Eur J Anat, 16 (3): 172-176 (2012)

ORIGINAL ARTICLE

Craniofacial morphometrics and macro-neurometrics of the fruit bat (*Eidolon Helvum*)

Olumayowa O. Igado[1], Temidayo O. Omobowale[2], Rasheed A. Ajadi[3], Helen O. Nottidge[2]

1- Department of Veterinary Anatomy, Faculty of Veterinary Medicine, University of Ibadan, Nigeria
2- Department of Veterinary Medicine, Faculty of Veterinary Medicine, University of Ibadan, Nigeria
3- Department of Veterinary Surgery, Faculty of Veterinary Medicine, University of Abeokuta, Ogun State, Nigeria

Summary

This study involved the measurement of craniofacial indices and linear neurometrics in the fruit bat, *Eidolon helvum*, which are found abundantly in Nigeria. The mean head weight was 38.7±2.74g, while the *rima oris* length, distance between medial *canthi*, and the height of the *philtrum* were 48.9±7.59 mm, 14.1±0.49 mm, 8.67±0.48 mm respectively. The brain weight and length of brain were 3.22±0.50 g and 2.79±0.18 cm respectively. The males had consistently higher values for most craniofacial and all neurometric parameters measured, while the female values were higher only in the width of the left external nares (5.08±0.55 mm in the females, and 5.0±0.39 mm in the males). Correlation studies revealed negative correlation between the weight of the animal and the weight of the brain. Data obtained from this study will serve as baseline data for craniofacial anatomy and neuro-anatomy research for the fruit bat, *Eidolon helvum*, and also in comparative anatomy with other breeds of bats.

Key words: Fruit bat – *Eidolon helvum* – Craniofacial indices – Neurometrics – Nigeria

Introduction

Bats are a ubiquitous and relatively unknown species of mammal with an undeserved unsavoury reputation. While some of them may cause damage to plants, animals, or humans (fruit bats or vampire bats), many of them are beneficial to humans (insect eating bats) and a number of bats are being used in various areas of research, especially in auditory research and exhibits (Crawford et al., 2002). The fruit bat (*Eidolon helvum*) belongs to the Order *Chiroptera*, Family *Pteropodidae* (DeFrees and Wilson, 1988), and is widespread throughout Africa (Juste et al., 2000). Morphological reports on the *Eidolon helvum* include stomach (Ofusori et al., 2008), pelvic osteology (Nwoha, 2000), and the gastrointestinal tract (Okon, 1977).

This study was designed to investigate the craniofacial morphometry and gross neurometrics of the African fruit bat.

Materials and Methods

A total of sixty (60) adult clinically healthy bats (30 males and 30 females) were used for this study. The bats were captured with mist nets set at foraging and drinking sites and also

Submitted: February 18, 2012
Accepted: July 27, 2012

Corresponding author:
Dr. Olumayowa O. Igado. Comparative Anatomy, Neuroscience and Environmental Toxicology Unit, Department of Veterinary Anatomy, University of Ibadan, Ibadan, Nigeria. Phone: +23408035790102. E-mail: mayowaigado@yahoo.com

at roost sites. They were transported to the laboratory in cages, anaesthesized with the xylazine-ketamine combination and weighed with a digital weighing scale (Microwa swiss balance®, Mettler-Toledo, Switzerland). The heads were severed at the atlanto-occipital junction and weighed. All procedures followed the Guide for the Care and Use of Experimental Animals (Faculty of Veterinary Medicine, University of Ibadan, Nigeria).

The removal of the brain was as follows: a sharp scalpel blade was used to cut the skin dorsally, in a mid-sagittal plane, from the nasal region to the base of the skull, at the region of the foramen magnum. The skin was reflected to expose the bone, and a saw was also used to make a mid sagittal cut on the skull. Special care was taken not to touch the underlying meninges and the brain. A periosteal elevator was inserted into the cut and used to tease away the bones overlying the brain and also the ones positioned laterally. The meninges were exposed and the brain was excised rostral to the olfactory bulb and caudal to the cerebellum (at the attachment to the spinal cord), and all attachments, like the cranial nerves, were severed and the brain removed as a whole and thereafter weighed.

The craniofacial indices and neurometrics (see Figs. 1 and 2) measured were determined as listed below:

***Rima oris* Length (ROL)**: This was measured, using a twine, as the distance between the lateral commissures of the closed lips. The linear measurement was then determined.

***Pinna* Lengths, Left and Right (PiLL & PiLR respectively)**: This was measured from the base of the *pinna* to its tip.

***Pinna* Widths, Left and Right (PiWL & PiWR respectively)**: This was measured as the widest distance between the lateral edges of the *pinna*.

Distance between Medial *Canthi* (DMC): Distance between the two medial *canthi* of the left and right eyes.

Palpebral Fissure Lengths, Left and Right (PFLL & PFLR): Distance between the medial and lateral commisures of each eye.

***Philtrum* Height (PH)**: Measured from the most dorsal and rostral aspect of the muzzle to the lowest aspect of the *philtrum*.

Width of the External Nares, Left and Right (ENWL & ENWR respectively): Maximum horizontal distance between the lateral and medial borders of each of the nares.

Height of the External Nares, Left and Right (ENHL & ENHR respectively): Maximum vertical distance between the dorsal and ventral borders of each of the nares.

Weight of Brain (WOB): This was determined with the aid of a digital weighing scale after removal and was recorded in grams.

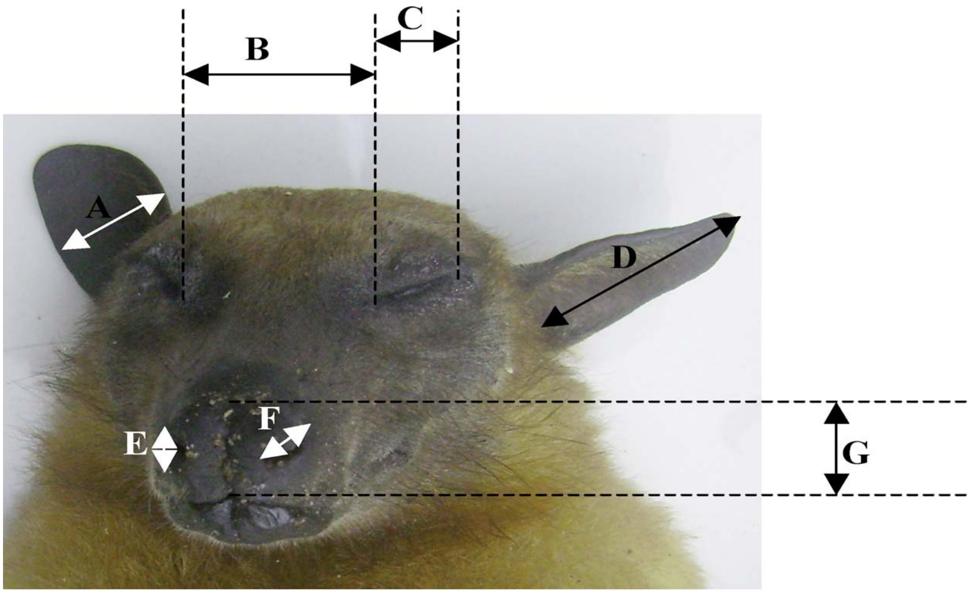

Fig. 1. Rostral view of the head of the *Eidolon helvum*, showing the width of the pinna (A), distance between medial canthi (B), palpebral fissure length (C), length of the pinna (D), height of external nares (E), length of the external nares (F) and philtrum height (G).

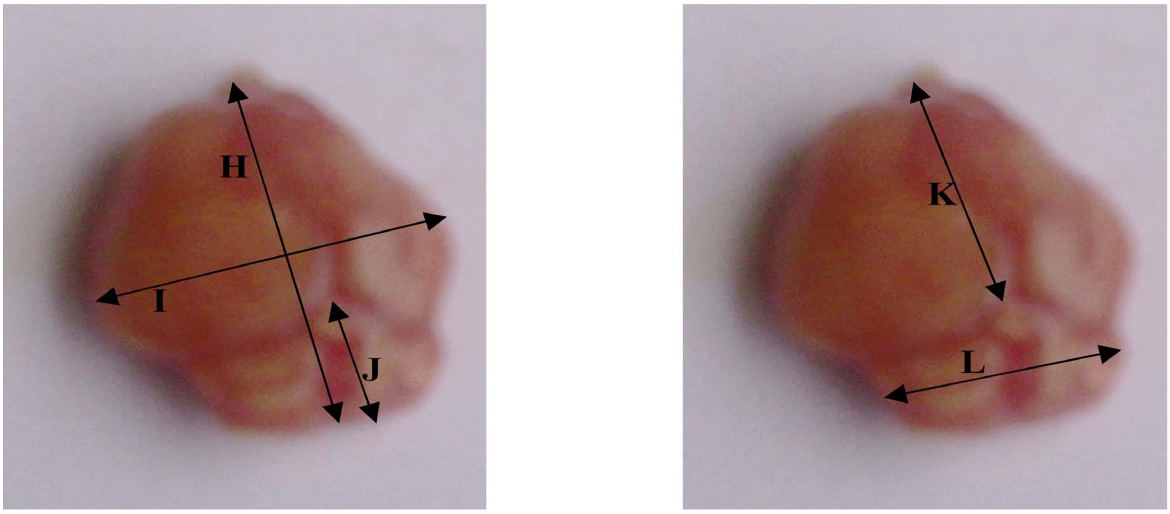

Fig. 2. Dorsal view of the brain of the *Eidolon helvum*, showing the length of brain (H), width of brain (I), length of cerebellum (J), length of cerebrum (K), width of cerebellum (L).

Length of Brain (LOB): Measured from the most rostral point of the olfactory bulb to the medulla oblongata.

Depth of Brain (DOB): Distance from the dorsal aspect of the cerebrum to the ventral aspect of the brainstem.

Length of Cerebrum (LOC): Distance from the rostral pole of the cerebrum to its most caudal pole.

Width of the Cerebrum (WOC): Widest distance between the lateral aspects of the two hemispheres of the cerebrum.

Height of Cerebellum (HOCB): Measured from the highest point of the median vermis to the roof of the fourth ventricle.

Length of Cerebellum (LOCB): Measured from the most rostral end of the cerebellum as the cerebellum makes contact with the cerebrum, to the most caudal point or far extremity, rostral to the *medulla oblongata*.

Width of the Cerebellum (WOCB): Measured as the greatest distance between the two lateral sides of the cerebellum.

Statistical analysis: All data were analysed using Graphpad prism soft ware (V4). Students t' test was carried out at $p<0.05$ level of significance.

Results

The results obtained are presented as mean ± standard deviation in Tables 1-5.

The overall average body weight of the bats used in this study was 224±25.5 g, with that of the males (232±24.8 g) being slightly higher than the females (213±25.0 g) (Table 1). Although no statistically significant differences were recorded ($p>0.05$), the values obtained for all the craniofacial and neurometric parameters measured were consistently higher in the males, except for width of the left external nares, which was 5.08±0.55 mm in the females, and 5.0±0.39 mm in the males (Tables 2 and 4). A slight asymmetry was observed between the left and right *pinna* lengths and width, and the left and right external nares height and width. Pearson's correlation analysis revealed a negative correlation between the weight of the animal and all neurometric parameters measured (including the weight of the brain), with the length of brain and length of cerebellum having the lowest values ($r = -0.333$), while the depth of the cerebellum showed the highest negative correlation ($r = -0.775$). In contrast, a positive correlation existed between the weight of the head and the neurometric parameters measured, with the exception of the depths of the cerebrum and cerebellum, which showed negative correlations ($r = -0.121$ and -0.248 respectively). The height of the *philtrum* and the DMC showed the highest positive correlations to the weight of the head ($r = 0.759$ and 0.758 respectively), while the right palpebral fissure length showed the lowest positive correlation ($r = 0.032$) (Table 5).

Table 1. Craniofacial indices in the *Eidolon helvum.*

ParametersN=60	WOA(g)	WOH(g)	ROL(mm)	PiLL(mm)	PiLR(mm)	PiWL(mm)	PiWR(mm)	DMC(mm)	PFLL(mm)	PFLR(mm)	PH(mm)	ENWL(mm)	ENWR(mm)	ENHL(mm)	ENHR(mm)
Mean ± S.D	224±25.5	38.7±2.74	48.9±7.59	24±3.17	24.5±3.42	17±1.59	16.5±1.82	14.1±0.49	11.8±0.94	11.3±0.92	8.67±0.48	5.03±0.43	4.78±0.48	3.86±0.36	3.63±0.72

Note: Results are presented as Mean ± Standard deviation. No statistically significant differences were observed between left and right values (p>0.05).
Key: WOA- weight of animal; WOH- weight of head; ROL- rima oris length; PiLL and PiLR - pinna length (left and right respectively); PiWL and PiWR - pinna width (left and right respectively); DMC- distance between medial canthi; PFLL and PFLR - palpebral fissure length (left and right respectively); PH- height of philtrum; ENWL and ENWR - width of external nares (left and right respectively); ENHL and ENHR - height of the external nares (left and right respectively).

Table 2. Craniofacial indices in the *Eidolon helvum* based on gender.

Parameters	WOA(g)	WOH(g)	ROL(mm)	PiLL(mm)	PiLR(mm)	PiWL(mm)	PiWR(mm)	DMC(mm)	PFLL(mm)	PFLR(mm)	PH(mm)	ENWL(mm)	ENWR(mm)	ENHL(mm)	ENHR(mm)
Male; n=30	232±24.8	40±1.62	52.4±8.11	25.4±1.77	26.1±1.97	17.1±1.56	16.6±1.96	14.1±0.33	12.1±0.83	11.6±1.01	8.84±0.38	5±0.39	4.88±0.45	3.99±0.42	3.82±0.85
Female; n=30	213±25.0	36.8±3.19	43.7±1.1	21.9±3.85	22.2±4.09	16.7±1.85	16.3±1.87	14±0.72	11.3±1.0	10.7±0.501	8.41±0.54	5.08±0.55	4.64±0.54	3.68±0.14	3.35±0.43

Note: Results are presented as Mean ± Standard deviation. No statistically significant differences were observed between left and right values, and between male and female values (p>0.05).
Key: WOA- weight of animal; WOH- weight of head; ROL- rima oris length; PiLL and PiLR - pinna length (left and right respectively); PiWL and PiWR - pinna width (left and right respectively); DMC- distance between medial canthi; PFLL and PFLR - palpebral fissure length (left and right respectively); PH- height of philtrum; ENWL and ENWR - width of external nares (left and right respectively); ENHL and ENHR - height of the external nares (left and right respectively).

Table 3. Macro-neurometrics in the *Eidolon helvum.*

Parameters	WOB(g)	LOB(cm)	LOC(cm)	DOC(cm)	WOC(cm)	LOCB(cm)	DOCB(cm)	WOCB(cm)
Mean ± SD	3.22±0.50	2.79±0.18	2.06±0.39	1.35±0.25	2.0±0.29	1.08±0.15	0.58±0.07	0.60±0.14

Note: Results are presented as Mean ± Standard deviation.
Key: WOB- weight of brain; LOB-length of brain; LOC- length of cerebrum; DOC-depth/height of cerebrum; WOC-width of cerebrum; LOCB- length of cerebellum; DOCB- depth/height of cerebellum; WOCB- width of cerebellum.

Table 4. Macro-neurometrics in the *Eidolon helvum* based on gender.

Parameters	WOB(g)	LOB(cm)	LOC(cm)	DOC(cm)	WOC(cm)	LOCB(cm)	DOCB(cm)	WOCB(cm)
Male n=30	3.51±0.65	2.93±v0.11	2.38±0.25	1.55±0.14	2.23±0.18	1.15±0.21	0.63±0.04	0.65±0.21
Female n=30	2.94±0.04	2.65±0.07	1.75±0.07	1.15±0.07	1.78±0.11	1.0±0.00	0.53±0.04	0.55±0.07

Note: Results are presented as Mean ± Standard deviation. . No statistically significant differences were observed between male and female values (p>0.05).
Key: WOB- weight of brain; LOB-length of brain; LOC- length of cerebrum; DOC-depth/height of cerebrum; WOC-width of cerebrum; LOCB- length of cerebellum; DOCB- depth/height of cerebellum; WOCB- width of cerebellum.

Table 5. Correlation coefficients (Pearson's correlation) of some craniofacial and macro-neurometric parameters in the *Eidolon helvum.*

	WOA	WOH	ROL	PiLL	PiLR	PiWL	PiWR	DMC	PFLL	PFLR	PH	ENWL	ENWR	ENHL	ENHR	WOB	LOB	LOC	DOC	WOC	LOCB	DOCB	WOCB
WOA	-	0.630	0.009	0.606	0.579	0.474	0.260	0.381	-0.199	0.022	0.651	0.117	0.213	0.200	0.250	-0.415	-0.333	-0.448	-0.671	-0.700	-0.333	-0.775	-0.471
WOH	0.630	-	0.505	0.508	0.382	0.556	0.223	0.758	0.214	0.032	0.759	0.310	0.534	-0.009	-0.208	0.104	0.735	0.706	-0.121	0.191	0.542	-0.248	0.295

Discussion

The higher body weight of the males compared to the females is in consonance with earlier findings in the fruit bat (Odukoya et al., 2009), and also with the observation by Campbell (1990) that males of most species are usually heavier than the females of the same age. However, in similar studies conducted on Sahel goats (Olopade et al., 2007) and the Japanese quail (Igado and Aina, 2010), the females had statistically significant higher body weights. Defrees and Wilson (1988) recorded higher values for the females when compared with the males, but their own study was conducted on gravid bats. This probably explains the reason for the higher weights recorded for the females in that study. In this present study, only non-gravid females were used. The heavier body weight of the males in this study is probably the reason why the males had higher craniofacial indices, especially considering that the body weight and also the weight of the head showed a positive correlation to most of the parameters determined.

The wider *rima oris* length observed in the males is similar to an earlier finding in male pigs (Olopade et al., 2011). It is speculated that this wider *rima oris* length may probably be due to the heavier body and head weights recorded in the males. The higher values recorded in the males for the *pinna*, palpebral fissure and external nares parameters might probably indicate that the males have the roles of protectors, as these may heighten their sense of hearing, sight and smell respectively in order to sense danger, and locate food. A wider distance between medial *canthi* (DMC) can also suggest that the more lateral placement of the eyes helps in survival, as witnessed in animals which are preys (Dyce et al., 2002), although the difference in DMC between male (14.1±0.33 mm) and female (14±0.72 mm) was not statistically significant ($p>0.05$). The craniofacial asymmetry observed in this study is consistent with earlier reports of measurements between the two halves of an animal's body (Sisson and Grossman, 1975). In a study conducted by Blackwood et al. (2010), in a captive colony of three species of fruit bats (flying foxes - Pteropus spp), values obtained for the right and left palpebral fissure lengths (13.45±0.44 mm and 13.45±0.51 mm respectively) were higher than the values obtained in this current.

The head and brain accounted for 17.4% and 1.53% respectively of the whole body weight in the male; and 17.1% and 1.4% respectively in the female. The relative head and brain weights observed in this study differs from those reported in the Japanese quail (male- 4.92% and 0.51% respectively; female- 3.93%, 0.46% respectively) (Igado and Aina, 2011), Sahel goat (male- 6.97% and 0.45% respectively; female- 6.29%, 0.40% respectively), WAD (relative head weight male- 7.26%; female- 14.03%) (Olopade et al., 2007), Large white pigs (relative brain weight-0.14%) (Felix et al., 1997). This is consistent with the observation in humans (Skullerud, 1985), and the Sahel breed of goat (Olopade et al., 2007), where the females had smaller brains. The reason for this sexual dimorphism is not clear presently. A positive correlation was exhibited between the weight of the head and most of the neurometric parameters. This is reflected in the results obtained from this study where the males had heavier heads and brains relative to the females, but also differs from the results obtained in Japanese quails (Igado and Aina, 2010), where the males had higher values for the head weight, but lower values for the brain weight.

In conclusion, results obtained from this data could be useful in the field of comparative, regional and clinical anatomy, morphophysiology, neuro-anatomy and physiology research and gender studies of bats, especially the Chiroptera.

References

Blackwood SE, Plummer CE, Crumley W, MacKay EO, Brooks DE, Barrie KP (2010) Ocular parameters in a captive colony of fruit bats. *Vet Ophthalmol,* 13: 72-79.

Campbell NA (1990) Biology. 2nd edition. The Benjamin/Cummings publishing Company Inc, New York, pp 229-343.

Crawford RL, Jensen D, Allen T (2002) Information resources on bats. AWIC Resource Series No. 17.

DeFrees SL, Wilson DE (1988) Eidolon helvum. *Mammalian Species*, 312: 1-5.

Dyce KM, Sack WO, Wensing CJG (2002) Textbook of Veterinary Anatomy. Third edition, Saunders.

Félix B, Léger ME, Albe-Fessard D, Marcilloux JC, Rampin O, Laplace JP (1999) Stereotaxic atlas of the pig brain. *Brain Res Bull,* 49: 1-137.

Igado OO, Aina OO (2010) Some aspects of the neurometrics and oculometrics of the Japanese Quail (*Coturnix coturnix japonica*) in Nigeria. *J Morphol Sci*, 27: 133-135.

Juste J, Machordom A, Ibañez C (2000) Morphologic and allozyme variation in *Eidolon helvum* in the gulf of Guinea (West-Central Africa). *Biol J Linn Soc,* 71: 359-378.

Nwoha PU (2000) Sex differences in the bony pelvis of the fruit-eating bat, *Eidolon helvum*. *Folia Morphol,* 59: 291-295.

Odukoya SA, Ofusori DA, Adeeyo OA, Ayoka OA, Abayomi TA, Ajayi SA, Falana BA (2009) Comparative biochemical studies of the pregnant and non pregnant uterine limbs of the frugivorous bat, *Eidolon helvum*. *J Cell Anim Biol,* 3: 175-178.

Ofusori DA, Enaibe BU, Falana BA, Adeeyo OA, Yusuf UA, Ajayi SA (2008) A comparative morphometric analysis of the stomach in rat *Rattus norvegicus*, Bat *Eidolon helvum* and pangolin *Manis tricuspis*. *J Cell Anim Biol,* 2: 79-83.

Okon EE (1977) Functional anatomy of the alimentary canal in the fruit bat, *Eidolon helvum*, and the insect bat, *Tadarida nigeriae*. *Acta Zoologica*, **58:** 83-93.

Olopade JO, Kwari HD, James SC, Ofua M, Onwuka SK (2007) Some aspects of the neurometrics of the Sahel goat in Nigeria. *Eur J Anat*, 11: 101-104.

Olopade JO, Igado OO, Nwafor CI, Alamu AO, Onwuka SK (2011) Some aspects of the craniofacial indices and macro neurometrics of the Nigerian local pig (*Sus Scrofa*). *IJAE*, In press.

Skullerud K (1985) Variations in the size of the human brain. Influence of age, sex, body length, body mass index, alcoholism, Alzheimer changes, and cerebral atherosclerosis. *Acta Neurol Scand, Suppl* 102: 1-94.