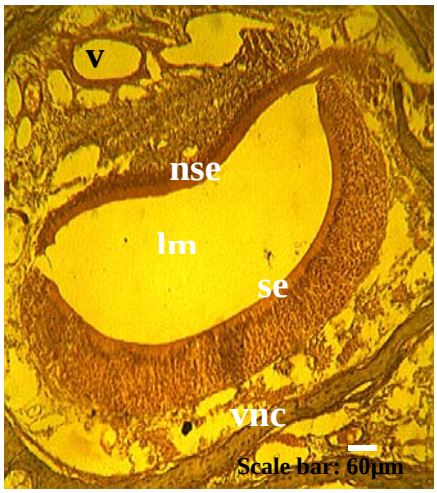

Figure 2: Vomeronasal organ with large vein (v), vomeronasal capsule (vnc)

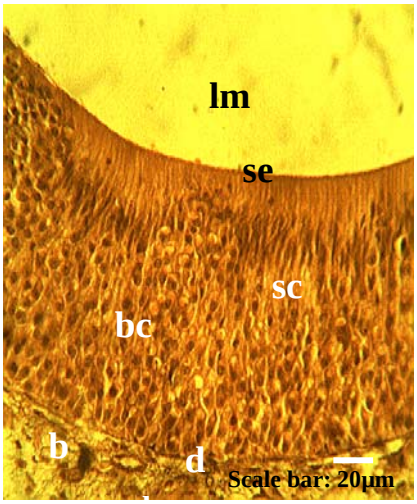

Figure 3: Sensory epithelium: sc - supporting cells, bc - bipolar neurons, b - basal cells, d -dendrites

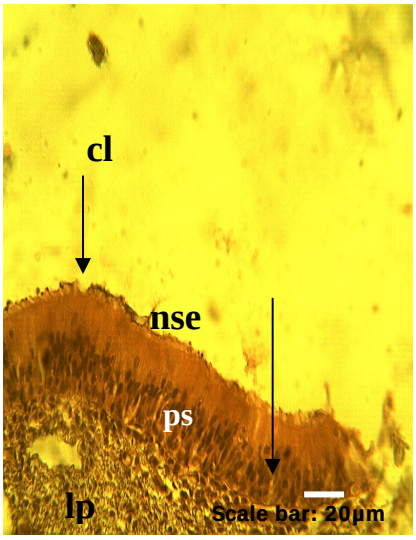

Figure 4: Nonsensory epithelium (nse), ps - columnar cells, lp - laminar propria, basal cells – arrows, cilia - cl

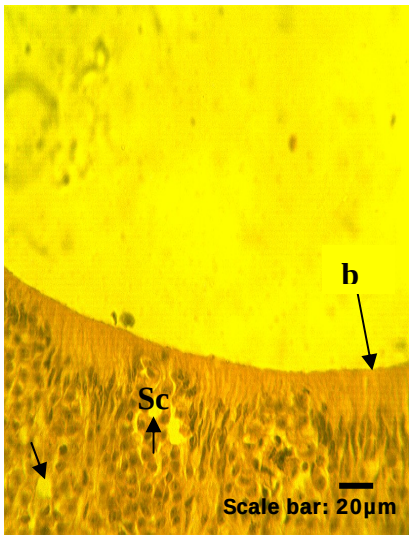

Figure 5: Sensory epithelium: microvillary surfaces (b), supporting cells - sc, intraepithelial capillaries (arrows)

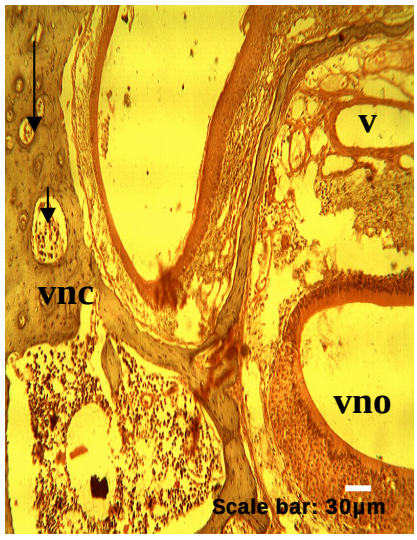

Figure 6: Relationship of vno and capsule (vnc). Note ossified areas (arrows)

Mochizuki, 1983), sheep (Kratzing, 1971b) and golden hamster (Taniguchi and Mochizuki, 1982).

The cells of the vomeronasal sensory epithelium of the African giant rat show some similarities in number and in the arrangement of the apical process and microvillary 'brush borders', as observed in rats (Garrosa *et al*. 1986) several other rodents. This may have important functional implication in reception of stimuli. Many capillaries, several arterioles and large veins on the lateral non-sensory epithelium make the vomeronasal organ a highly vascularised structure. Such an irrigated structure as the VNO with similarities to the neighbouring nasal mucosa suggest that the VNO in AGR consists of an erectile tissue as in most mammals so far studied.

Intraepithelial blood vessels seen in the vomeronasal organ of AGR could be of phylogenetic consideration. Such blood vessels have been described in lower vertebrates, Guinea pig (Sangari *et al.,* 2002), mouse (Cushieri and Bannister, 1975), but have not been observed in VNO of higher mammals where the vomeronasal epithelia are gradually reduced (Jordan, 1972). It can be suggested that the presence of intraepithelial blood vessels is to provide nourishment for the thick epithelium and permit exchange of metabolites (Cushier, 1975). The relationship of these blood vessels with vomeronasal endocrine regulation remains to be verified.

Vomeronasal glands were also observed to be located within the VNO (lateral wall) and some outside the vomeronasal capsule close to the respiratory mucosa. The communication of these extracapsular glands with lumen of the organ is feasible through the gap existing in the capsule, which are also used by the nerves.

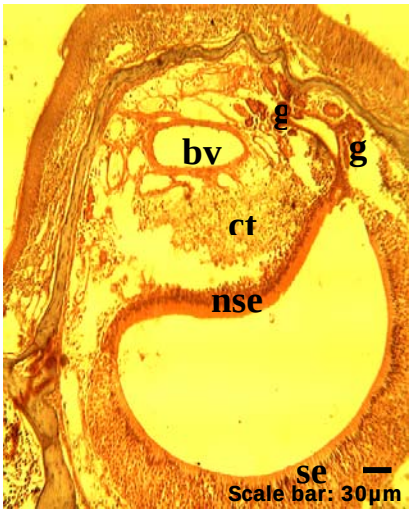

Figure 7: Components of lateral wall: glands (g), blood sinuses (bv), abundant connective tissue (ct)

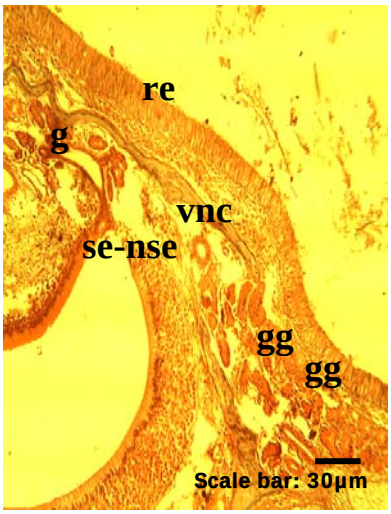

Figure 8: Vomeronasal glands (g) in intracapsular (g) and extracapsular positions (gg), respiratory epithelium (re), epithelia boundary between sensory and nonsensensory (se-nse)

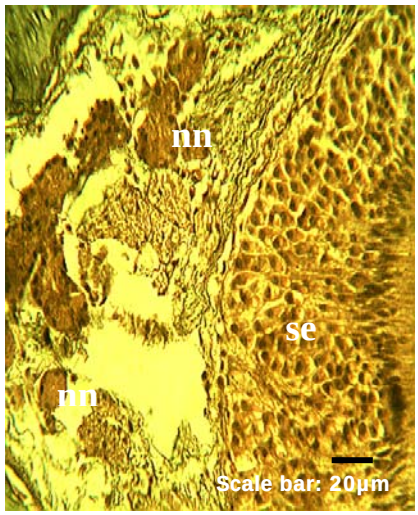

Figure 9: Vomeronasal nerves (nn), vomeronasal sensory epithelium (se)

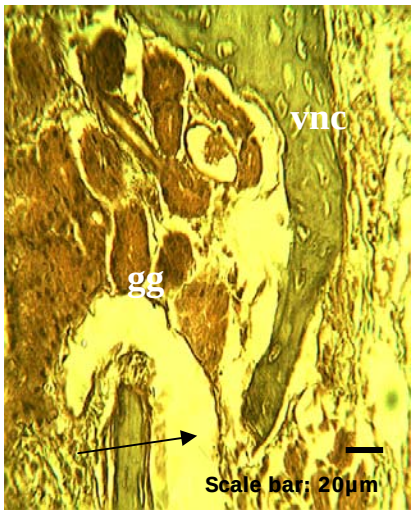

Figure 10: Vomeronasal glands, vomeronasal capsule (vnc) with a gap (arrow)

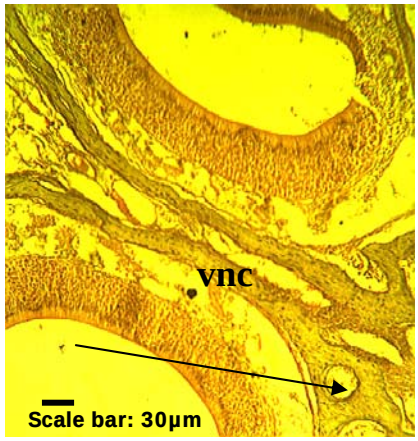

Figure 11: vomeronasal cartilage with ossification (arrow)

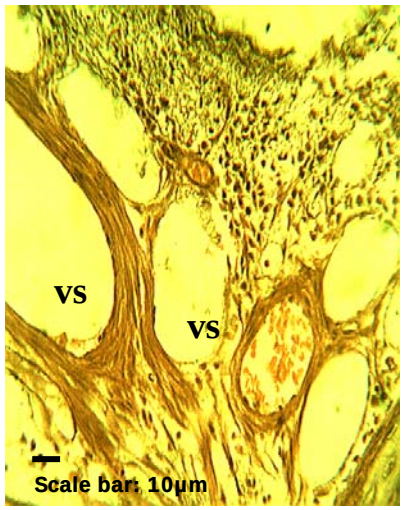

Figure 12: Venous blood sinuses (vs)

The ossification of the vomeronasal cartilage (capsule) in some areas is found in most rodents, but not in higher mammals (ungulates and carnivores) (Salazar *et al.,* 1997). The vomeronasal capsule serves the protective function of the organ and plays a major role in the pump-mechanism associated with reception of stimuli during vomerolfaction.

In conclusion, we hope that this study revealing the histological features of vomeronasal organ in African giant rat will form basis for future studies on the organ.

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