



THE PRELIMINARY INVESTIGATION INTO THE GROSS AND MORPHOMETRY OF THE HEAD, BRAIN, AND BASIC SENSORY CENTERS OF THE AFRICAN FRUIT BAT (*EPOMOPS FRANQUETI*) FOR FOOD FORAGING, ADAPTATION AND SURVIVAL IN IBADAN, NIGERIA.

Oyetunde K. Ekeolu

Department of Veterinary Anatomy,

University of Benin, Nigeria.

oyetunde.ekeolu@uniben.edu

Olumayowa O. Igado, Adedunsola A. Obasa

and Samuel G. Gbadebo Olukole

Department of Veterinary Anatomy

University of Ibadan,

Nigeria

ABSTRACT

African fruit bat, *Epomops franqueti* is a megachiroptera of the family pteropodidae and phytophagous. This preliminary work aimed at elucidating the bat brain machineries involved in foraging for food, its adaptation and survival. The gross anatomy and morphometrics of the head and brain were investigated to establish the echolocation capability, visual sensibility, and the olfaction acuity by measuring the whole brain weights, length, and diameter. Ten adult male African fruit bats were used for this work and their average body and head weights were $72.35 \pm 10.36\text{g}$ and $14.76 \pm 1.53\text{g}$ respectively, while the brain weight was $1.89 \pm 0.07\text{g}$. Our findings revealed that the brain of *E. franqueti* was small brain with relative weight of 2.57%. The relative weight of the head was 20.39%. The mean length of the brain was $28.7 \pm 0.10\text{ mm}$, the olfactory lobe had a mean length of $3.5 \pm 0.10\text{ mm}$, while the cranial and caudal colliculi had average diameter of $3.6 \pm 0.02\text{ mm}$ and $1.2 \pm 0.02\text{ mm}$, respectively, with strong indication that the bat depends more on the visual senses with a well-developed optic nerve, for its phytophagous nature.

Keywords: *Epomops franqueti*, brain, olfactory lobe, cranial colliculi, caudal colliculi, optic nerve



INTRODUCTION

The components of the head include the skin of the head, ears, nostrils, the musculature of the head, the skull, and the brain (Hirasawa and Kuratani, 2015). The mammalian head is unique to each species (Odigie *et al.*, 2017). Therefore, within species there are variation in the head conformation (Hanot *et al.*, 2021). Also, the changes in the head conformation within mammalian species gives the firsthand identity of an animal (Buzek *et al.*, 2022). The morphological variations in the head of several bats have been investigated by Vanderelst *et al.* (2015) and Ramírez-Fráncel *et al.* (2021). Also, mammalian brains, including some species of bat's brain have been studied (Igado *et al.*, 2012, Willemet, 2012). In the study of sensory specialization and foraging ecology, bat is a good model to study (Hutcheon *et al.*, 2002). The visual and auditory capabilities sense centers in the brain on foraging in some species of chiroptera have been reported. These centers include the superior and inferior colliculi respectively (Hu, 2006). Variation in total brain mass and mass of three brain regions which are olfactory bulb, hippocampus, auditory centers have been investigated in some Megachiroptera and microchiroptera to better understand

this apparatus of survival (Hutcheon *et al.*, 2002). Also, neuroanatomical investigations into the common vampire bat brain shows that the species has large neopallium volume among bats and precise olfactory capacities (Bhatnagar, 2008).

Data on brains of megachiropteran bat such as *Rousettus* are also available in literature (Bhatnagar, 2008). *Epomops franqueti* is a megachiropteran and an African fruit bat found in West Africa including Nigeria (Maganga *et al.*, 2014) and, with other species of bats, are carriers of disease-causing viruses in Africa (Gonzalez *et al.*, 2007, Maganga *et al.*, 2014). *E. franqueti* contribute to the continuous successful reproduction of plants like papaya, guava, and cashew, as fruit bats have been shown to contribute to over 90% of the seed dispersion in tropical and savanna habitats of Africa (Mickleburgh *et al.*, 2009).

Although Igado *et al.* (2012) reported the craniofacial morphometrics of *Eidolon helvum*, a large fruit bat, there is paucity of information in literature on the anatomy of the head and brain of *Epomops franqueti*, a megachiropteran.

The socio-economic importance and the foraging behavior in relation to *E. franqueti* adaptation and survival necessitates this study on the basic anatomy of the *E. franqueti* head



and brain to generate base line data which are not available in literature, in other to complement the several studies in other species of bats and open a new vista for further research work.

Materials and Methods

Ten adult male African fruit bats were captured in their roost at the University of Ibadan using mist net. They were then put in the cage to stabilize them for a period of 72 hours. Almond leaves were used to provide roof over the cages to mimic their natural habitat. They were provided with clean water from a nipple drinker. The African fruit bats life weights were measured using Microvar® weighing balance (Microvar, U.K). They were then anaesthetized using ketamine HCl (Biotechnica Pharma Global (BPG), China) at 25mg/kg body weight intramuscularly on the medial side of the thigh muscle.

The head was decapitated at the level of the Atlanto-occipital joint. The weight of the head was measured. Immediately whole head was fixed in 10% formalin. Then the brain was carefully harvested using scalpel blade, scissors, and forceps. Grossly, the brain was studied, and the morphometrics were taken and recorded. The brain dimensions were taken using plastic tape and a Draper® 115mm vernier caliper and metric tape (Mektronics,

Australia; SKU: DRA39493). The brain was weighed using Microvar® weighing balance. The brain was then observed.

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Statistical Analysis,

Data were expressed as Mean \pm Standard Error of mean and subjected to statistical analysis with Student's Paired-t- test using Graph Pad prism 5 (Windows® Graph pad software). The level of significance was set at $p \leq 0.05$.

Results

The Head

Non-metric observation

The head of *Epomops franqueti* appeared to be wedge in shape, cut out of a rectangle. The head was dolico-cephalic. The large eyes were cranio-laterally placed on the head with a brownish colour and round pupil. The palpebral fissure ran parallel to the horizontal axis. The thin external ear was simple and oval. The ear bore patterns of line that numbered between 5 and 8, seen against light. On the caudal aspect, the ear was attached dorso-laterally to the head by an incomplete ring of cartilage. The hair around the base of the ear was bleached to white. The rostrum was long with external nares that were divided by a philtrum. The philtrum extended to the rima oris,



that is the mouth. The upper lip had folds that were somewhat pliable.

Metric observation

The mean weight of the African fruit bat was 72.35 ± 10.36 g. he relative weight of the whole head was 20.39%. The mean value of the whole head length was 56.7 ± 0.14 mm. The length of the left pina, 20.8 ± 0.12 mm was statistically non-significant compared to the right, 20.7 ± 0.04 mm ($P > 0.05$). The width of the left and right pinas mean values were 13.2 ± 0.04 mm and 13.7 ± 0.042 mm respectively. The mean values of the right and left pina width were statistically non-significant. The length between the base of the pinna and the lateral canthi for both the left and right sides were 13.5 ± 0.23 mm and 12.5 ± 0.47 mm respectively. The values were statistically non-significant when compared. The length between the base of the pinna and the medial canthi for both the left and right side of the head were 21.4 ± 0.13 mm and 20.5 ± 0.27 mm, respectively and were statistically non-significant when compared. The left palpebral fissure length was 8.5 ± 1.20 mm while the right palpebral fissure lengths was 8.7 ± 0.27 mm. There was no statistically significant difference between the length of the left and right palpebral fissure. Also, there was no statistically significant difference when the two palpebral fissures

lengths were compared to the length between the medial canthi, respectively. The diameter between the medial canthi diameter was 13.6 ± 0.19 mm. The diameter between the wings of nostril was 4.6 ± 0.15 mm. The mean values for the width and height of the nostrils of the *E. franqueti* were 3.1 ± 0.6 mm and 6.0 ± 0.21 mm respectively. The average length of the rima oris of the bat was 41.1 ± 0.12 mm (Table I, Plate 1).

The Brain

Non-metric observation

The brain was encapsulated within thin meninges. The brain mass was richly supplied with blood vessels. The longitudinal fissure separated the cerebrum into the two cerebral hemispheres while the transverse fissure separated the cerebrum from the cerebellum. These fissures were supplied with blood vessels. There were little or no cerebral convolutions, but a relatively big bulbous pyriform lobe was presented (Plate 2 & Plate 3). Cranial to the well-developed optic nerves and chiasma, the optic bulb branched into a pair of lobes. The thin basilar artery, contained in the ventral fissure on the brain stem, between the medial boundary of the piriform lobe and the mesencephalon, branched to supply the caudal part of the olfactory bulb (Plate 2 & Plate 3).



The part of the dura mater that enclosed the pituitary gland was dense and located just cranial to the pons (Plate 3). The trapezoid body of *E. franqueti* brain was almost as large as the pons. It formed the boundary between the pons and the medulla oblongata. It therefore formed the medial boundary between the paraflocculus of the cerebellum which was closely related to the bony meatus. In between them was the vestibulo-cochlea nerve. The vestibulo-cochlea nerve was a small nerve compared to the optic nerve. The tectum of the bat's mid-brain presented a larger cranial colliculus than the caudal colliculi. The commissural fibers of the caudal colliculi were wider than that of the cranial colliculi. The arbor vitae were conspicuous and formed branches of white mater. The corpus pineal of the African fruit bat, *Epomops franqueti* was well developed (Plate 3).

Metric Observation

The mean weight of the African fruit bat was 72.35 ± 10.36 g. The relative brain weight was 2.57%. There was statistically significant difference ($P < 0.05$) when the whole weight of the head with mean value of 14.76 ± 1.53 g was compared to the brain weight with mean value of 1.89 ± 0.07 g. With an average length of the head of 56.7 ± 0.14 mm, the length of the head is

twice that of the brain with an average whole brain length of 28.7 ± 0.10 mm. The whole brain width mean value was 18.40 ± 0.08 mm. The left and right cerebral hemisphere length measures 17.60 ± 0.12 mm and 17.21 ± 0.15 mm respectively while mean cerebellum was 4.8 ± 0.04 mm. The mean value of the olfactory bulb length was 3.5 ± 0.10 mm. That of the vermis was 8.0 ± 0.07 mm. There was statistically significant difference when the cranial colliculi 3.6 ± 0.02 mm and caudal colliculi 1.2 ± 0.02 mm mean values were compared (Table 2, Plate 2 & Plate 3).

Discussion

Morphometric analysis of organs may reveal small structural changes that cannot be observed by qualitative analysis (Mayhew *et al.*, 1990; Oto *et al.*, 2009). Consequently, quantitative evaluation has been used to reveal the state and functional capacities of brain regions in humans and animals (Marsden & Rowland 1965, Olude *et al.*, 2016). The right and left features of head measured for *Epomops franqueti* in this study has symmetrical dimensions with no significant variation in their statistical values as it has been recorded for many mammals (Klingenberg, 2015). *E. franqueti* has a simple ear with the absence of tragus unlike in the insectivorous bat with a complex ear (Hayley *et*



al., 2020). The dolico-cephalic head, and skull of *E. franqueti* further emphasized why the average brain length of *E. franqueti* is higher than that of *Eidolon helvum* (Igado *et al.*, 2012). *E. franqueti* has a smaller brain weight of (1.89 ± 0.07) g which is twice that of the vampire bat, (0.99) g (Baron *et al.*, 1996) but twice less the weight of *E. helvum* with brain weight of 3.22 ± 0.50 g (Igado *et al.*, 2012). However, *E. helvum* is a fruit bat. The whole brain length is (28.7 ± 0.10) mm, twice the length (16.8) mm of the brain of *Desmodus rotundus* (Baron *et al.*, 1996) that was reported to have a very large neocortex volume (Bhatnagar, 2008). The well-developed optic nerve of *E. franqueti* reported in the present study suggests that this species of African fruit bat does not depend on echolocation capacity as a means of survival in their habitat when they forage but rather on their vision. This is consistent with the findings of Hu (2006) that some bats use more vision than hearing when they forage. This is also in congruence with report by Baron *et al.*, 1996 on *Rousettus*, a mega chiropteran. The olfactory bulb of *E. franqueti* is highly developed with main and accessory lobes. It makes 12% of the whole brain length mm of *E. franqueti*. This is similar to the findings in the vampire bat (Mann, 1963). It is also in line with the investigation carried

out on the brain of African giant rat (AGR) by Olude *et al* (2016) where the olfactory bulb is 25% of the rodent's brain of about (64.3 ± 0.24) mm. Thus, this suggest that *E. franqueti* depends on its vision and sense of olfaction for feeding. In this study, the vestibulocochlear nerve is small compared to the optic nerve. In previous study it has been documented that vestibular system aids balance in the powered flight of Old-World bats so that the radius of the cochlear correlates with the body size of this bat (Kalina *et al.*, 2014). However, the smaller size of the caudal colliculus compared to the cranial colliculus observed in *E. franqueti* suggest that this organ in this species is not the major sense of perception but proprioception since the cranial and caudal colliculi are related to the senses of vision and hearing respectively (Mann, 1963; Hu, 2006; Bhatnagar, 2008), and size is a function of acuity in sense organs (Hu, 2006).

Conclusion

This work has also generated base line data for the gross morphometrics of the brain of *E. franqueti* for further research work. The African fruit bat, *Epomops franqueti* is a non-echolocating megachiropteran bat. It has a well-developed visual sense, optic nerve, chiasma and cranial colliculi than the vestibulochochlear system of the echolocation bats.



Conflict of Interest

None declared.

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Table I: shows the morphometrics of *Epomops franqueti* Head and Body Weight

S/N	Head Parameters	MEAN ± SEM	Head Relative Weight
1	WH	14.76±1.53 g	RHW 20.39 %
2	WHL	56.7±0.14 mm	
3	WHD	27.3±0.12 mm	
4	WHH	22.7±0.17 mm	
5	LLP	19.2±0.04 mm	
6	LRP	19.0±0.37 mm	
7	WLP	13.2±0.04 mm	
8	WRP	13.7±0.04 mm	
9	LPL	8.5±1.20 mm	
10	RPL	8.7± 0.27 mm	
11	LLC	13.5±0.23 mm	
12	RLC	12.5±0.47 mm	
13	LMC	21.4±0.13 mm	
14	RMC	20.5±0.27 mm	
15	DMC	13.6±0.19 mm	
16	HN	3.1±0.6 mm	
17	WN	6.0±0.21 mm	
18	DWN	4.6±0.15 mm	
19	PH	3.5±0.4 mm	
20	LRO	41.1±0.12 mm	

*The average weight of the animal, **WA** is (72.35±10.36) g



KEYS

WA: Weight of Animal; **WH:** Weight of Head; **RHW:** Relative Weight of Head; **WHL:** Whole Head Length; **WHD:** Whole Head Width; **WHH:** Whole Head Height; **LLP:** Length of left Pina; **LRP:** Length of Right Pina; **WLP:** Width of left pina; **WRP:** Width of Right Pina; **LLC:** Length from left lateral canthus to the base of the left pinna; **RLC:** Length from the right lateral canthus to the base of right pinna; **LMCB:** Length from the left medial canthus to the base of the left pina; **RMCB:** Length from the medial right canthus to the base of the right pina; **DMC:** Diameter between the media canthi; **HN:** Height of Nostrils; **WN:** Width of Nostrils; **PH:** Height of philtrum; **LRO:** Length of Rima Oris

Table 2: shows the morphometrics of *Epomops franqueti* Brain and Body Weight

S/N	Brain Parameters	MEAN± SEM	Brain Relative Weight
1	WB	1.89±0.07 g	RBW (2.57) %
2	WBR	28.7 ± 0.10 mm	
3	WDB	18.4 ± 0.08 mm	
4	WHB	10.3±0.12 mm	
5	LCB	17.60 ± 0.12 mm	
6	RCB	17.21 ± 0.15 mm	
7	CBL	4.8 ± 0.04 mm	
8	VMD	8.0 ± 0.07 mm	
9	OBL	3.5 ± 0.10 mm	
10	DCR	3.6 ± 0.02 mm	

**The average weight of the animal, WA is (72.35±10.36) g*

WB: Weight of Brain; **RBW:** Relative Weight of Brain; **WBR:** Whole Length of brain; **WDB:** Whole width of brain; **LCB:** Whole length of left cerebral hemisphere; **RCB:** Whole length of right cerebral hemisphere **CBL:** Whole length of cerebellum; **VMD:** Length of vermis; **OBL:** Whole length of olfactory bulb; **DCR:** Diameter of lateral colliculi; **DCA:** Diameter of caudal colliculi

PLATES

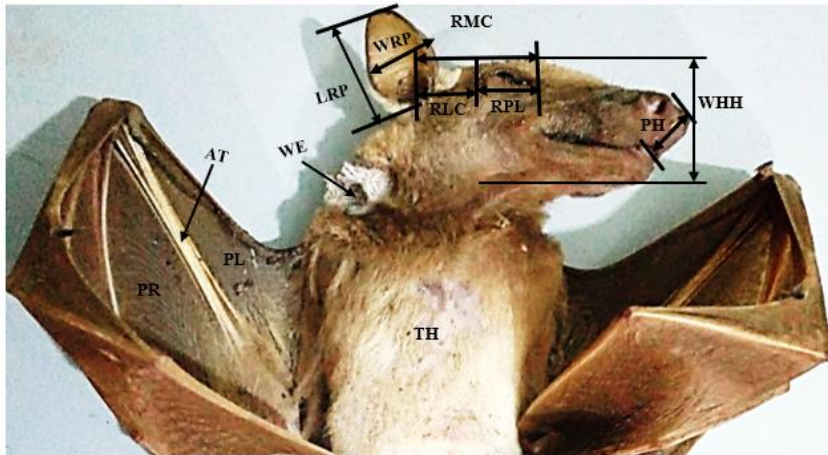


Plate 1. The right view of the head of *Epomops franqueti* and some of the parameters measured: The length of the right palpebral fissure (RPL), the length between right lateral canthus to the base of the ear (RLC), the length between the right medial canthus to the base of the ear (RMC), the length of the right pinna (LRP), the width of the right pinna (WRP), the length of the philtrum (PH) and the whole height of the head (WHH). Also, the antibrachium (AT), propatagium (PR), plagiopatagium (PL), white epaulette (WE) and the thorax (TH) are shown.

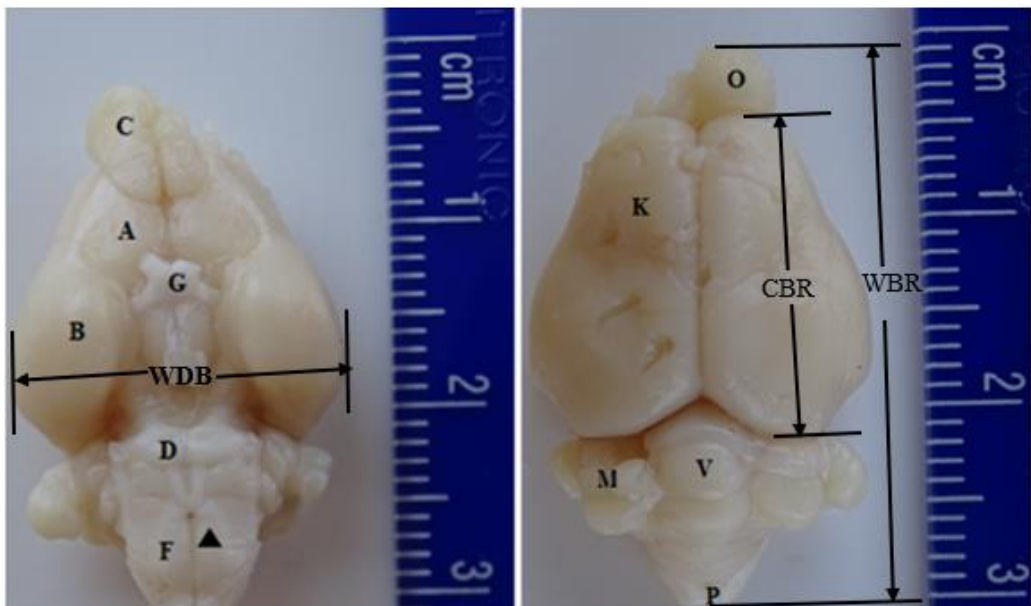


Plate 2: The ventral (a) and dorsal (b) views of *Epomops franqueti* brain

The ventral view (a), showing the olfactory bulb (C), olfactory trigone (A), optic chiasma (G), pons (D) trapezoid body (F), and the black arrowhead points to the ventral fissure that contains the cerebral basilar artery. The whole width of brain (WDB), measured between the widest points on the cerebrum.

The dorsal view (b) showing olfactory lobe (O), the cerebral hemisphere (K), lateral cerebellar hemisphere (M), vermis of the cerebellum (V) and the medulla oblongata (P) of *Epomops franqueti* brain. The whole length of brain (WBR), measured from the most rostral point on the olfactory lobe to the most caudal point on the cerebral hemisphere.

Note that the cerebral hemisphere has little or no convolution.

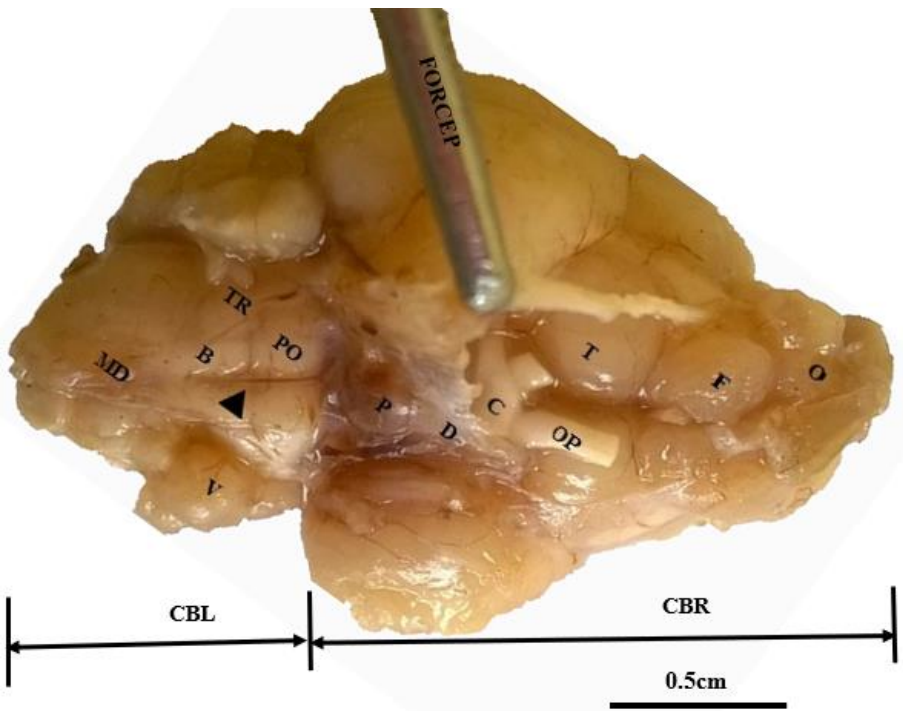


Plate 3. The ventral view of *Epomops franqueti* brain showing: the olfactory (cranial) lobe (O), Accessory (caudal) olfactory lobe (F), olfactory trigone (T), optic nerve (OP), optic chiasma (C), dura mater (D), the pituitary gland (P), pons (OP), trapezoid body (TR), pyramidal tract (B), medulla oblongata (MD), paraflocculus of the cerebellum (V), and the black arrow head points to the cerebral basilar artery. Note that the pituitary gland is closely attached to the mid-brain as it is not connected to a stalk. The dura matter is held with forceps, observe the thickness of the dura mater at that region.