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Morphology and Histoarchitectural Study of the Cerebellum of Grasscutter (*Thyonomys swinderianus*) and Hedgehog (*Atelerix albiventris*)

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Abstract

The study investigated the general morphology and histoarchitecture of the cerebellar of grasscutter and the Hedgehog. Six grasscutters and six hedgehogs were used for the study. They were obtained from Jobavic farm in Ilorin, Nigeria. The animals were euthinised, transcardially perfused with 0.9% of normal saline followed by 4% paraformaldehyde solution. The brains of the animals were removed and the cerebellum detached, weighed and processed for histological purposes and comparism. The findings of the study show a well-organised gyration and sulci in the grasscutter compared to the hedgehog. The brain and cerebellar weights of the grasscutter are comparably larger than that of the hedgehog. However, the cerebellar cortices and the histoarchitecture of the two animals are similar with little variations in the cellular layers especially in the Pukinje cell layer. The study concludes that though there are no marked histological differences between the cerebellar cortices in the two animals, the observed complex motor functions in the grasscutter maybe explained by the complexities in their cerebellar gyration and sulci.

Keywords: Grasscutter, Hedgehog, Cerebellar cortices, Histoarchitectural, Morphology

Introduction

Grasscutters (*Thryonomys swinderianus*) belong to a small family of Africa hystricognath rodents (Woods *et al.*, 2005) which are regarded as cane rats because they live in plantation farms especially sugarcane plantations. They are wild hystricomorphic rodents found mostly in Africa (Adoun, 1993) and are considered to be the second largest African rodent after the porcupine (Asibey and Addo, 2000). Cane rats grow to nearly 2 feet (0.61 m) in length and weigh a little less than 8.6 kg at adulthood. They feed on agricultural crops such as, maize, wheat, sugarcane and cassava which often earn them the label of agricultural pests. They are also consumed as meat (bush meats) by locals and inhabitants of the areas where they are found (Mathews *et al.*, 2008).

Hedgehog also regarded as Urchin or hedge pig, are mostly found in Europe, Asia, Africa and New Zealand. They have adaptation to nocturnal and insectivorous life, although, depending on the species, some of them maybe more or less active during the day and they are easily recognized by their spines, which are hollow hairs made stiff with keratin. They have enjoyed widespread popularity as folk medicine in the treatment of rheumatism and arthritis (Qumsiyeh *et al.*, 1996). Hedgehogs are found in hedgerows, fields, open woods and gardens. The only predator is Barger (Hof *et al.*, 2010), but the European Eagle owl has also been found to be one of its predator. Their spiny protection resembles that of the unrelated rodent porcupines and monotreme echidnas.

There are about 5,000 to 6500 quills on the average hedgehog; however, the quills are used for protection against predators. Following paucity of literatures on the morphology and histoarchitectural designs of their cerebellum, the present study was designed to look into their morphological and histoarchitectural parameters between the brains and cerebellar cortices of the Grasscutter and Hedgehog.

Materials and methods

The protocol for this experiment was approved by the Faculty of Basic Medical Sciences Animals Ethic Committee which parallel that of the International Guideline on the use of experimental animals in researches and studies. Six adult Grasscutters (*Thryonomys swinderianus*) and six Hedgehogs (*Atelerix albiventris*) were obtained from Jobavic farm in

Ilorin, Nigeria.

To avoid attrition, the animals were transported in an iron cage to the department of human anatomy laboratory, University of Ilorin, Ilorin, Kwara state, Nigeria. The animals were euthanised with intramuscular injection of 20 mg/kg body weight of ketamine, perfused transcardially first with 0.9% of normal saline then followed by 4% paraformaldehyde solution. After the perfusion fixation, the skulls were opened and the brain exposed with the aid of a bone nibbler. The brains were removed, weighed and recorded. The cerebelli were also detached, weighed and recorded.

The detached cerebelli were sectioned serially in sagittal plane and histologically stained using Haematoxylin and Eosin (H&E), Marshland, Glee and Erikson (MGE) stains.

Data Analysis

Qualitative analysis of the sagittal stained sections of the cerebellum were studied under the light microscope while the weight of the cerebellum were reported as mean $\pm$ SEM and test statistics was performed using statistical software SPSS version 16.

Results

Morphometric result

The morphometric observation shows that the grasscutter cerebellar cortices present a more complex and organized gyri and sulci when compared to that of the hedgehog (Figure 1).

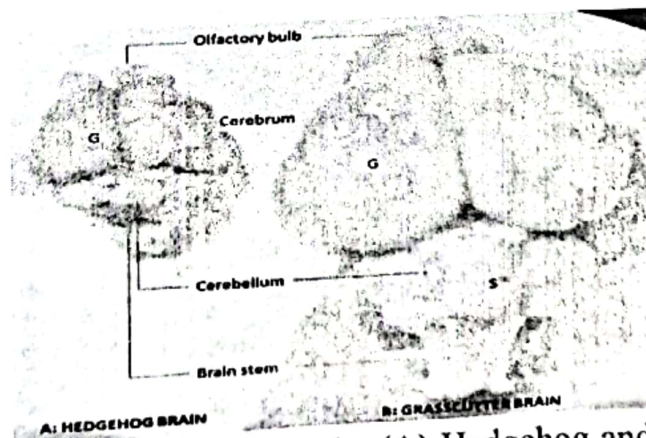


Figure 1: The gross morphology of the (A) Hedgehog and (B) Grasscutter showing (G) gyri, olfactory bulb, and (S) Sulci

The average mean weight of the brain of Grasscutter was $9.82 \pm 0.49\text{g}$ and $1.48 \pm 0.087\text{g}$ for the Hedgehog. There was no statistical significance difference within the groups but there are significance difference between those of the grasscutters and the Hedgehogs. The mean average cerebellar weight in grasscutters was $1.28 \pm 0.08\text{g}$ and $0.21 \pm 0.01\text{g}$ for the Hedgehogs (Table 1).

The mean brain-body weight ratio in the two animals shows a higher ratio in the grasscutter compared to that in the hedgehog, while the ratio of the brain to the body weight for the grasscutter was 1:1:80 and for the hedgehog, it was 1:1:27 (Figure 2).

Table 1: showing quantitative data of the cerebella weight, brain weight and body weight of Grasscutter and Hedgehog

Animals	Cerebella weight (g)	Brain weight (g)	Body weight (g)
Grasscutter	1.28 ± 0.08	9.82 ± 0.49	1800 ± 214.5
Hedgehog	0.21 ± 0.01	1.48 ± 0.87	191.03 ± 5.94

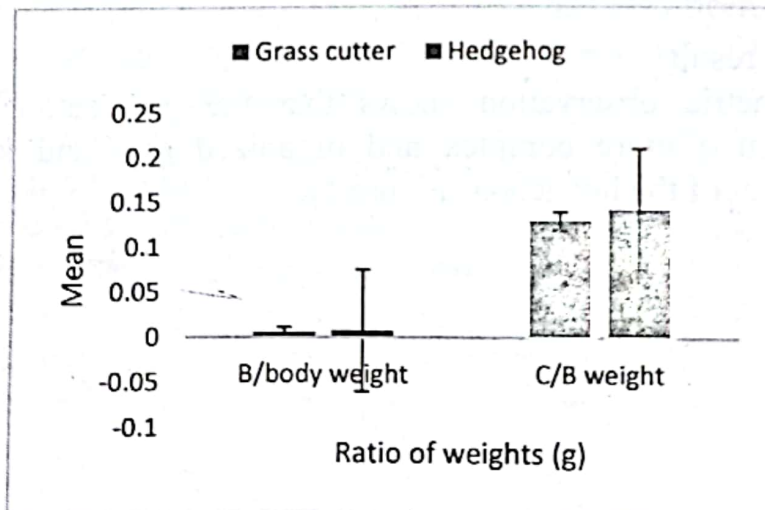


Figure 2: Showing the ratio of the (B/B) brain-body weight and (C/B) cerebella-brain weight ratio in the Grasscutter and Hedgehog. The bar indicates the standard deviation.

Histological Section Result of the Cerebellum

The histological sections of the cerebella cortices of Grasscutter and hedgehog following Haematoxylin and Eosin (H&E) and Marshland, Glee and Erikson (MGE) stains show that the cerebella histoarchitecture in the cellular layers are of similar organisational patterns, but there are notable differences in the abundance of some cells, such as the satellite cells, granule cells and the Pukinje cell in the grasscutter when compared to that of the hedgehog (Figures 3 and 4).

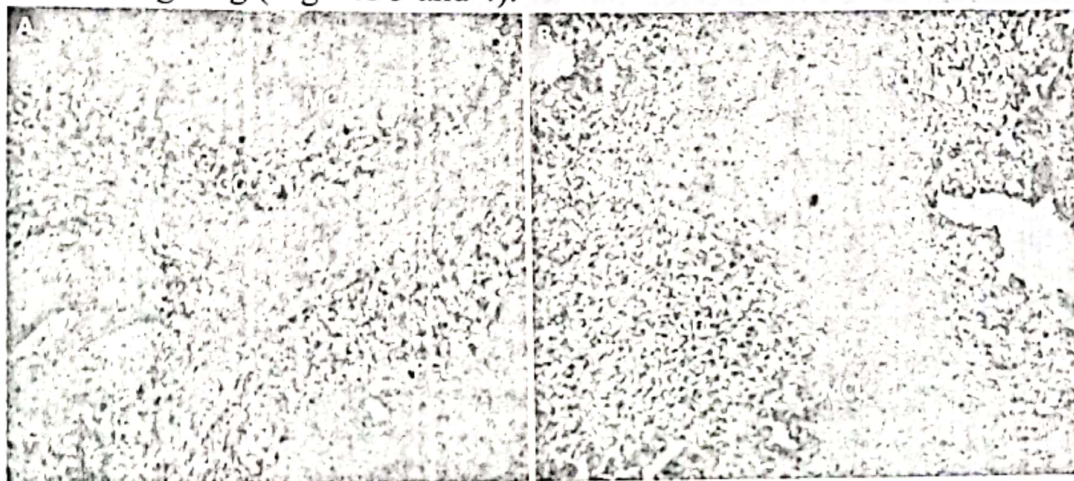


Figure 3: Representative photomicrograph of the cerebellar cortices of A (Grasscutter) and B (Hedgehog) showing the outer molecular layer (MCL), middle Purkinje cell layer (PCL) and inner granular layer (GCL). H&E stain (X 100)

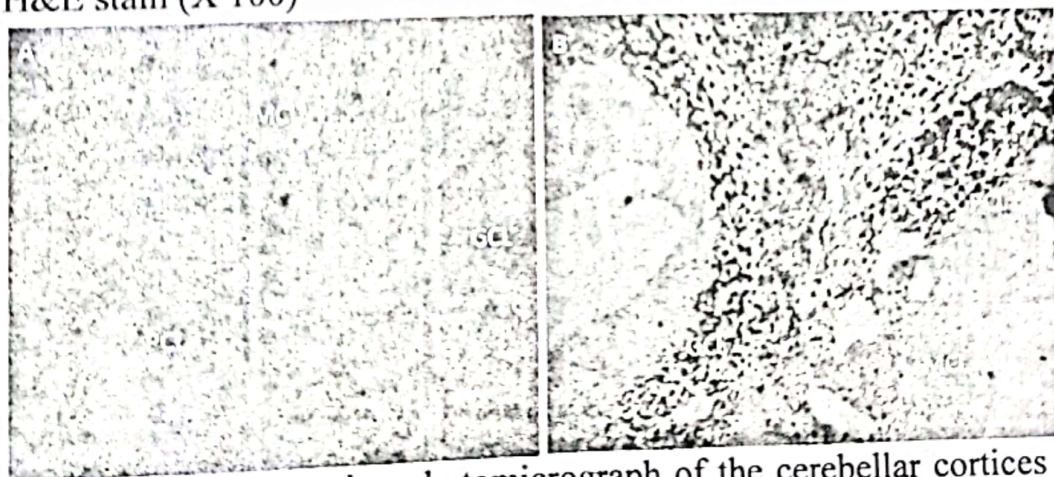


Figure 4: Representative photomicrograph of the cerebellar cortices of A (Grasscutter) and B (Hedgehog) showing the outer molecular layer (MCL), middle Purkinje cell layer (PCL) and inner granular layer (GCL). MGE stain (X 100)

Discussion

The complexity of the brain and cerebellum are key determinants of behavioral differences amongst different animal species, especially in mammals whose interspecies variations in their cerebellar morphology were mostly associated with distinct behavioral differences (Sultan and Braitenberg, 1993). The findings of the present study show that grasscutters have higher cerebellar weight, body weight, and gross body size compared to hedgehogs. Though, there are no statistical significant differences in the brain-body weight and the cerebellar-brain weight ratio between the two animals, the complexity in the behavioral patterns in the grasscutters can be explained by the presence of numerous sulci and gyri in the grasscutters.

This observation was also collaborated with the findings of Hadair and Ansari in 2012, which reported that the degree of folding in neural structures like the cerebellum might be correlated with behavioral and cognitive functions. Studies have also shown that folding of laminated structures like cerebrum and cerebellum increases the processing capacity and ability in animals. However, in mammals, some of the interspecies variation in cerebellar morphology was thought to be associated with distinct behavioral differences found in different mammals (Sultan and Braitenberg, 1993).

The relatively large cerebellum size in relation to their weight and size could partly explain the superior functionality observed in grasscutters compared to those of the hedgehogs. The present study findings were strengthened by the findings of Llinas 2004 that reported that sensory and motor neural functions can be influenced by the relative sizes of the cerebellum.

Though, there are some similarities in the cerebellar gyrations and sulci organizations of the grasscutter and hedgehog, the cerebellum of grasscutter have well folded folia (gyri) with well-developed sulci compared to those of hedgehog. Earlier report from Byanet *et. al.*, 1987, shows that the cerebellar cortexes of grasscutter have well developed folia and deep intervening sulci.

This could partly explain why grasscutters have more robust, complex and high locomotory activities and functionality compared to the hedgehogs. Morphometric data are often used as an indirect measurements of metabolic rate and sometimes body functions. The grasscutters with their high cerebella weights, body weights, gross body size, and brain weights when compared to the hedgehog will certainly have a higher superiority in functionality behavioral complexities.

Carpenter, 1972 reports that sensory and motor neuronal functions can be influenced by the size of their cerebellum, and following that observation, it is safe to imply that grasscutters are more likely to have better regulation of their sensory and motor neuronal functions compared to the hedgehog. This finding was evidenced in their life patterns and behaviours. The present study showed that the ratio of the brain-body weight of grasscutter was 1:1:80 while in the hedgehog was 1:1:27, this observation confirmed the independence of brain weight of the animals to their body weights and size.

The cerebellum-brain ratio in the two animals shows no statistical significant difference, but the slightly high ratio of the cerebellum-brain weight in the grasscutter compared to that of the hedgehog could account for the differences in their motor activities between the two animal models.

The microscopy anatomy of the cerebellar cortexes of both animal models revealed a three cell layered cell structure comprising of different cell types. The cortex is surrounded by a centrally located white matter, and the cell layers found within the cortex are the molecular, the middle Purkinje layer, and the granular layer. Victor, 2000 and Fletcher, 2006 in their earlier studies strengthened the findings of the present study where they have shown that there are three layers of cerebellar cortex in different animal's models and man.

The outer molecular layers of the two animal models consist of two types of cells; the basket and stellate cells. These are similar to the same types of cells described by Standring *et al* in 2008 as inhibitory interneurons in other animal models. The middle Purkinje layer is a single cell layer consisting of the cell body and its dendrites projecting into the molecular and or the granular layer known as the Purkinje cells. These Purkinje cells

are often referred to as the largest neurons in the brain (Gruol and franklin, 1987). The third layer in the cerebellar cortex in the two animal models was the inner granular layer which comprises dense packed granule cells; which are the highest populated cells in the brain. However, the granular layer in the grasscutter was more densely packed compared to that of the hedgehog with granule cells while the Purkinje cell layer was more prominent in the grasscutter.

Functionally, since the granule cells played significant role in coordination and movement (Fletcher, 2006), this may explain the structural basis why grasscutters have better coordination in their various activities compared to the hedgehog. Studies have shown that cortexes of experimental animals become relatively heavy if the animals live in a relatively diverse, stimulating and enriched environment (Milton, 1974). These could partly explain the complexity in the neuronal density, size and connectivity observed in the grasscutter compared to that of the hedgehog. The ability of the grasscutter to perform higher and coordinated motor functions better than the hedgehog could also be due to their habitation in enriched environment compared to those of the hedgehog. Enrich environment with complexity in the numbers of gyration and sulci. stimulate neurogenic cells in the brain and cerebellum in animals. Hence, adapting to various environments required complex neural processes that need significant contribution of the cerebellum. This certainly could explain why grasscutter adapt better to their environment compared to hedgehog.

Conclusion

The study concludes that the cerebellar cortexes of the two animal models though similar in morphology and histoarchitectural design, there are significant differences between their sizes, weights and number of cells types in their cerebellar layers. The differences in the total numbers in gyri and sulci organizations between the animal models explained the differences observed in the behavioral activities of the animals.

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