

Anatomical Investigation into the Brain of Wild African Parrot (*Poicephalus senegalus versteri*): Gross and Quantitative Study

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Abstract Knowledge on the anatomy of the brain of parrot is important with respect to the current advancement in comparative avian anatomy. This investigation was aimed at reporting some landmarks anatomical features on the brain of the wild African parrot that will be valuable in obtaining a baseline information in this species. Ten apparently healthy adult wild African parrots were euthanized using Pentobarbital sodium (Nembutal®) at 40mg per body weight. Sex was not kept into consideration in this study. Quantitative study of the body and brain indicated mean weights to be 163 ± 4.36 g and 4.78 ± 0.21 g, with whole brain having length and width measuring 3.66 ± 0.19 cm and 2.06 ± 0.07 cm respectively. The cerebral surface is thrown into three deep depressions; the interhemispheric fissure flanked by two cerebral valliculae. Two large bulges, the Wulst are prominent on the dorsum of the cerebral hemispheres an indication of a good cognitive behaviour. Extensively large optic tracts project from optic lobes suggesting that the parrot possesses high auditory activity.

Keywords Anatomical, Brain, Morphology, Parrot, Wild

1. Introduction

The African parrot is of the Kingdom; Animalia, Phylum; Chordata, Class; Aves and Order; Psittaciformes. The *Psittacus* and *Poicephalus* are dominant in West Africa, often considered as similar taxa [1, 2]. Wild parrots have features, which include; a strong, curved bill, an upright stance, strong legs, and claw zygodactyl feet. Most of the wild species possess diverse colour, exhibit little or no sexual dimorphism in the visual spectrum [3]. They form the most variably sized bird order in terms of body length. In the wild, their diets include seeds, nuts and fruits but sometimes eat animals and carrion [4].

Recently in Nigeria, most private schools have been involved in keeping pet animals of various species including parrots, which now make the demand for this bird to be on an increase because of its ornamental peculiarity. Despite its wide distribution, large scale domestication of this species and its population has not been documented in Nigeria unlike that of the guinea fowl where large scale domestication has

been established and its population has been estimated at 44 million in captivity [5]. Meat from parrots is yet to be considered as delicacy in Nigeria but are seen sold in cages in local market/road sides and this serves as source of income for rural dwellers [6].

Brain morphology using quantified data is an important area of research in neuroscience. Scanty documentation exists on the anatomy of the brain of parrot, especially in Nigeria. Work done on the anatomy of the wild parrot includes; those on some body organs of the wild parrots [7]. This present study was aimed at investigating the gross and morphometric aspects of the brain of wild indigenous parrot and to correlate its behavioural pattern to live birds. Baseline data generated will aid in giving further information on brain of the wild African parrots.

2. Materials and Methods

2.1. Experimental Birds

In this study, sex was not kept into consideration. Ten (10) apparently healthy wild adult African parrots were purchased from a village marketer in Shika, a village outskirts of Zaria town, Kaduna State Nigeria. Birds were transported in a standard ventilated Laboratory cage to the animal unit in the Department of Veterinary Anatomy, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria. They were kept

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and fed for a period of one month for pre-conditioning using ground-nut, watermelon and water given *ad libitum*.

2.2. Animal Handling, Restraint and Treatment

Parrots when calm are friendly but aggressive when not properly handle. Rope made of cotton was used to restrain the parrots. This was achieved by gently holding the base of the wing while another hand placed on the feet of the parrot. By this, the parrot is lifted out of the cage and place on the surface of the table. At this point the legs and wings are pull towards the body and a rope is tied round the wings, legs and body. Each live bird was weighed using digital electronic balance (Citizen Electronic Scale, PVT. Ltd. Hamburg, Germany, Sensitivity: 0.01g), weight of rope was taking before the restrain was made. When the parrots were weight, they were euthanize using (Pentobarbital sodium) Nembutal® at 40 mg per body weight before brain extraction.

2.3. Brain Extraction

Extraction of brain was achieved by making an incision from the left dorsal orbital rim to the right dorsal rim of the opposite side over the frontal bone with a surgical blade; another cut was made from the lateral canthus to the point of the nostrils on both sides. This was repeated using a hand saw-like blade for bony structures, with a gentle traction the forebrain was exposed. To expose the cerebellum, a separate incision was made along the lateral canthus of the eye on either side over the foramen magnum. The falx cerebri and tentorium cerebellar were separated thereby exposing the brain *in situ*. The cranial nerves and meninges were carefully severed as the forebrain is elevated from the skull floor; the brain was removed as described by [8] and immersed in normal saline while morphologic evaluations progresses.

2.4. Brain Morphometry and Morphology

Immediately after each brain was extracted, they were weighed using (sensitive electronic balance; Mettler P 1210, AG, Switzerland, Sensitivity 0.001g). Length and width were obtained using ruler and digital Vernier caliper MG6001DC (General Tools and Instruments Co., New York; sensitivity of 0.01 cm) with values recorded in centimeter. Definitions of gross anatomical structures was based on standard information on avian anatomy, *Nomina Anatomica Avium* [9].

2.5. Separation of the Various Brain Components

The forebrain was separated from the rest of the brain by exposing the cerebral crura at the caudal poles of the cerebrum. A cut was made at this point and the forebrain detached. Once the forebrain is removed, the brain stem and the cerebellum is exposed. The left and right cerebral hemispheres were separated by cutting through along the interhemispheric fissure and corpus callosum using a scalpel blade. The cerebellum is attached to the brain stem via two cerebellar peduncles. Incision was made at the base of the

lateral peduncles (*brachium restiformis* and *brachium conjunctiva*) to remove the cerebellum. The incision into regions of pontimesencephalic and pontimedullary flexures was made to free midbrain, pons and medulla oblongata from the brainstem.

2.6. Statistical Analysis

Analysis of the body, brain and its component was made using statistical package for social science (SPSS) version 17.0. In the analysis, the descriptive statistics was expressed as Mean \pm Standard Error of the Mean. Student t-test was used to compare the level of significant and value of $p < 0.05$ was considered significant.

3. Results

Table 1. Weights of brain and other components in grams n=10

Organs	Weight/g	Length/cm	Width/cm
	Mean \pm SEM	Mean \pm SEM	Mean \pm SEM
Live body weight	163 \pm 4.36	-----	-----
Whole brain	4.78 \pm 0.21	3.66 \pm 0.19	2.06 \pm 0.07
Forebrain	3.37 \pm 0.23	2.50 \pm 0.80	2.40 \pm 0.17
Left Cbr Hemisphere	2.39 \pm 0.18*	2.40 \pm 0.06*	1.19 \pm 0.09*
Right Cbr hemisphere	2.27 \pm 0.16*	2.20 \pm 0.02*	1.12 \pm 0.05*
Cerebellum	0.97 \pm 0.13	1.01 \pm 0.07	0.88 \pm 0.09
Midbrain	0.28 \pm 0.04	0.56 \pm 0.07	0.39 \pm 0.05
Optic lobe	0.24 \pm 0.06	0.61 \pm 0.54	0.28 \pm 0.04
Pons	0.18 \pm 0.02	0.76 \pm 0.05	0.31 \pm 0.04
Medulla oblongata	0.67 \pm 0.07	0.80 \pm 0.05	0.64 \pm 0.05
Brain stem	0.77 \pm 0.05	2.15 \pm 0.14	1.50 \pm 0.05

SEM; Standard Error of Mean, n= Number of experimental birds used, Cbr; Cerebrum, *= significant.

3.1. Brain Morphometry

The mean body and brain weights of parrot were 163 \pm 4036 g and 4.78 \pm 0.21 g respectively. The mean length and width of the brain were 3.66 \pm 0.19 cm and 2.40 \pm 0.07 cm respectively. The mean length and width of the forebrain were almost same size but not statistically significant. The mean weights, length and width of the left and right cerebral hemispheres were significant at $p < 0.05$. The mean weight and length of the cerebellum was 0.97 \pm 0.13 g and 1.01 \pm 0.07 cm. The midbrain and optic lobes are derivatives of the mesencephalon in birds with mean weights to be 0.28 \pm 0.04 g and 0.24 \pm 0.06 g respectively. The brainstem had a mean weight, length and width to be 0.77 \pm 0.05 g, 2.15 \pm 0.14 cm and 1.50 \pm 0.05 cm respectively.

3.2. Gross Morphologic Features

The dorsal cerebral surface of the brain was observed to be thrown into three depressions that meet at the rostral inception of the interhemispheric fissure that appears as curbs. The right and left cerebral valleculla extends caudally

from the rostral limit of the interhemispheric fissure which is deeper and gradually faint out at the caudal pole of the cerebral hemispheres. The vallecule merges with Wulst at the caudal pole to form a convex cerebral surface. The vallecule is markedly occupied by large blood vessels which tapers out caudally. The right and left Wulst is the most swollen part on the dorsum of the cerebrum. It is partitioned by an interhemispheric fissure medially and laterally it is bounded by right and left vallecule. It narrows rostrally and broadens caudally with blood vessels crossing its surfaces. The dorsal cerebral surfaces were seen to be tremendously marked by vallecule, interhemispheric fissure, Wulst and the olfactory bulb. The cerebellum is relatively smaller, projected upward and separated from the caudal limits of the cerebral hemispheres by thick arachnoid fold (Figure 1A). The olfactory bulb was seen attached to the rostral limits of the cerebral hemispheres by an olfactory stalk. The optic tracts are large whitish stalk-like exiting from the optic lobes that bifurcates to appear as two cornual processes. The right and left optic lobes appear round to oval like projections on the caudoventral ends of the cerebrum (Figure 1B).

4. Discussion

The mean brain weight has been reported to be lower than body weight of most species of bird and could thus differ in birds of the same body weight [10]. The lengthening nature of the brain might be as a result of the forward protruded skull and elongation of the cervical region which might have influenced brain length and weight [11]. The left cerebral hemisphere was slightly higher than the right side and was significant at $p < 0.05$. This agrees with the general statement that functional asymmetry of the brain can be used in testing hemispheric variation in the brain of birds which

have great effects on the functionality of an organ [12, 13] and side of the body which the brain controls [14]. This implies that the left cerebral hemisphere in the wild Africa parrot has greater activity over the right cerebral hemisphere on the part of the body it controls.

Presence of large olfactory bulbs shows that the parrot possesses a relative sense of olfaction. Olfaction in birds in the wild is for survival from predators and location of prey and birds possess a variable degree of olfaction and this is similar with the general report that the olfactory sense of birds is poor [16] and could differ in some species of bird such as the brown Kiwi, vultures and canaries which have well-developed sense of smell [17, 18].

The vallecule in birds aids in visual acuity and is slightly convex, curved supersulcus bending posterior-medially on either side of the cerebrum. This statement is in agreement with those of [19] in Africa ostrich, but disagrees with those [20] in domestic pigeon where they are found on the lateral surface of the cerebral hemisphere. These morphological features could be useful in species differentiation and birds which have vallecule placed superiorly have good visual acuity. This indication makes the parrot have good vision to locate its prey in the wild.

The Wulst or the hyperpallium is located on the anterior dorsal portion of the cerebral hemispheres. This is similar to the report of Stingelin, that Wulst in birds corresponds to mammalian cerebral complex cognitive functions that are associated with higher-level consciousness in mammals [21]. The Wulst is placed anterior-most on the cerebrum in helmeted guinea fowl [22] and posterior-dorsal in duck [23]. The domestic pigeon showed a well-developed Wulst, suggesting that the level of consciousness is high and is an important sensory organ in the pigeon.

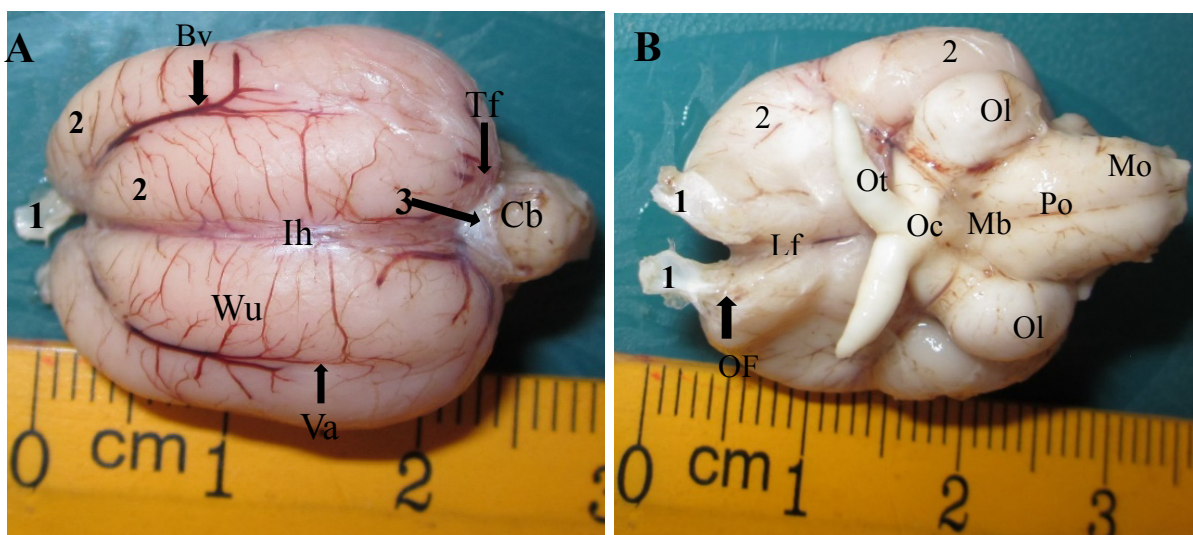


Figure 1. A: Dorsal view of the brain of parrot indicating, 1; Olfactory bulb, 2; cerebrum, 3; Arachnoid, Bv; Blood vessel, Ih; Cerebral interhemispheric fissure, Va; vallecule, Cb; cerebellum, Wu; Wulst, Tf; Transverse fissure. B: Ventral aspect of the brain indicating, Of; Olfactory tract, Lf; Longitudinal fissure, Oc; Optic chiasm, Mb; Midbrain, Ol; Optic lobe, Po; Pons, Mo; Medulla oblongata

The cerebellum in the wild Africa parrot is relatively not folded. Folding of the cerebellum influences motor behaviour, eye movement, balance with display of different forms of flight, dexterity and posture [24]. This implies that the wild Africa parrot has to stabilize its motor system before taking on its prey. The cerebellum was also observed to be small, rounded to oval which is similar to those of the chicken and pigeon [25]. The size and position of the cerebellum in the band owl, vultures and eagle is round, positioned upward and backward [26]. These variations explain the fact that size and position of the cerebellum in birds is associated with size and posture of the bird and most large birds possess smaller size of cerebellum and are mostly flightless or short distance flyers [27].

The shape of the optic lobe is relatively small and oval-like structure. This finding is in agreement with reports on kiwi, band owl and humming birds [28], but disagree with reports on pigeon where they are large and circular in shape [29]. Generally, parrots are said to possess a very small optic lobe [30].

5. Conclusions

Presence of olfactory bulb indicates good olfaction in the parrots. The cerebellum with less folding show parrots are short distance fliers with less dexterity. Research in neuroscience is using various tools, considering the fact that there is growing concern over adaptation from the wild to domestication in birds.

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