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ORIGINAL ARTICLE

Structural Organization Of The Olfactory Bulb Of Wild Ferret Pigeon (*Columba Livia)*

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SUMMARY

Fourteen brain samples (Ten for morphometry, two for gross and two for histological studies) were used in this study. The mean body weight of the wild ferret pigeon was 214 ± 13.37 g. The brain weight, length and width obtained from this study was 1.61 ± 0.07 g, 11.41 ± 0.25 cm and 15.62 ± 0.25cm. The mean height and volume were 12.04 ± 0.30 cm and 1.66 ± 0.9 $cm^{3.}$ There were significant differences between mean brain weight and volume. Morphologically, the olfactory lobe was observed to be bilobed structures on the rostro-ventral aspect of the cerebral hemispheres and was smaller compared to the entire cerebrum. The cellular layer was observed to be made up of; the olfactory nerve layer, glomerular layer, mitral cell layer and granule cell layer. The mitral or tuft cells resembles small pyramidal cells whose nuclei were centrally located, dark stained and are principal neurones of the olfactory lobe. Some of the processes were directed towards the granule and glomerular layers. The granular cells were numerous with dark stained nuclei. There is a corresponding increase in the brain volume as the brain weight increases. Grossly, the olfactory bulb is not developed. The mitral cell confers olfaction in animals as such, this bird has better olfaction compare to other birds.

Key Words: Structural, organization, olfactory, wild, pigeon

INTRODUCTION

Generally, it is believed that avian species do not have a well-developed sense of olfaction; however, some birds use their olfactory abilities in several situations (Roper, 1999). More recent research has introduced the complexity and depth of the avian sense of smell. Birds with high olfactory ratios were typically ground-dwelling carnivores, small New-World

vultures, or marine birds; kiwis, turkey vulture, tubenoses (Procellarii formes) (Bang and Wenzel, 1985). The research of Bang and Wenzel (1985) sparked a wave of olfaction research that has broadened the horizons of the understanding of the olfaction in birds.

The foraging behaviour of kiwis (Wenzel, 1968; Cummingha *et al*., 2003) navigation of rock pigeons are well-known examples of activities involving olfaction in birds (Bonadonnia and Nevitt, 2004). With the recent advances in research on olfaction in animals, particularly, in mammals, the molecular histological and neural circuits in the olfactory system are being analyzed in many animal species; however, research on avian olfaction remains stagnant (Wenzel, 2007). Progress in research on avian olfactory bulb as a fundamental science has been slow because not only the olfactory abilities of birds, but also the physiologic significance of olfactory shows a marked species variation (Hutchison and Wenzel, 1980). There is dearth of information on the structural organization of the olfactory lobe in the wild ferret pigeon in Nigeria.

Research work done on the brain of some birds are those of (Wanmi *et al*., 2016) on the cerebrum and optic lobe of helmeted guinea fowl and sense of olfaction in birds (Rastogi, 2007).

However, basic information on the structural features of the olfactory bulb of wild ferret pigeon may aid in understanding its sense of olfaction and survival in the wild.

MATERIALS AND METHODS

Animal Source

Fourteen brain samples were used for this study. Birds were caught using nets trap in Jos, Plateau State. The birds were transported in three locally made ventilated cages and kept in the Department of Veterinary Anatomy Laboratory, faculty of veterinary medicine, Ahmadu Bello University, Zaria for a week where feed (garin, groundnut) and water *(ad libitum*) with adequate ventilation were made available.

Brain Extraction

The entire skull was soft and pliable, scalpel blade and rat tooth forceps were used for extraction of the brain. Birds were euthanized using Nembutal at 40 mg/body weight. Thereafter, decapitation was made and the heads fixed in 10 % neutral buffered formalin for 3 – 5 days. After proper fixation, a dissection was made at the angle of the beak up to the level of the occipital bone. The upper portion of the dissected area is pulled off gradually using the rat tooth forceps until the entire brain was exposed. The cranial nerves were severed to ease the lifting of the brain from the cranium. Extracted brain samples were fixed in Bouin's solution for routine staining.

Gross and Morphometry

The weights of whole bird and brain were taken using digital electronic balance; (Model JJ1000, Max. 1000g, d=0.01g, e=10d, No. 211011011098, Made in China and Analytical Weighing balance, Adventure QHAUS Corporation, Item No. AR3130, Max. Capacity= 310g Readability= 0.001g). Photographs of the dorsal and ventral aspects were taken using cannon digital camera (4x optical zoom lens 5.0 - 20.0 mm, 15.1 mega pixels Apple, Cannon) and Digital Handheld Microscope, (Magnification 1000x, 5x Zoom, 3D stand high speed DSP).

Histological Procedure

Two (2) samples of olfactory bulbs were used for histological study. The samples fixed in Bouin solution for 24hours and were later kept in a beaker under a running tap water to wash off the excessive preservatives. The samples were there after transferred into a container with increasing serial concentration of alcohol (70 %, 80 %, 95 % and 100 %) with an interval of 24 hours for each stage of dehydration. Tissues were again cleared in xylene for 2 hours before

infiltrating with molten paraffin wax at 50 ^{o}C and blocked in paraffin according to standard procedures
(Kiernan, 1990) and labeled. Transverse sectio ns were made, at the thickness of 7µm, using J ung rotary microtome (Model 42339, Berlin, G ermany) and labeled. The sections were mount ed on glass slides and allowed to dry, deparaf finized, stained, dehydrated and cover sliped u sing diphynylphthalate propylene xylene as mountant. Sections were stained with Einarson's stain. Photomicrographs of sections were taken using digital eyepiece (Scopetek DCM500, Resolution: 5M pixels, attached to a light microscope (OLYMPUS- XSZ107BN, Hamburg, Germany).

RESULTS

The mean body weight of the wild ferret pigeon was observed to be 214 ± 13.37 g. The brain weight, length and width obtained from this study was 1.61 ± 0.07 g, 11.41 ± 0.25 cm and 15.62 ± 0.25cm. The mean height and volume were 12.04 ± 0.30 cm and 1.66 ± 0.9 $cm^{3.}$ There were significant differences between mean brain weight and volume (Table 1).

Table 1: The mean weights of the body, brain, length, width, height and volume wild ferret Pigeon (n= 10)

Brain data	Min	max.	Mean ± SEM
Body weight (g)	1.39	3.10	214 ± 13.37
Brain weight (g)	1.27	2.07	1.61 ± 0.07**
Brain length (cm)	9.89	12.94	11.41 ± 0.25*
Brain width (cm)	12.19	17.16	15.62 ± 0.39*
Brain height (cm)	10.10	14.16	12.04 ± 0.30*
Brain volume (cm^3)	1.10	2.10	1.66 ± 0.9**

Significance at P < 0.05, % = Percentage, **= Significant, *=Not significant, SEM = Standard Error of Mean

The forebrain was observed to be made up of the olfactory bulb and two cerebral hemispheres. From the dorsal view of the brain, the olfactory lobe was not visible as compared to the ventral view. The olfactory lobe was a bilobed structures attached on the rostroventral aspect of the cerebrum. It was smaller compared to the entire cerebral hemispheres and the olfactory tract was cannot be seen (Plate I and Plate II.

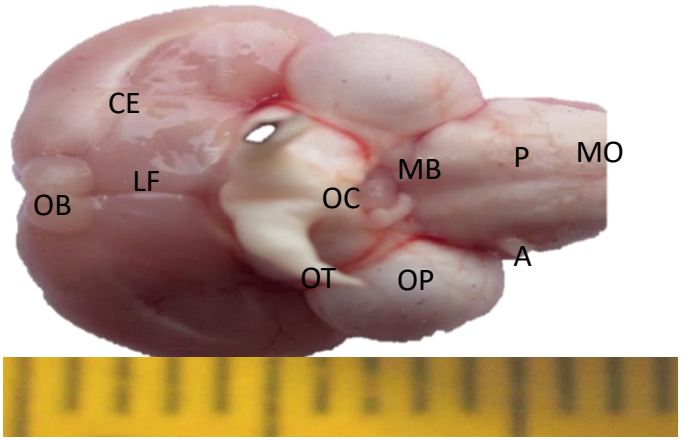

Plate I: Ventral surface of the wild ferret pigeon brain, showing; Olfactory bulb (OB), Cerebrum (CE), Longitudinal fissure (LF), Optic tract (OT), Optic chiasm (OC), Midbrain (MB), Pons (P), Auricle (A), Optic lobe (OP), Medulla oblongata (MO). Magnification, X 12.1

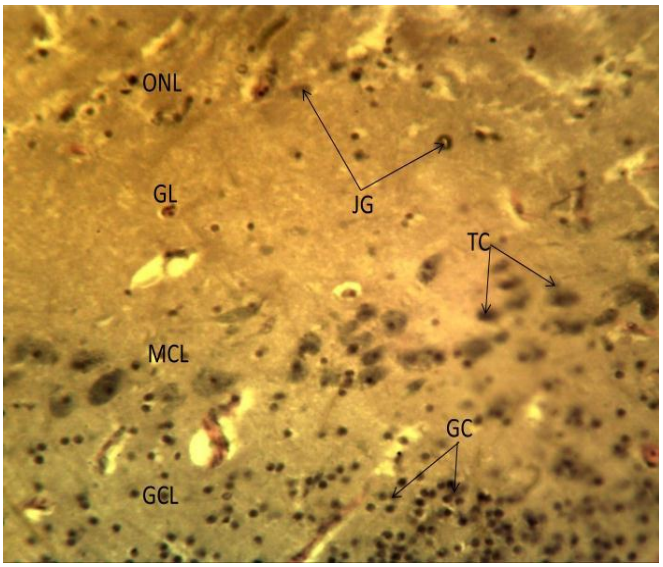

Plate II: Transverse section of the olfactory lobe of the wild ferret pigeon, showing; Olfactory nerve layer (ONL), Glomeruli Layer (GL), Juxtaglomerular cell (JG), Tuft cell (Mitral cells) (TC),
Mitral cell layer (MCL) and Granular cell layer (GCL). Einarson‟s stain, X 400.

DISCUSSION

In this study, the mean body and brain weights, width and volume of the wild ferret pigeon were higher, but their differences were not significant. These results are in agreement with the findings obtained by Nikitenko, (1965) and Umosen, (2007). Both author observed that the mean brain weights of the males were higher than those of the females in alciform and helmeted guinea fowls, respectively. The brain weight in this study increase as the body weight increased. This is in agreement with the findings of Portman and Stingelin (1961), that brain weight always increase less than the body weight; and that galliformes had the lowest values, which were not constant and could thus differ in the birds of the same body weight.

There was a highly significant ($P < 0.001$) correlation between mean brain weights to the volume. This indicates that as the brain weight increased there was a corresponding increase in the brain volume. This statement is in agreement with that obtained by Bunyamin *et al*. (2001), who reported that in most female birds, brain volume is higher than those of the male.

The olfactory lobe was not visible dorsally, but visible from the ventral view. The olfactory lobe was a small bilobed structure relative to the entire size of the cerebral hemisphere. This report is consistent with the results of the pioneer study by Crosby and Humphrey (1939) who observed that most birds have smaller olfactory lobes, often paired. This observation is in agreement with Makoto *et al.* (2009) in the Japanese jungle Crow and with general report that the olfactory sense of birds is poor

(Husband and Shimizu, 1999), and could differ in some species of birds such as the brown Kiwi, vultures, canaries and albatroses with well-developed sense of smell (Bang and Cobb, 1968; Nevitt, 1999).

The olfactory bulb has four layers, which were not clearly delineated from one another. These layers include; the olfactory nerve layer, the glomerular layer, the mitral cell layer and the granular layer. The juxtaglomerular cells were scattered and not well developed but the mitral cells, which is the main neuron of the olfactory lobe were found to be irregularly distributed thus preventing the distinction of the external and internal plexiform layers found above and below the mitral cells of most mammalian olfactory lobes. The result of the present study is in agreement with the findings of Wachowiak and Shipley (2006) and Root *et al*. (2008) who reported sparse distribution of juxtaglomerular cells in mammals. Although a sparse distribution of juxtaglomerular cells does not imply poor olfaction, but have been shown to play an important role in processing the information transmitted by the olfactory receptors in mammals as well in the Drosophilae. With this, the wild ferret pigeon is likely to have some degree of olfaction due to the sparse distribution of juxtaglomerular cells and mitral cell. Andres (1970) in his study reported that the mitral and juxtaglomerular cells are well developed in mammals, that are more evolutionarily advanced, that have well-developed sense of smell but are poorly developed in reptiles and fish. In some birds such as duck (wood duck), that have well-developed sense of smell, large olfactory bulbs are observed (Bang, 1971) and mitral/juxtaglomerular cells are found to be distributed in the glomerular layer (Rebiere *et al*., 1983). Makoto *et al.* (2009) observed that the quails and mouse has high sense of olfaction due to distinct development of the external and internal plexiform layers that surround the layers of glomeruli cells. In hierarchy, , vultures, quails has higher sense of olfaction compared to that of the wild ferret pigeon because of additional involvement of the internal plexiform layer to the mitral and juxtaglomerular cells.

CONCLUSION

This study is able to report presence of mitral cell, which is the major cell that transmit sense of olfaction as such; the wild ferret pigeon has better olfaction.

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REFERENCES

ABRAHAM, R.C. (1958). *Dictionary of Modern Yoruba*. University of Ibadan Press Ltd, London, Pp. 486.

ABULUDE, O., WAKILU, A., YOMI, A. and PATRICIA, A. (2006*)*. Studies on pigeon bird (*Columba livia Guinea G)*. Anatomical Weight, Proximal Composition, Selected Mineral Contents and Sensory Evaluation, 5(4): 1473-1478.

ANDRES , K. H. (1970). Anatomy and Ultrastructure of the Olfactory Bulb in Fish, Amphibian, Reptiles, Birds and Mammals. Wolstenholme G.E.W. and Knight, J. (Editors). Ciba Foundation on Taste and Smell in Vertebrates, London: Churchill, Pp. 177 - 194.

BANG, B.G. (1960). Anatomical evidence for olfactory function in some species of bird. *Nature*, 188: 547 -:549.

BANG, B.G., COBB, S. (1968). The size of the olfactory bulb in 108 species of birds. *Acta Anatomica*, 85: 55 - 611.

BONADONNA, F. and NEVITT, G. A. (2004). Partner-specific odour recognition in Antarctic sea birds. *Science*, 306:835.

BANG B.G. and WENZEL, B.M. (1985). *Nasal cavity and olfactory system*. King A.S, McLelland J. (Editors), form and function in birds. Volume 3. London: Academic Press, Pp.195-225.

BRAND, S. (2008). "*Systema Naturae 20*00/Classification, Class Aves". *Project:* The Taxonomic. In: *http://www.taxonomy.nl/Main/Classification/51354.htm*. Retrieved on 4th February, 2009.

BURNE, T. H. and ROGERS, L. I. (1996). R esponses to ordorants by the domestic c hick. *Physiology and Behaviour*, 60:1441-1447.

CORNELL LABORATORY of ORNITHOLOGY, (2003). All about birds. http:www.birds.cornell.edu/AllAboutBirdGuide/Rock Pigeon dtl.html. Retrieved on 19th February, 2008.

CROSBY, E. C. and HUMPHREY, T. (1993): Studies of the vertebrate telencephalon. *Journal of Comparative Neurology, 71: 121–213.*

CUNNINGHAM, G. B., VAN BUSKIRK, R. W., BONADONNA, F., WEIMERSKIRCH, H. and NEVITT, G. A. (2003). A Comparison of the olfactory abilities of three species of procellariiform chicks. *Journal of Experimental Biology*, 206:1615-1620.

FAO (2002a): Food for all statistical data bases. *http:www.agriza.* Retrieved on 3rd May, 2002.

HUTCHISON, L. V. and WENZEL, B. M. (1980). Olfactory guidance in foraging by procellariiformes. *Condor*, 82: 314-319.

HUSBAND, S. and SHIMIZU, T. (1999): Evolution of the avian visual system. *http://luna.cas.usf.edu/husband/evolve/default.htm.* Retrieved on 23rd November, 2004.

IBRAHIM, M. A. and ABDU, P. A. (1992). Ethnoagroveterinary perspective of poultry management health and reproduction among Hausa/ Fulani of rural Nigeria. Practical Science Session Nigeria Veterinary Association, *Pp.* 172 - 181.

KIERNAN, J. A. (1990): Histological and Histochemical Methods: Theory and Practice. Oxford Pergamon Press, London, Pp. 320 - 344.

MAKOTO, Y., AKIKO, H., TORU, R., NAOKI, S., MASAT, A., YSHISHIRO, W., SHOEI, S. and MAUMI, I. (2009). Histological properties of the nasal cavity and olfactory bulb of the Japanese jungle crow (*Corvus macrorhynchos*), 10: 1093.

NEVITT, G. (1999). Foraging by seabirds on an olfactory landscape. *American Scientist*, 87: 46 - 54.

PARKES, K. C. (1987). Columbiformes. McGraw-Hill Encyclopedia of Science and Technology.6th Edition. McGraw-Hill Book. Company. New York, Pp. 177.

RAMASWAMY, S. (1978). Removal of the Brain, A New Procedure. *Italian Journal of Anatomy and Embryology*, 82: 105-110.

REBIERE, A., DAINAT, J. and BISCONATE, J. C. (1983). Autoradiographic study of neurogenesis in the duck olfactory bulb. *Developmental Brain Research*, 282: 113 - 122.

ROOT, C. M., MASUYAMA, K., GREEN, D. S., ENELL, L. E., NESSEL, D. R., LEE, C. H. and WANG, J.W. (2008). A presynaptic gain control mechanism fine-mechanism olfactory behavior. *Neuron*, 59: 311 - 321.

RASTOGI, S. C. (2007). Respiration. In: Essential of animal physiology. New Age Inter (P) Ltd. Pp. 263-285.

ROPER, T. J. (1999).Olfactory in birds. Slater P.J.B, Rosenblatt J.S, Snowden C.T, Roper T.J, (editors).Advances in the study of behaviour. Volume 28. New York Academic Press, Pp. 247-332.

WACHOWIAK, M. and SHIPLEY, M. T. (2006): Coding and synaptic processing of sensory information in the glomerular layer of the olfactory bulb. *Seminar in Cell Developmental Biology*, 17: 411 - 432.

WENZEL, B. M. (2007). Avian Olfactory. Then and Now. *Journal of Ornithology*, 148: 191-194.

WENZEL, B.M. (1968). Olfactory Process of the Kiwi. *Nature*, 220:1133-1134.