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Research Article

Morphormetric Study of the Forebrain and Cerebellum of the Wild Rock Pigeon (*Columba livia*)

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ABSTRACT

Despite this species of bird is widely in distribution in Northern Nigeria, scanty documentation exist on the neuroanatomy of this species of wild bird. Measurement of weight, length, width, height and volume of the intact brain, cerebrum and cerebellum were conducted using; a sensitive electronic balance (Mettler P 1210, Mettler AG, Switzerland, Sensitivity 0.001g), volume was estimated by water displacement method. Measurements of the dimensions of each brain, forebrain and the cerebellum were obtained using a digital vernier caliper, meter ruler and thread. Thirty wild rock pigeons (15 male and 15 females) were used for this study. The mean body weights obtained from this study were observed to be 214.4±13.37 g and 218.6±12.05 g for female and male, respectively. The mean brain weight values obtained from female and male were 1.611±0.07 g and 1.72±0.07 g, respectively. There was no significant difference in the mean length of both sexes (Table 2). The percentage forebrain lengths were about 67.13 % for both sexes (Table 2) and the mean brain volume of the female wild rock pigeon is higher than that of the male. The mean brain height of the female was lower as compared to that of the male, even though there were no significant differences in their mean heights. Indications from various segments of this study show that the mean body and the brain weights of the male wild rock pigeon were higher than those of the female.

Key words: Morphormetric, Forebrain, Cerebellum, Wild pigeon

INTRODUCTION

Generally, most birds are feathered, bipedal, winged, endothermic (warm-blooded) and egg laying vertebrate animals (Brand, 2008). Most rock pigeons (*Columba livia*) which are indigenous to this environment also have the above characteristics and were derived from the rock pigeon (Cornell Laboratory of Ornithology, 2003) that belongs to the family, Chordate; Class, Aves; Order, Columbiformes; family, Columbidae; Genus, *Columba;* Specie, *Columba livia* (Miller and Harley, 1996).

Pigeons are worldwide in distribution and among the most intelligent animal species, which undergo annual migration and able to sense the earth's magnetic field (Wiltschko and Wiltschko, 1996), communicate using visual signals, calls (Johnson and Clayton, 2000; Suthers *et al.,* 2004) and have high parental care after hatching (Blechman, 2007). The bird ranges from the Gambia to Northern Nigeria east to Abyssinia, Somaliland and Kenya. They lay white eggs in a nest (Abraham, 1958) and are one of the few groups of birds that can drink water by sucking instead of having to till the head back after each mouthful. They feed mostly on corn, millet, groundnut, the seeds of trees and shrubs and are fast and powerful in flight (Ibrahim and Abdu, 1992). Most pigeon are terrestrial but frequently roosting on roofs, trees and have a dark bluish grey head, neck and chest with glassy yellow, greenish reddish along its neck and wing feathers weighing about (Beauchamp and Guy, 1999). Generally about 300 species and 12 subspecies are recognized but in Nigeria there are about 21 species and 2 subspecies (Gibbs *et al.,* 2000). The adult rock pigeon has cere which is distinctive on the beak, weighs 238-380 g with a 64-72 cm wingspan. The adult female is almost identical to the male, but the irridescence on the neck is less intense and more restricted to the rear and sides, while that on the breast is often obscure (Blechman, 2007).

Pigeons have been shown to be a delicacy in most advanced countries of the world. Humans have long been closely associated with the domesticated members of this family (Parkes, 1987). This close association is very important in enhancing food production because most people live under deplorable conditions with shortage of protein-rich food in most African countries which has reached serious level (FAO, 2002a). In Nigeria, the

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pigeon has many uses ranging between religious, social and ritual functions as well as consumption (Abulude *et al*., 2006). In the Guinea Savannah zone of Nigeria it is considered as a good source of meat due to its good taste and very high protein content of about 60.63 - 66.92 % (Abulude *et al.,* 2006). Despite the size of this bird, they are often sold in market places alive in cages and sometimes as pepper soup in joints in villages and towns. Most are bred for food and also serves as source of steady income for rural dwellers, religious activities and traditional ceremonies (Ibrahim and Abdu, 1992).

This study was aimed at providing some basic data on the neuroanatomy of the rock pigeon in respect to their survival both in wild and domestication.

MATERIALS AND METHODS

Management of experimental birds

Thirty (15 males and 15 females), apparently, healthy and matured rock pigeons (*Columba livia*) were purchased from local bird's hunters in Gashaka village of Taraba state, Nigeria. According to the hunters, they use net traps to catch the birds. The birds were transported in locally made ventilated cages and kept in the Department of Veterinary Anatomy Research Laboratory, Ahmadu Bello University, Zaria. They were kept for two weeks for pre-conditioning to stabilize them. During this period, birds were given access to feed, water *(ad libitum*) and adequate ventilation was made available.

Experimental design

Thirty rock pigeons were used for the study and each live bird was restrained using a rope made of cotton and weight was taking using digital electronic balance (Citizen Electronic Scale, PVT. Ltd. Hamburg, Germany, Sensitivity: 0.01g). The weight of each live bird was recorded in gram (g) after deducting the weight of the rope and that of the weighing container from the weight of the bird. After weighing, the birds were sacrificed according to procedure briefly described by Umosen (2007). Briefly, the skin over each skull was stripped off and the lower jaw was also cut at its point of articulation with the quadrate bone, using a scissor and freed from the skull. At the point of the nostrils, an incision was made and the upper beak was removed and the eye bulbs were punctured. Each brain still in the skull was immersed in a labeled sample container, containing Bouin solution and kept for three days, then followed by extraction.

Extraction of the brain

Each brain was extracted by making an incision from the left dorsal rim to the right dorsal rim of the orbital fossa over the frontal bone, using a small hand saw-like blade. Another cut was made from the lateral canthus to the point of the nostrils on both side and a gentle traction was made and the forebrain was exposed. To expose the cerebellum, another cut was made along the lateral canthus of the eye on either side over the foramen magnum. The falx cerebri and tentorium cerebellar were pulled off, thereby exposing the brain *insitu.* The brain was removed by gently lifting of the forebrain while severing other parts of the meninges that were attached to the skull as described by Ramaswamy (1978). Gradually, the entire brain were removed and fixed in Bouin solution for about 2-3 days to facilitate proper penetration of the preservative.

Separation of the forebrain and cerebellum

The forebrain was separated from the rest of the brain by gently pulling the occipital poles to expose the *corpus callosum.* The *corpus callosum* together with the *septum pellucidum* and the rostral commissure of the fornix were severed at the midline. The caudal pole of the cerebral hemispheres overlapping the optic lobe was raised dorsally from the transverse cerebral fissure and an incision was made through the optic tract to free the cerebral hemispheres from the brainstem and cerebellum. Once the forebrain is removed, what is left is the brain stem and the cerebellum is exposed. The cerebellum was attached to the brain stem via two cerebellar peduncles. The cerebellum was separated from the brainstem by raising the flocculi thereby exposing the cerebellar peduncles. An incision was made at the base of the lateral peduncles (*brachium restiformis and brachium conjunctiva*). Definitions of gross anatomical structures were based on standard information on avian anatomy. *Nomina Anatomica Avium* (Baumel *et al*., 1993) was used for the anatomical nomenclature.

Morphometric study

Thirty brain samples (15 males and 15 females) were used for morphometric analysis. Measurement of weight, length, width, height and volume of the intact brain, cerebrum and cerebellum were conducted. Weighing of each brain and parts of the brain used for this study were obtained using a sensitive electronic balance (Mettler P 1210, Mettler AG, Switzerland, Sensitivity 0.001g). Brain volume was estimated by water displacement method as described by Scherle (1970). Measurements of the dimensions of each brain, forebrain and the cerebellum were obtained using a digital vernier caliper, meter ruler and thread.

Statistical analysis

Morphometric data of the body, whole brain, forebrain and cerebellum were analyzed using statistical package for social science (SPSS) version 17.0. In the analysis, the descriptive statistics were expressed as Mean ± Standard Error of the Mean. Also, correlation analysis was carried out using Pearson correlation to determine the significance in the values obtained between male and female birds. Values of $P \leq 0.05$ were considered significant.

RESULTS

Weights and dimensions

The mean body weights obtained from the wild rock pigeon were observed to be 214.4±13.37 g and 218.6±12.05 g for female and male, respectively. This indicates that the mean body weight of the male was slightly higher than that of the female. The mean brain weight values obtained from female and male were 1.611±0.07 g and 1.72±0.07 g, respectively. There were no significant differences between mean weights of both sexes. The weights of the forebrain and cerebellum for both sexes accounted for about 46 % and 13.53 % of the

total brain weight. The mean forebrain weight of the male pigeon was 0.98±0.06 g which was observed to be higher than that of the female (Table 1).

The mean brain width was observed to be 16.21±0.19 mm in the female which was higher compared to that of the male which was seen to be 15.62±0.39 mm. The mean length values for the forebrain and cerebellum in both sexes were the same and all the values of all the parameters did not differ significantly though the percentage width of the forebrain for male and female were about 69 % and 65 %, respectively with male forebrain being higher. The cerebellum of the female accounted for 40.61 % and with mean length of 5.66±0.16 mm (Table 3).

The mean brain height of the female was lower as compared to that of the male, even though there were no significant differences in their mean heights. There were differences in the percentage forebrain and cerebellum heights with the female accounting for 68.26 % being higher than that of the male which was 60.28 % (Table 4).

There were significant differences between the mean brain volume of the male and that of female, and the male mean brain volume was higher than that of the female. This indicates that differences exist between mean brain volumes of both sexes. The male cerebellum volume was higher than that of the female, and there was a significant difference between the male and female whole brain volume (Table 5).

DISCUSSION

In this study, the mean body and brain weights, width and volume of the wild rock pigeon were found to be higher in the male than in the female, 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 was found to 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 that of 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.

Table 1: The body and brain weights of the male and female wild rock pigeon (in grams)

	Female (n=15)			male (n=15)		
Weight (g)	Min-Max	Mean ± SEM	%	Min-Max.	Mean ± SEM	%
Body	139-310	214±13.37	-	144-181	218±12.05	-
Whole brain	1.27-2.07	1.611±0.07	-	1.45-2.12	1.72±0.07	-
Forebrain	0.06-0.97	0.72±0.06	46.86	0.03-0.98	0.98±0.06	46.86
Cerebellum	0.12-0.28	0.21±0.01	13.53	0.12-0.28	0.20±0.01	13.53

%= Percentage, SEM = Standard Error of Mean; The mean brain length of both males and females were 16.86±0.37mm and 16.70±0.57mm, respectively. There was no significant difference in the mean length of both sexes. The percentage forebrain lengths were about 67.13 % for both sexes (Table 2).

Table 2: The brain length of male and female wild rock pigeon (in mm)

	Male (n = 15)			Female (n=15)		
Length (mm)	Min – mix	Mean ± SEM	%	Min – mix	Mean ± SEM	%
Whole Brain	14.8-19.29	16.86±037	-	9.06-19.08	16.70±0.59	-
Forebrain	9.89-12.94	11.41±0.25	67.13	10.19-12.81	11.42±0.25	67.12
Cerebellum	6.92-8.99	8.20±0.17	46.60	7.76-9.11	8.44±0.11	47.75

%= Percentage, SEM = Standard Error of Mean

Table 3: The brain width of male and female wild rock pigeon (in mm)

	Male (n = 15)			Female (n=15)		
Length (mm)	Min – mix	Mean ± SEM	%	Min – mix	Mean ± SEM	%
Whole Brain	12.19-17.16	15.62±0.39	-	16.25-17.81	16.21±0.19	-
Forebrain	14.54-17.12	16.08±0.19	69.71	15.25-17.81	16.37±0.19	65.89
Cerebellum	5.21-5.97	5.55±0.09	34.70	5.01-7.01	5.66±0.16	40.61

%= Percentage, SEM = Standard Error of Mean

Table 4: The brain height of male and female wild rock pigeon (in mm)

	Male (n = 15)			Female (n=15)		
Height (mm)	Min – mix	Mean ± SEM	%	Min – mix	Mean ± SEM	%
Whole Brain	10.10-14.16	12.04±0.30	-	10.91-12.57	11.98±0.15	-
Forebrain	6.39-8.86	7.86±0.18	60.64	7.29-8.58	7.95±0.13	68.26
Cerebellum	5.14-7.87	6.89±0.18	23.86	5.99-7.42	6.61±0.14	29.02

% = Percentage, SEM = Standard Error of Mean

Table 5: The brain volume of male and female wild rock pigeon (ml)

	Female (n = 15)			male (n=15)		
Volume (ml)	Min – mix	Mean ± SEM	%	Min – mix	Mean ± SEM	%
Whole Brain	1.10-2.10	1.66±0.9	-	1.40-2.10	1.85±0.05	-
Forebrain	0.40-1.00	0.71±0.47	50.00	0.60-1.00	0.89±0.03	51.00
Cerebellum	0.02-0.23	0.13±0.02	15.50	0.07-0.33	0.23±0.05	16.50

%= Percentage, SEM = Standard Error of Mean

There was a highly significant (P<0.001) correlation the weight of brain to forebrain and weight of cerebellum of the male. This indicated that as the brain weight increased in the female, there was a corresponding decrease in the forebrain weight of the female wild rock pigeon. There were no sex differences in weights and percentages of forebrain and cerebellum. There were significant differences in the volume of the brain in both sexes and the mean brain volume was observed to be higher in the male. This statement is in agreement with the result obtained by Bunyamin *et al*. (2001), who reported higher mean brain volume in male birds than those of the females in the lamb, rat and birds. These could be as a result of species differences and/or because the findings could not specify brain volumes of sexes involved.

Generally, the percentages of forebrain width, length, height and volume were observed to be high in both sexes. The increase in the percentage of the forebrain might have been as a result of lengthening nature of the cerebral hemisphere, which covered almost three quarters of the entire length of the brain stem.

There were not significant differences in the various parameters of the cerebellum, but there were differences in the correlations between both sexes in their width, height and volume. It was observed that the values of the cerebellum were always lower than that of the forebrain. This observation is in agreement with that of Umosen (2007), who also recorded lower values of the cerebellum in the morphometric study of the cerebrum and cerebellum of the helmeted guinea fowl. This might have been the result of the compressed nature of the folia.

Conclusions

Indications from various segments of this study show that the mean body and the brain weights of the male wild rock pigeon were higher than those of the female domestic pigeon. This study also shows that the length of the forebrain accounted for about 67.13 % of the total brain length in both sexes.

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