

Histological Aspects of Cerebrum and Cerebellum in Adult Male and Female Mongoose (*Herpestes edwardsii*)

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Abstract

BACKGROUND: Mongooses are small carnivores residing in different regions from Africa to southeast Asia. The Indian gray mongoose (*Herpestes Edwardsii*) is one of the mongoose species that is mostly found in southern Asia particularly India and the south of Iran. Anatomical studies on the animal's brain have always been of interest to the scientist due to its high importance in various branches of biology, such as zoology, veterinary medicine and ethology.

OBJECTIVES: Our study aimed to enrich the current data pool by providing a histological description of the mongoose's brain. The present study was conducted to investigate the histomorphologic and histomorphometric aspects of cerebrum and cerebellum of the Indian grey mongoose.

METHODS: For this purpose, eight adult mongooses were considered, which were in an end-stage disease or the status of approaching death. In the following, after removing the skull, the brain structure was accurately dissected and placed in 10% buffered formalin. The samples were embedded in paraffin, cut into serial sections and stained using standard Hematoxylin and Eosin protocol.

RESULTS: In this study, the thickness of the white matter and cortex layers in the cerebrum and cerebellum, the number of neurons and neuroglia cells per unit area, and morphological features of tissue of the organs were measured and recorded. The results of cell count showed that the cell density of neurons in female and neuroglia in male were higher, significantly ($P \leq 0.05$). Also in the cerebellum, the Purkinje cells were oval to round and were very close to the granular layer.

CONCLUSIONS: Despite minor differences, it could be concluded that the general morphologic and morphometric characteristics of cerebrum and cerebellum for mongoose are similar to the other animals. Although the study of these features has not been done in a wild carnivore so far, these features can be considered as an intermediate between rodents and human.

KEYWORDS: Cerebellum, Cerebrum, Histomorphology, Histomorphometry, Mongoose

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Introduction

Mongoose are small carnivores occupying various regions from Africa to southeast Asia. The genus *Herpestes* contains 10 species and is considered the oldest genus in the order Carnivora, dating back to approximately 30 million years (Shil *et al.*, 2012). The Indian gray mongoose (*Herpestes edwardsii*) is a mongoose species that is principally found in southern Asia particularly India, Pakistan, the South of Iran, Sri Lanka and some other parts of Asia. Also, body mass in males is considerably more than females (Rasouli *et al.*, 2015).

The brain is made of three main parts: cerebral, cerebellum, and medulla oblongata. The cerebrum is the largest part of the brain and involves reasoning, learning, sensory perception, and emotional responses. On the other hand, the cerebellum is responsible for the maintenance of equilibrium of the body by coordinating somatic motor activity and by regulating muscle tone. This part is more important in active vertebrate genera since it is intimately involved in the control and maintenance of muscle tones and thereby motor coordination (Dyce *et al.*, 2017). Brain study in animals is important for animal's welfare and knowledge about the nervous system function, physiology, behavior habits, and developmental anatomy.

Histological studies on cerebrum and cerebellum have been of interest to the anatomical scientists in the last decade. The micro-anatomy of the cerebrum has been studied and described in human, mouse (Treuting and Dintzis, 2012), rabbit, rat (Ibegbu *et al.*, 2014), and guinea pig (Musa *et al.*, 2016). Moreover, (Pal *et al.*, 2003; Irimescu *et al.*, 2015; Treuting and Dintzis, 2012; Danmairgo *et al.*, 2016; Sur *et al.*, 2011; Musa *et al.*, 2016; Beheiry, 2015) provide valuable

information about the cerebellum histological aspects in the fowl, chinchilla, mouse, catfish, birds, guinea pig, and camel, respectively. Also, Jardim-Messeder *et al.* (2017) carried out extensive comparative studies on the number of brain neurons and their brain-size in various carnivores including one of the mongoose species.

Comparative morphology has been served as evidence for evolution and indicates that various animals share a common ancestor. This allows scientists to classify animals based on similar characteristics or diversity of their body structures. There is a dearth of information on the comparative histological organization of the cerebrum and cerebellum in the carnivores. In addition, this study may be helpful for a better understanding of the brain structural variations related to behavioral habitats and functional anatomy of this species.

Our study aimed to enrich the current data pool by providing a comparative histological description of the mongoose's cerebrum and cerebellum.

Materials and methods

Eight adult mongooses (4 male and 4 female) which have been found in the surrounding areas of Shiraz (capital of the Fars province-Iran) were used for this study over the last two years. The age of the animals was estimated to be more than one-year-old with respect to the teeth inspection. These fresh specimens in an end-stage disease or the status of approaching death (severe hypothermia; 36 °C body temperature) were admitted to anatomy laboratory in veterinary faculty, Shiraz University, Shiraz, Iran. All these activities were done in coordination with ethical rules of the department

of environment of Fars province. The obtained Licence No was: 5599/700 / 93 / p.

The animals were euthanized with Ketamine 10% and Xylazine 2%. Then 10% buffered formalin solution was injected into the lateral ventricles by creating a small pore in the frontal bone. In this way, the fixative material was well distributed in the cerebral ventricles and the subarachnoid space and the nervous tissue became more firm. These methods were performed based on the study of Musa *et al.* (2016).

The specimens were then transferred into the big containers of phosphate buffered formalin solution, 24 h later, the skull was removed and the brain was exposed. Then, the tissue samples were collected from parietal and frontal lobes of the right cerebral hemisphere and right cerebellar hemisphere (Figure 1). These samples were embedded

in paraffin, cut into serial sections, and stained using a standard Hematoxylin and Eosin protocol (H&E stain). In this study, the thickness of the white matter and cortex layers in the cerebrum and cerebellum, the number of neurons and neuroglia cells per unit area, and morphological features of the tissue of the organs were measured and recorded by Image Pro 7 plus software (Pal *et al.*, 2003). In the following, a comparison is made between the results regarding the histological aspects of cerebrum and cerebellum and those of literature data about the other species.

Statistical analysis

Analysis of morphometric data was carried out with Student's t-test using the SPSS software (Version. 23) at the significance level $P \leq 0.05$.

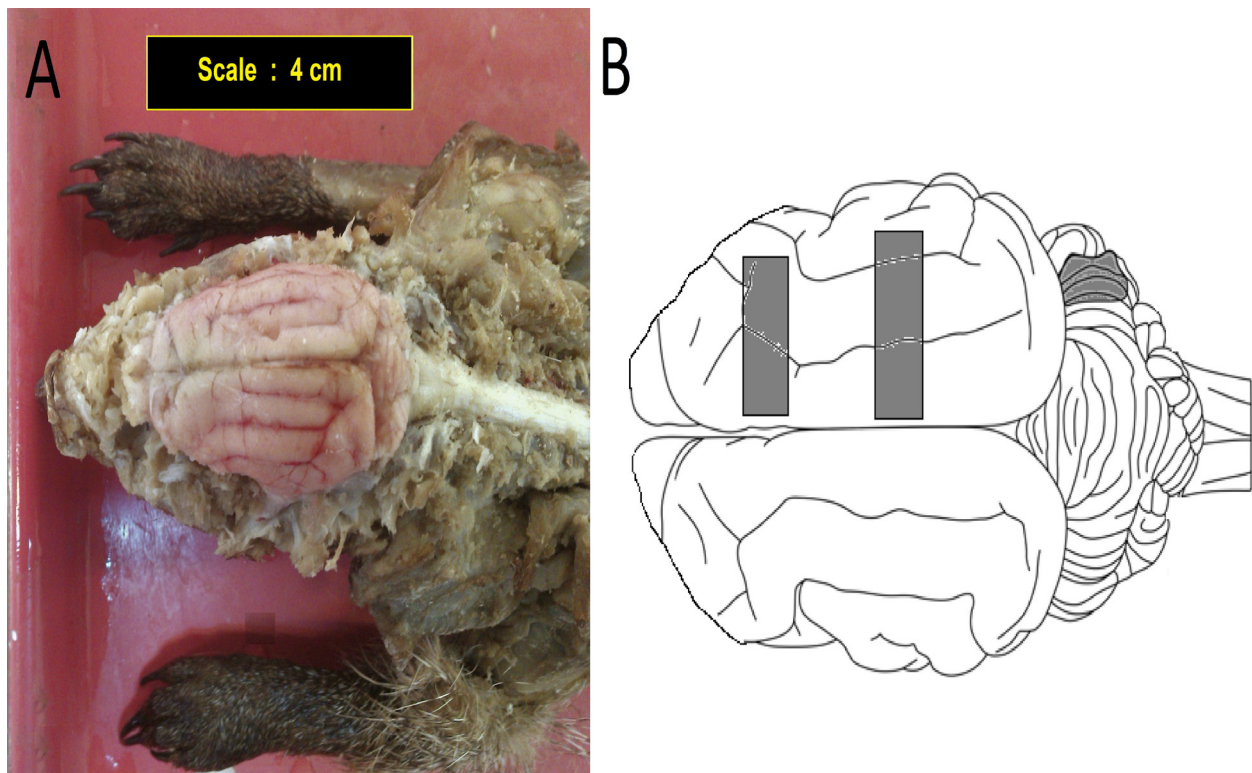


Figure 1. A: Structure of the brain after removing the skull in an adult mongoose (Dorsal view). B: Areas for tissue sampling of the cerebrum and cerebellum

Results

The mongoose's cerebral histological section consists of two distinguished materials: gray matter and white matter. The gray matter or cerebral cortex is situated externally while the white matter is situated internally (Figure 2). The results of the studies on thickness measurements of the white and gray matter layers, as well as

the ratio between them in the frontal and parietal lobes, are summarized in Table 1. Further, the results of studies on the cellular density of neurons per unit area of gray matter, and also the neuroglia cells per unit surface area of white matter are reflected in Table 1. All the results and significant differences were performed considering $P \leq 0.05$.



Figure 2. Photomicrograph of the frontal lobe of the cerebrum in the male mongoose. Stain: H&E. White matter (wm) and Grey matter (gm)

Table 1. Thickness of the gray matter and white matter of the cerebrum, their ratio, and cellular density per unit area (Mean \pm SD) both in male and female mongoose.

	Frontal lobe		Parietal lobe	
	Male(n=4)	Female(n=4)	Male(n=4)	Female(n=4)
Gray matter thickness (mm)	0.994 \pm 0.084	0.803 \pm 0.025*	1.245 \pm 0.164	0.723 \pm 0.02*
White matter thickness (mm)	0.717 \pm 0.15	0.63 \pm 0.29	0.92 \pm 0.042	0.613 \pm 0.07*
Ratio of gray matter to white matter	1.38 \pm 0.11	1.27 \pm 0.12	1.35 \pm 0.1	1.19 \pm 0.14
Number of neurons per unit area of gray matter (n/mm ²)	17430.80 \pm 1029	19140 1610.28 \pm	18565.45 \pm 2566.88	19120.43 \pm 1475.5
Number of neuroglia cells per unit area of white matter (n/mm ²)	11577.55 \pm 892.28	8625.32 \pm 532.12*	10370 \pm 480	7665.67 \pm 989.44*

(* significant difference $P \leq 0.05$).

The observations of the present study showed that the layers of the frontal lobe in cerebrum cortex are relatively recognizable so that the molecular layer of the cortex was a marked layer with very few cells. The outer granular and pyramid layers are close and distinguishable from each other. The internal granular and pyramidal layers are highly interconnected. However, as the outside moves

to the medullary area, the pyramidal cells (Betz cells) becomes larger. The polymorphic layer also has high cell density and cellular forms. The boundary between the gray matter and the white matter is also clearly evident (Figure 3A). The mentioned features are also seen in the parietal lobe. The difference is that six layers appear more clear and distinct from each other (Figure 3B).

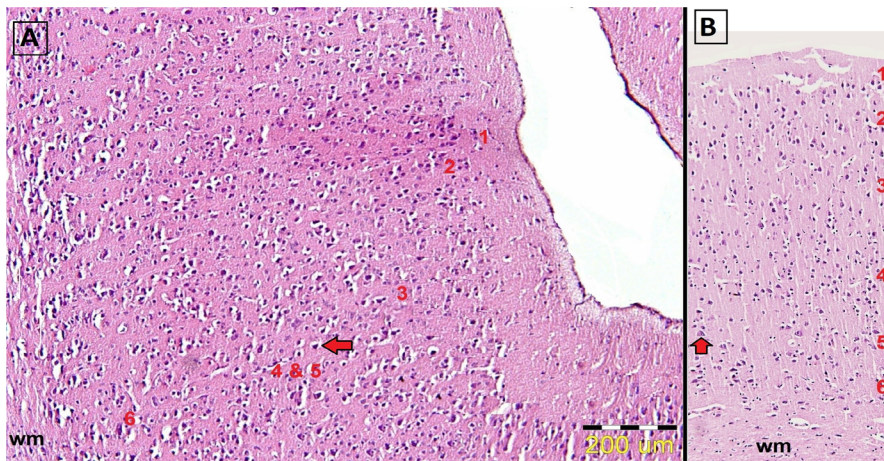


Figure 3. Photomicrograph of cortex layers in the parietal lobe (A) and frontal lobe (B) in the mongoose's cerebrum. Stain: H&E.

White matter (wm), Betz cell (red arrow), Molecular layer (1), External granular layer (2), External pyramidal layer (3), Internal granular layer (4), Internal pyramidal layer (5), Polymorphic layer (6).

Histologically, the cerebellum also has white and gray matter. The cerebellar white matter was observed to be featureless. Moreover, its function as a germinal zone is controversial. Microscopic examination of the mongoose

cerebellum samples represented the usual structure of the cerebellar cortex or grey matter in all animals: the outer, molecular, the middle layers are composed of a single row of purkinje cells and an inner granular layer (Figure 4).

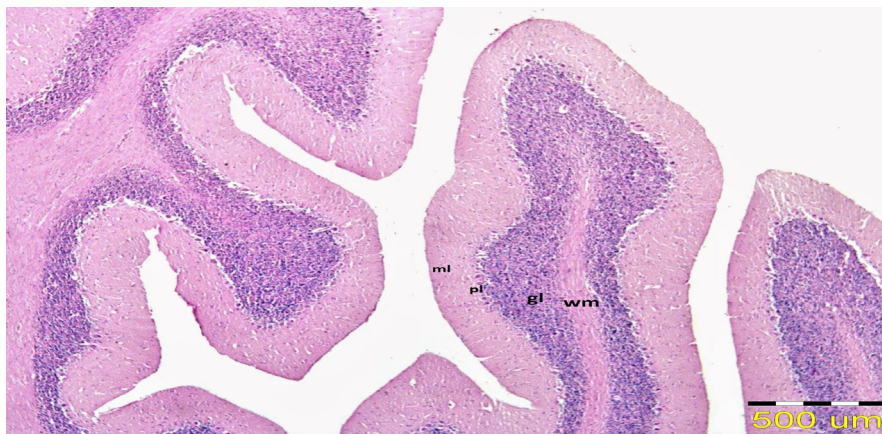


Figure 4. Photomicrograph of mongoose's cerebellum. Stain: H&E.

White matter (wm), Molecular layer (ml), Purkinje cells layer (pl), Granular layer (gl)

The results of the thickness measurements of white matter, gray matter, and also various layers of gray matter are summarized in Table 2, considering $P \leq 0.05$. Further, the results from studies on density measurements of cells per

unit area (n/mm^2) for different layers of gray matter are presented in Table 2. It should be noted that because of the low thickness of the purkinje cell layer, the density of these cells has been measured in unit length (n/mm).

Table 2. Thickness of the cerebellum layers and their cellular density per unit area (Mean \pm SD) in the male and female mongoose

	Male (n=4)	Female (n=4)
Thickness of white matter (mm)	0.15 \pm 0.69	0.136 \pm 0.023
Thickness of gray matter (mm)	0.425 \pm 0.02	0.362 \pm 0.07
Thickness of molecular layer (mm)	0.21 \pm 0.4	0.205 \pm 0.029
Thickness of granular layer (mm)	0.193 \pm 0.13	0.143 \pm 0.42
Thickness of Purkinje cell layer (mm)	0.026 \pm 0.00	0.023 \pm 0.005
Cellular density in the molecular layer of the cerebellum (n/mm^2)	290.00 \pm 15.05	362.5 \pm 10.15*
Cellular density in the granular layer of the cerebellum (n/mm^2)	6540.49 \pm 532.12	8249.35 \pm 602.04*
Cellular density in the Purkinje cell layer (n/mm)	16.34 \pm 2.91	14.48 \pm 1.05 *

(* significant difference $P \leq 0.05$).

In the molecular layer, we are able to see the stellate and basket cells, as well as numerous rich dendritic branches from the purkinje cells, oriented eccentrically towards the external surface of the cortex. In this layer, the basket cells are placed next to the Purkinje cells and the stellate near the outer surface. The middle layer includes the characteristic purkinje cells. Our photomicrographs indi-

cate that their soma is circular or oval-shaped, the length is about 20 μm , and width of about 15 μm , in both sexes. The granular layer presented a high concentration of heterochromatin granular cells and few golgi cells with a pale appearance in between. Among the granular cells, there were small spaces called cerebellar islands appearing as irregular light areas (Figure 5).

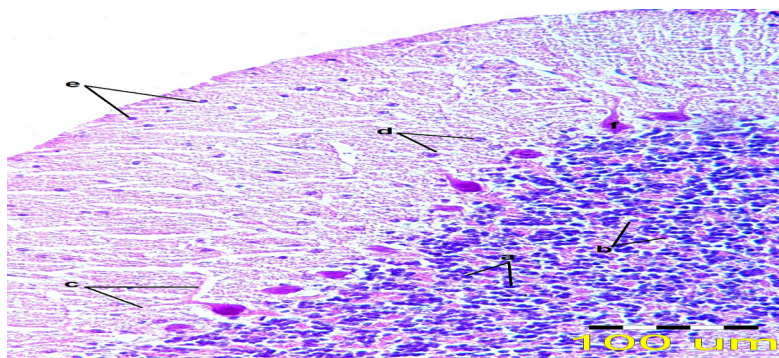


Figure 5. Photomicrograph of cortex layers of the mongoose's cerebellum. Stain: H&E.

Granular cells of the granular layer (a), Golgi cells of the granular layer (b), Dendritic branches of Purkinje cells (c), Basket cells of the molecular layer (d), Stellate cells of the molecular layer (e), Soma of Purkinje cell (f)

Discussion

The present study showed that the gray matter and white matter in the cerebrum are placed in the cortex and center, respectively, which is similar to other animals (Dellman and Eurell, 1998). In the molecular layer, cell density was very low, due to the presence of dendritic fibers of the neurons in the underlying layers, which helps to distinguish this layer from other layers (Figure 3). This layer is thicker in Indian guinea pigs than that of laboratory mouse and rats (Treuting and Dintzis, 2012). In addition, the highest proportion of gray matter to white matter was found in the frontal lobe of male mongoose. This proportion is lower in the female mongooses in two lobes unclearly (Table 1).

Under it, external granular cells are observed and below it, there is a row of small to medium pyramidal cells that are related to the outer pyramidal layer. In the frontal lobe, the inner granular layer is combined with the inner pyramidal layer of the large pyramidal cells and the polymorphic layer was thick with high cell density. This is while these two layers in the parietal lobe are separated and the thickness of the polymorphic layer is less (Figure 3). Studies on guinea pigs showed that there is no external pyramidal layer in this animal, but the rest of the layers exist (Musa *et al.*, 2016). Also, in the laboratory mouse, the second and third layers are combined, but other layers are separated. In humans, all six layers are distinct and clear (Treuting and Dintzis, 2012).

The remarkable point in these layers is the high thickness of the polymorphic layer and the increased betz cells in the cortex, as compared to studies on rats, guinea pigs and rabbits (Ibegbu *et al.*, 2014). This may be the reason why carnivores like mongoose have more sense of understanding and intel-

ligence than rodents (Kelly and Stick, 2003). Therefore, the agility and intelligence of this animal in nature are related to these characteristics.

In this study, it was determined that all layers of the cerebellar cortex, as well as white matter in male, are more than female. However, the difference is not significant (Table 2). It is necessary to note that molecular and granular layers in the cerebellar folia summits are thicker and have a lower thickness in the folia fissures. This is while the white matter thickness is constant in all areas of the cerebellum (Figure 4). However, studies on human, camel, chicken, and pigeon show that in the cerebellum folia fissure only the granular layer has a lower thickness (Pal *et al.*, 2003; Sur *et al.*, 2011; Beheiry, 2015).

In cellular density measurements of the cerebral tissue, it was found that the cell density of the neurons (n/mm^2) in the female mongoose is higher than male, while the density of neuroglia cells was higher in males (Table 2). These results are in good agreement with studies conducted on human (Witelson *et al.*, 1995). The performed research shows that the density of cortical neurons in banded mongoose is lower than that of other carnivores and is not related to the domestication or body mass (Jardim-Messeder *et al.*, 2017). Given the smaller size of females, these findings are consistent with the present study.

Pearson (1972) stated that throughout all vertebrate genera the organization of cells and axons within the cerebellum had a similar and distinctive appearance. A number of small star-shaped cells found in a scattered manner close to the periphery of the cerebellar molecular layer represented stellate cells (Figure 5). This is also in agreement with studies performed on fowl, camel, catfish, and chinchilla (Irimescu *et al.*, 2015; Dan-

maigoro *et al.*, 2016).

The present study stated that most of the purkinje cells had a circular or oval shape, and their nucleus is large and has a specific nucleolus. In humans, camel, and fowl purkinje cells are reported to have a circular and cylindrical shape and are flask-shaped (Pal *et al.*, 2003). In the laboratory mouse and guinea pig, these cells were less and lacking in regular form and had less cytoplasm, thus, the purkinje cells appear to be more similar to human. However, in humans, these cells are more spaced than granular layers (Treuting and Dintzis, 2012). This study showed that unlike humans, granular layer cells are found between purkinje cells, which was consistent with the studies performed on the other animals (Beheiry, 2015; Bacha, 2000).

This study showed that the cell density in the 1mm length of the purkinje cell layer in male and female mongoose was 16.34 and 14.48, respectively. Studies performed on other animals showed that this number is generally higher in birds, for example, in pigeon it is 27.39, in duck it is 20.98, in domestic chicken it is 18.9, and in humans it is 6.6 (Sur *et al.*, 2011; Pal *et al.*, 2003).

Purkinje cells are considered as the most important cells of the cerebellum according to their functional capabilities, as well as the most emphasized cells in behavioral and cognitive studies (Pal *et al.*, 2003). This study and previous studies have shown that the form and amount of cytoplasmic content of purkinje cells, in proportion to their number, has more to do with these capabilities.

The granular layer was the innermost layer of the cortex and was situated between the purkinje cell layer and a medullary layer of white matter. The appearance of the nucleus of the granular cells was due to the bulk of the nuclei, as well as to the lymphocytes

(Figure 5). In studies done on humans and chickens, it was observed that golgi cells were interspersed with granular layers and the purkinje layer had a large size. This was different from our observations on camel and goat (Pal *et al.*, 2003; Beheiry, 2015).

According to our studies, it could be concluded that the general morphologic and morphometric characteristics of cerebrum and cerebellum of mongoose are considered as an intermediate between rodents and humans. In addition, the range of the evolution of these structures in the mongoose is consistent with the perceptual and functional capabilities of the animal compared to the other animals. This work could probably be the first histological study on the brain of a wild carnivore. Our results provide an incipient description in this direction and we consider that further stereotaxic studies and other kinds of staining are needed to provide more accurate cerebral and cerebellar histological landmarks.

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Conflict of interest

The authors declared that there is no conflict of interest.

References

- Bacha, WJ., Bacha, LM. (2000) Color Atlas of Veterinary Histology (2nd ed.). Lippincott, Williams and Wilkins, Baltimore Maryland, Virginia, USA . p. 148-149.
- Beheiry, RR. (2015) Histological, immunohistochemical and scanning electron microscopic studies on the cerebellum of dromedary camel (*Camelus*

- dromedarius*). J Vet Anat., 9(1), 25 – 38.
<https://doi.org/10.21608/jva.2016.37446>
- Danmaigoro, A., Hena, SA., Ibrahim, AA., Shehu, SA., Mahmud MA. (2016) Comparative morphometry and histological studies of the cerebellum of catfish (*Clarias gariepinus*) and tilapia (*Oreochromis niloticus*). JALSI., 7(4), 1-6. <https://doi.org/10.9734/JALSI/2016/28147>
- Dellman, HD., Meclure, RC. (1998) Central nervous system, text book of histology (5th ed.) Leaex and Febiger, Philadelphia, USA. p. 150-199.
- Dyce, KM., Sack, WO., Wensing, CJG (2017) Textbook of Veterinary Anatomy (5th ed.) Saunders Press. London, UK. p. 479 – 490.
- Ibegbu AO., Adubazi, P., Yahaya, BO., Musa, SA. (2014) Comparative micromorphological studies of the cerebrum in three mammalian species: rabbits (*Oryctolagus cuniculus*), wistar rats (*Rattus norvegicus*) and African giant rats (*Cricetomys gambianus*). J Vet Anat., 7(1), 33 – 47. <https://doi.org/10.21608/jva.2014.44726>
- Irimescu, I., Bolfa P., Crisan, M., Dezdrobitu, C., Damian A. (2015) Macroscopical and histological aspects of the cerebellum in chinchillas, Agriculture and Agricultural Science Procedia., 6, 350-357. <https://doi.org/10.1016/j.aaspro.2015.08.093>
- Jardim-Messeder, D., Lambert, K., Noctor, S., Pestana, FM., Castro Leal, ME., Bertelsen, MF., Alagaili, AN., Mohammad, OB., Manger, PR., Herculano-Houzel, S. (2017) Dogs have the most neurons, though not the largest brain: trade-off between body mass and number of neurons in the cerebral cortex of large carnivoran species. Front Neuroanat., 12,111:118. <https://doi.org/10.3389/fnana.2017.00118>. PMID:29311850
- Kelly, RM., Stick PL. (2003) Cerebellar loops with motor cortex and prefrontal cortex of a nonhuman primate. J Neurosci., 23, 8432-44. PMID:12968006
- Musa, SA., Yahaya, FM., Omoniyi, AA., Timbuak, JA., Ibegbu, AO. (2016) Comparative anatomical studies of the cerebrum, cerebellum, and brainstem of males guinea pig (*Cavia porcellus*) and rabbit (*Oryctolagus cuniculus*). J Vet Anat., 9(2), 1 – 14. <https://doi.org/10.1523/JNEUROSCI.23-23-08432.2003>
- Pal, B., Chowdhury, S., Ghosh, R.K. (2003) Comparative anatomical study of the cerebellum of the man and fowl. J Anat Soc India., 52 (1), 1-8. <https://doi.org/10.1080/14484846.2018.1560679>
- Pearson, R. (1972) The Avian Brain. In: The Cerebellum . (1st ed.) Academic press. London , UK. p. 235-278.
- Rasouli, B., Gholami, S., Ahrari, MS. (2015) Topographic and morphometric studies on the spinal cord of the male and female indian gray mongoose (*Herpestes edwardsii*), CIBTech Journal of Zoology., 4(3),75-82.
- Shil, SK., Das, BC., Uddin, M., Rahman ML., Quasem MA. (2012) Anatomy of digestive and respiratory system of Indian grey mongoose (*Herpestes edwardsii*) Univ j zool Rajshahi Univ., (31), 83-84. <https://doi.org/10.3329/ujzru.v31i0.15438Univ>
- Sur, E., Ozurlu, Y., Ozaydin, T., Colakoglu, F., Unsal, S., Yener, Y. (2011) Comparative histometrical study of the cerebellum and the determination of some Agnor parameters in different avian species. Bull Vet Inst Pulway., 55, 261-265. <https://doi.org/10.1159/00089120>
- Treuting, PM, Dintzis, SM. (2012) Comparative Anatomy and Histology, A Mouse and Human Atlas, (1st ed.) Academic Press, Elsevier. New York , USA. p. 340-370.
- Witelson, SF., Glezer II., Kigar, DL. (1995) Women have greater density of neurons in posterior temporal cortex. J Neurosci., 15(5), 341-3428. <https://doi.org/10.1523/JNEUROSCI.15-05-03418.1995>. PMID:7751921

مطالعه بافت شناسی مخ و مخ چه در خدنگ نر و ماده بالغ (*Herpestes edwardsii*)

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چکیده

زمینه مطالعه: خدنگیان، گوشتخوارانی کوچک می باشند که در نواحی وسیعی از قاره آسیا و آفریقا یافت می شوند. خدنگ هندی خاکستری گونه ای از این خانواده است که در هند و نوار جنوبی ایران دیده شده است. مشخصات آناتومیکی مغز به دلیل اهمیت این ساختار در شاخه های مختلف بیولوژی مانند جانورشناسی، دامپزشکی و رفتار شناسی همواره مورد توجه متخصصین امر بوده است.

هدف: مطالعه ی حاضر بیان کننده توصیفات بافت شناسی از ساختمان مخ و مخچه خدنگ می باشد تا بدین ترتیب کمبود های اطلاعاتی که در این زمینه وجود دارد تا حدی جبران گردد.

روش کار: به منظور رسیدن به این هدف تعداد ۸ قلاده خدنگ که به علت حوادث طبیعی در مراحل پایانی زندگی یافت شدند، استفاده شد. پس از برداشت جمجمه و نمونه گیری از اندام های مذکور، نمونه ها در ماده فیکساتیو قرار گرفت. در ادامه مقاطع بافتی به صورت سریالی اخذ شد و از روش رنگ آمیزی هماتوکسیلین - انوزین به منظور ارزیابی های هیستولوژی استفاده شد.

نتایج: در این بررسی ضخامت لایه های مختلف در مخ و مخ چه و هم چنین تراکم سلولی در این لایه ها اندازه گیری و شمارش شد. در مخ شمارش سلولی نشان داد که تراکم نورون ها در جنس ماده و تراکم سلول های نوروگلیا در جنس نر، به صورت معنی داری بیشتر است ($P \leq 0.05$). در مخچه سلول های پورکنز ظاهر بیضی با گرد داشته و با فاصله ی کمی از لایه گرانولار دیده می شدند.

نتیجه گیری نهایی: به نظر می رسد که خصوصیات کلی مورفولوژیک و مورفومتریک مخ و مخچه در خدنگ از همان چهارچوب موجود در سایر حیوانات تبعیت می کند. اگرچه اطلاعات ما پیرامون جنبه های هیستولوژی مغز در گوشتخواران وحشی ناچیز است، با این حال می توان این ویژگی ها را بینابین انسان و جوندگان دانست.

واژه های کلیدی:

هیستومورفولوژی، هیستومورفومتري، خدنگ، مخ، مخچه.