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Morphological and Histological Study Of The Cerebrum In A Nocturnal Bird Species (Barn Owl)*TytoAlba*

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Abstract

Morphological and histoarchitecture aspects on the cerebrum of (barn owl) were made to find outthe cerebrum size, design and the description of cerebral region components at the light microscopic level by using Haematoxylin – Eosin and periodic acid schift (PAS) stain methods. The result of the morphological aspects revealed that the cerebrum was large and an obtuse triangle in shape, its surface had a slight furrow. Sagittal sections revealed the location, arrangement and size of pallial and subpallial cerebral divisions. The result of the microscopic examinations indicated that the large and massive hyperpallium (wulst) was thick,hypertrophied wired, and multilaminate structure reflect their wider stereoscopic night vision. The dorsolateral corticoid area (CDL) contained three different cell groups. The well developed dorsal ventricular ridge (DVR) contained mesopalliumnidopallium and arcopallium, contained voluminous nuclear heterogeneous neuron groups and pyramidal cells. The higher density of the large pyramidal cells were found in the nidopallium (nest pallium) that is surrounding the crescent shap lateral ventricle. The striatum had a striated appearance due to its special histoarchitecture. The pallidum was the smallest and the deepest among cerebral subdivision, it had a pale appearance.

Key words Cerebrum, Nocturnal birds,Owl.

Introduction

Birds have relatively large brain, it is associated with the forebrain enlargement [1,2,3]. The forebrain in birds is dominated by the telencephalon hemisphere (cerebrum), which provides a great capacity for learning, memory, attention, integration and consciousness [4,5]. The avian telencephalon includes a large cortical components [6,7,8]. The dorsal ventricular ridge (DVR) in birds is a nuclear matter [4,9, 10,11], its function is to serve as a linkage between inputs and motor outputs [12]. The present study is based on the cerebrum of (barn owl) Tyto alba, the only member of the family Tytonidae, which belonges to the class Aves and order Strigiformes. As seen in (Fig.1), it is a medium sized owl and has a distinctive heart shaped facial disc, relatively small eyes and lacks ear tufts [13]. The study aims to focuse the histoarchitecture and the pattern of different neurons distribution in a nocturnal bird species cerebrum (barn owl), since nocturnal birds possess cleary different cerebrum regions associated with their wide stereoscopic night vision [6,14].

Material and Methods

Five healthy adult (barn owl) were utilized in this investigation, obtained from the spinning market during autumn season. The brain was obtained from the skull by careful dissection of the whole brain.The cerebrum were submersion fixed in 10% buffered formalin. Sagittal and three coronal sections were made by a sharp knife, fixed in 10% buffered formalin, washed,dehydrated through ascending grades of alcohol, cleared and embedded in paraffin wax. Eight microns thick sections were cut by using rotary microtome. The paraffin wax was removed by immersing the slides in xylene. The slides were passed through descending grades of alcohol, distilled water. The sections were stained with Haematoxylin-Eosin (H&E) and periodic acid schift reagent (PAS) cleared with xylene and mounted with D.P.X. as per usual method[15].

Result

1- Morphlogical description of cerebrum:

Two large cerebral hemisphere were situated in the anterior part of the brain. The surface of the two hemisphere as seen in (Fig. 2) had a slight furrow with no deep grooves (sulci) and wrinkles (gyri). The inter hemispheric fissure was narrow and bridged over by a meninges. The cerebrum form as seen in (Fig. 3) was an obtuse triangle, the curvature of the anterior hemisphere was so rounded that the two olfactory bulbs can only be viewed on the ventral surface. (Fig.4)shows the location, arrangement and size of the pallial and subpallial cerebral divisions. The pallium consisted of outer and large inner cortical areas.The outer contained: the hyperpallium (wulst), it was a large massive pillow viewed also on the dorsal side of each hemisphere, demarcated by obvious groove that houses large blood vessels named the vallecula (Fig.2); the piriform cortex; the dorsolateral corticoid area (CDL); and the hippocampal complex, it sits on the top of the brain like mushroom cap. The large inner cortical areas of the pallium named the dorsal ventricular ridge (DVR), it was well- developed and had three subdivisions: the mesopallium (middle pallium),it was positioned below the dorsolateral corticoid area, above the nidopallium. The nidopallium (nest pallium) was found surrounding the lateral ventricle; the archopallium (arched pallium), this was a narrow zone located caudally in(barn owl) cerebrum(Fig.4). The subpallium occupied the inner parts of each hemisphere, its location was underneath the nidopallium, it was further divided into two main subdivisions: the striatum and the pallidum, the later was the deepest and the smallest amoung cerebral subdivisions(Fig.4). Each cerebral hemisphere enclosed a narrow cavity named lateral ventricle.

2- Histological structure of the cerebrum

The (barn owl) hyperpallium (wulst) was thick (Fig.4), wired and multilaminate hypertrophied structures, the fibro molecular layer contained few scattered neurons and consisted mainly of dendritic extensions with a horizontally- oriented axons; the hyperpalliumaccessorium (HA),a broad layer of medium sized neurons; the outer and inner bands of intercalates hyperpalliumaccessorium (IHA); the hyperpallium intercalates suprema (HISm) and the hyperpalliumdensocellulare (HD) a deep lying layer of large cells,it contains no pyramidal neurons but instead stellate cells and each cell was star shaped, the dendrites extended in all directions (Fig.5). The piriform cortex was a superficial thin sheet of cells. The thin superficial dorsolateral corticoid area (CDL) contained three main different cell

groups,as seen in (Fig.6): the predominant projection neurons classified into a- small,medium sized horizontal cells with smooth moderately branching dendrites and b- spinous projecting neurons; aspinous local circuit neurons with short axons that ramify locally and stellate neurons with sparse spinous dendrites and locally arborizing axons. The areas of the hippocampal complex protruding above the lateral ventricle were subdivided into dorsolateral (DL); dorsomedial (DM) and ventral aspects of hippocampus.Different classes of neurons were distinguished: pyramidal,pyramidal like,multipolar and ovoid local circuit neurons,the later ranging from small to large size (Fig.7). The mesopallium,nidopallium and arcopallium were together designated as the dorsal ventricle ridge (DVR), it contained a voluminousnuclear mass of a heterogeneous neuron groups and pyramidal cells. (Fig.8) shows the majority of the small neuron with granular appearance distributed in a random pattern; lossely packed neurons oriented.parallel tothe surface; glial neurons; small sizes of pyramidal neurons; number of axonal collaterals extended superficially toward the surface and spiny dendrites. (Fig.9) shows the higher density of the large pyramidal cells, that are found in the nidopalliumcomparsing with other types of neurons. The large pyramidal neurons could be recognized by their large somata, greater length of the single thick apical dendrite that extending in the direction of the upper layers of neighboring cortical surface, and itsbasal dendrites that is originated from the lower corners of each pyramidal extending to either side far beyond the width of the lower(DVR). Thelateral ventricle had acrescentshap, surrounding by the (DVR) especially nidopallium. It can be seen also the choroid plexuses ventrally within parts of the wall of the lateral ventricle. (Fig.10) shows the highly specialized tissue of the choroid plexus that projects as elaborating folds with many villi. At higher magnification of (Fig.10) it can be seen that each villus of the choroid plexus contained a thin layer of a well vascularized pia mater covered by cuboidal ependymal cells. The striatum is consisted of a large mass of different neurons; large masses of mylinated axon bundles and spiny dendrites passing through them giving to this region its striate appearance (Fig.11) and therefore its name. The pallidum was the smallest and the deepest cerebral region, it had a sparse distribution of different neurons , giving this region its pale appearance (Fig.12) and therefore, its name.

Discussion

Barn owl had large and obtuse triangle shaped cerebrum, in comparison to that, It was small and tapers in grey gooses and pekin ducks; large and trapezoid in oriental white stork [3]. The cerebral hemisphere surface had a slight furrow without any gyrus or sulcus,it was similar to that of swimmers fowls and birds of prey,while the surface was entirely smooth in ratitae and in many passeres [16]. The hyperpallium (wulst) was relatively small in potoos (Nyctibidae); nightjars (Camprimulgidae) [6],and it was very much reduced with shallow vallecula in kiwi [17,18],this finding was different in barn owl,it was large massive,with obvious vallecula. The histomorphological result indicated that the wulst was a multilaminate hypertrophied structure,each of these laminae were well developed in barn owl,which reflects their wider stereoscopic field compared to other diurnal birds [5,14]. Wulst neurons were selective for orientation,movement direction,spatial freguency and binocular disparity [6]. The avain visual wulst was the telencephalic target of the ascending thalamofugal visual

pathway thus it was considered equivalent to the striate cortex of mammals [6,14]. The neurohistological aspects of the thin superficial dorsolateral corticoid area (CDL) in barn owl involved the different three cell groups,this observation was in accordance with that in strawberry finch Estrildaamandava [7],they stated that this corticoid area in birds corresponds the entorhinal cortex of mammals.The hippocampal complex in barn owl apperead like a mushroom cap situated on the top of the brain and divided histologically into three subdivisions with different classes of neurons.This finding was similar to that of non stoting birds [8] and unlike to that of wood pecker [19] and homing pigeon [20]. The hippocampal complex in both birds and mammals was important for the processing and retention of spatial,rather than purely visual memory [21,22]. Perhaps not surprising,the area of the songbird brain with a highest estrogen- making capability was the hippocampal complex [11]. Barn owl had well developed dorsal ventricular ridge (DVR),among birds the best developed DVR was in crows and parrots [4,9] and the less developed was in pigeon and dove [10]. The DVR in barn owl had three subdivisions (mesopallium, nidopallium and arcopallium),similar observation was made by [11,23] on song birds and on passerines[20]. The voluminous nuclear mass of the DVR in barn owl was occupied in song bird about 75% of telencephalon volume and not organized histoarchitectonically into layers as stated [4,11].TheDVR receives visual auditory and somatosensory information and sends motor outputs to the basal ganglia [4], it was also thebasic function of mammalian isocortex [12]. The neurohistological aspects of the DVR in barn owl involved the presenceof pyramidal cells and non pyramidal cells (heterogeneous neuron groups). The later named also interneurons,they could be either excitatory or inhibitory,they make local connections and do not leave the cortex. Pyramidal cells were excitatory,they received incoming nerve fibers from the thalamus and from other areas of cortex as well as from nearby neurons,its axon could be extended more than a meter down to the spinal cord as stated by [4,16]. The subpallium (striatum and pallidum) also called the basal ganglia [11,23],they comprised major centers of the extra-pyramidal motor system that affected by many neurotoxic agents and play a role in several neuronal degenerative disease [16].

References

1- Iwaniuk,AN.; Dean,k. M. and Nelson. J.F. (2005). Interspecific allometry of the brain and brain regions in parrots (Psittaciformes): comparisons with other birds and primates. Brain Behv. Evol.,65: 40-54.
2- Cnotka,J.; Gunturkun,O. ; Rehkamper,G.; Gray,DR. and Hunt,GR. (2008). Extraordinary large brains in tool using new Caledonian crowsCorvusmoneduloides.Neurosci. Lett.,433(3) :241-245.
3- Peng,K.; Feng,Y.; Zhang,G.; Liu,H. and Song,H. (2010). Anatomical study of the African ostrich. J. Vet. Anim. Sci.,34(3): 235-241.
4- Shimizu,T. (2009). Why can birds be so smart,background,significance and implications of the revised view of the avain brain. Comparative cognition and behavior reviews,4: 103-115.
5- Reiner,AN.; Yamamoto,K. and Katten,H. J. (2005). Organization and evolution of the avain forebrain. The Anatomical Record,part A,287A: 1080-1102.

6- Iwaniuk,AN. and Wylie ,D.R.W. (2006). The evolution of stereopsis and the wulst in camprimulgiform birds: a comparative analysis. Journal of Comparative Physiology,192 (12) :1313-1326.

7- Srivastava, U.C.; Chand, P. and Maurya, R.C. (2009). Neuronal classes in the corticoid complex of the telencephalon of the strawberry finch, Estrildamandava. Cell and Tissue Research,336(3): 393- 409.

8- Szekely, A. D. (1999). The avain hippocampal formation : subdivisions and connectivity. Behavioural Brain Research,98 (2) : 219-225.

9- Iwaniuk,AN. and Hurd,PL. (2005). The evolution of cerebrotypesin birds. Brain Behav. Evol.,65(4) : 215-230.

10- Rehknipera,G.; Frahma,H.D. and Cnotkaa,J.(2008). Mosaic evolution and adaptive brain component alteration under domestication seen on the background of evolutionary theory. Brain Behavior and Evolution,71:115-126.

11- Jarvis,ED.; Gunturkun,O.; Bruce,L.; Csillag,A.; Karten, H. ; Kuenzel, W.;Medina,L.; Paxinos,G.; Perkel,DJ.; Shimizu,T.; Striedler,G.; Wild, JM.; Ball, GF.; Dugas, F.; Durand,SE.; Hough,GE.; Husband,S. ; Kubikova,L.; Lee,DW.;Mello CV.; Powers, A.; Siang, C.; Smulders,TV.; Wada, K.; Whits, SA.; Yamamoto, K.; Yu, J.; Reiner, A. and Bulter, AB. (2005) Avain brains and a new understanding of vertebrate brain evolution. Nat. Rev. Neuro. Sci.,6(2): 151-159.

12- Wang, Y.; Prechtl, A.B. and Karten, H.J. (2010). Laminar and columnar auditory cortex in avain brain. ANAS, 107(28),:12676-12681.

13- Cholewiak,D.(2008). General description of owl from Wikipedia animal diversity web. The regents of the university of Michigam and its licensors: 1-20.

14- Corfield, J.R.;Gsell, A.C.; Brunton, D.; Heesy, CH.P.; Hall, M.I.; Acosta, M.L. and Iwaniuk, AN. (2011). Anatomical specializations for nocturnality in a critically endangered parrot,the kakapo Strigopshabroptilus.Plos ONE,6(8): 1-26.

15- Sood, R.(2009). Medical laboratory Technology: Methods and Interpretations 6thedi.,ch. 27, NewDelhi,India:1436-1450.

16- Blakemore, C.and Jennett, S. (2001). The oxford companion to the body. Encyclopedia.Com. http: \\www. Encyclopedia. Com.

17- Martin, G.R.; Wilson, k.j.; Wild, J.M.; Parson, S.; Kubke, M.F. and Corfield, J.(2007). Kiwi forego vision in the guidance of their nocturnal activites.Plose ONE 2(2): e198, Doi: 10.137\ Journal. Pone. 0000198.

18- Corfield, J.R.; Wild,J.M.; Hauber, M.E.; Parson, S. and Kubke, M.F.(2008). Evolution of brain size in the palaeognath Lineage with an emphasis on Newzealand ratites. Brain Behavior And Evolution,. 7: 187-199.

19- Volman,SF.; Grubb, TC. and Schuett, KC.(1997). Relative hippocampal volume relation to food storing behavior in four species of woodpecker. Brain Behav. Evol.,49(2): 110-120.

20- Tompol,T.; Davies, D.C.; Nemeth,A.; Sebesteny, T. and Alpar,A. (2000). A comparative Golgi study of chicken Gallusdomesticus and homing pigeon Columbalivia hippocampus. AinStructure And Function,201(2) : 85-101.

21- Colombo, M. and Broudbent, N.(2000). Is the avain hippocampus a functional homologue of the mammalian hippocampus. Neuroscience &Biobehavioral Reviews,24(4): 465-484.

22- Lee,D.W.; Miyasato and Clayton, N.S. (1998). Neurobiological bases of spatial learning in the natural environment: neurogenesis and growth in the avain and mammalian hippocampus. Neuro. Report.,9(7): R15-R27.

23- Jarvis, ED.(2009). Bird brain evolution. Encyclopedia of Neuroscience,2: 209-215.

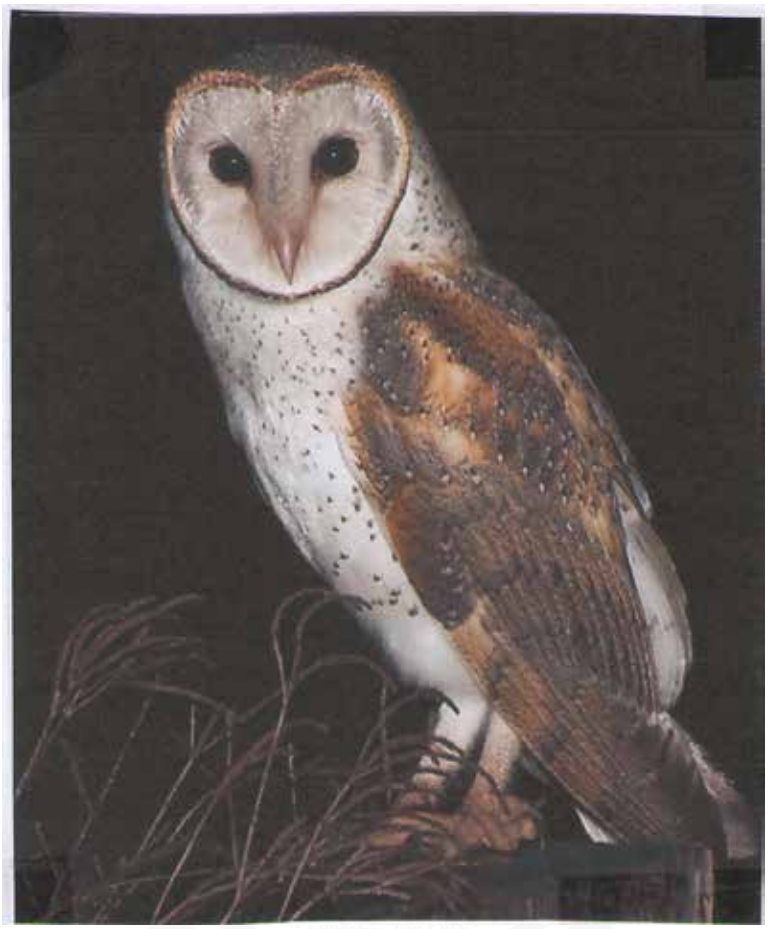


Fig (1): *Tytoalba* (barn owl).

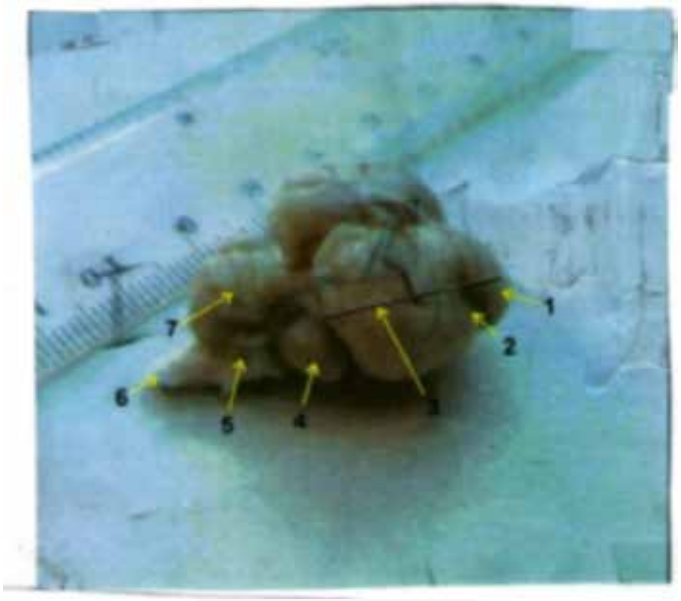


Fig. (2): Dorsolateral view of (barn owl) brain shows: 1- hyperpallium (wulst)2- vallecula 3-right cerebral hemisphere 4-optic lobe 5-medulla oblongata 6-spinal cord 7-cerebellum.

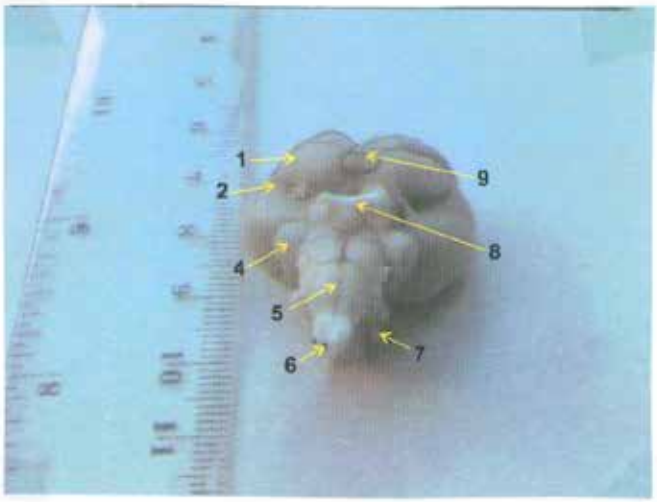


Fig.(3)Ventral view of (barn owl) brain showing:1- hyperpallium (wulst) 2- vallecula 4- optic lobe 5- medulla oblongata 6- spinal cord 7- cerebellum 8- optic chiasma 9- Olfactory bulb .

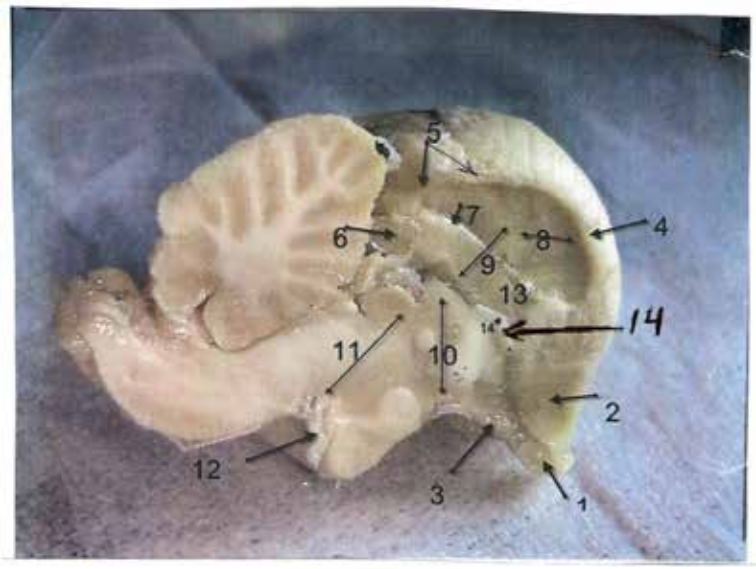


Fig. (4) Sagittal section through the brain of (barn owl) illustrates the following: 1- olfactory bulb 2-hyperpallium (wulst) 3-pirifrom cortex 4-dorsolateral corticoid area (CDL) 5-hipocampal complex 6-archopallium (arched pallium) 7-lateral ventricle 8-mesopallium (middle pallium) 9-nidopallim (nest pallium) 10-diencephalon 11-midbrain 12-optic chiasma 13-striatum 14-pallidum.

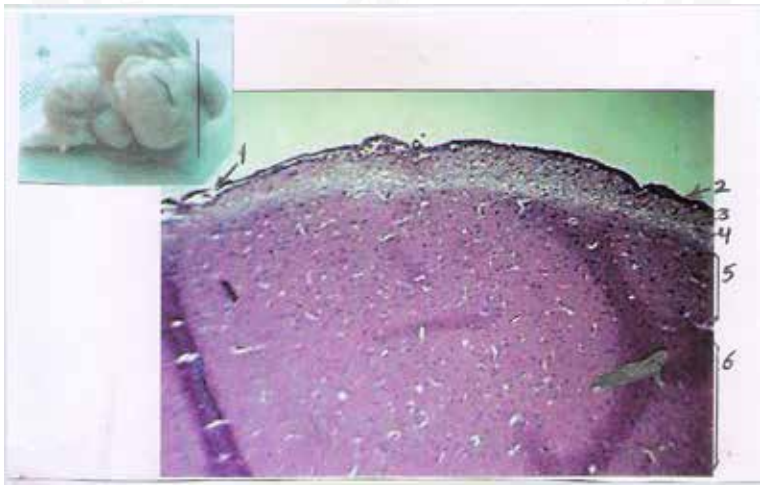
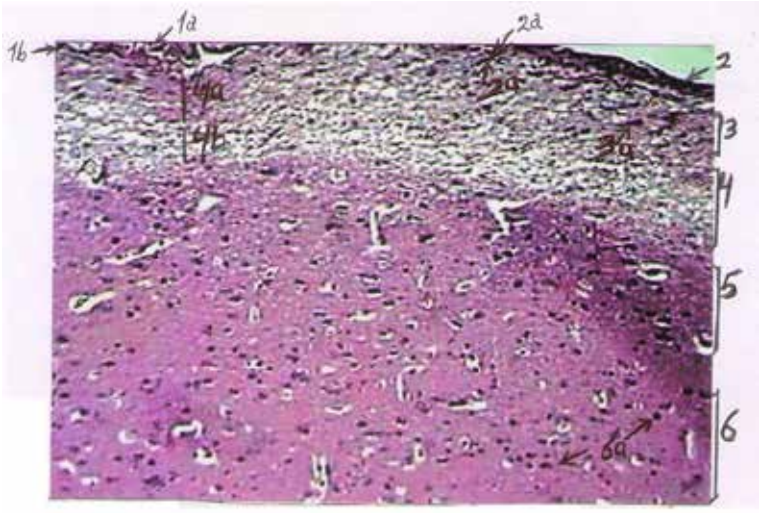


Fig. (5) A- First coronal section through the cerebrum of (barn owl) illustrates the hyperpallium (wulst) (PAS) (4X) 1-meninges 2- fibromolecular layer 3- hyperpallium accessorium (HA) 4- outer and inner bands of intercalates hyperpallium accessorium (IHA) 5-hyperpallium intercalates suprema (HISm) 6- hyperpallium densocellulare(HD)



B- An enlargement of section A (20X): 1- meninges [a- dura-archnoid b- pia mater.] 2a- neurons with horizontally oriented axon 3a- medium sized neurons 4a- outer 4b- inner bands of intercalates hyperpallium accessorium (IHA) 5- hyperpallium intercalates suprema (HISm) 6- hyperpallium densocellulare (HD) 6a- stellate cells

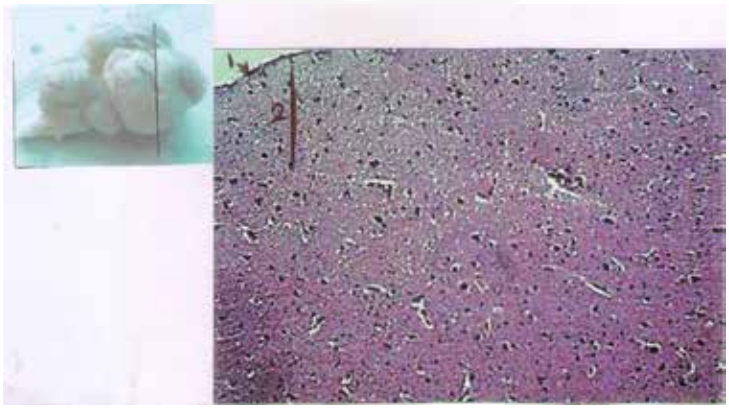
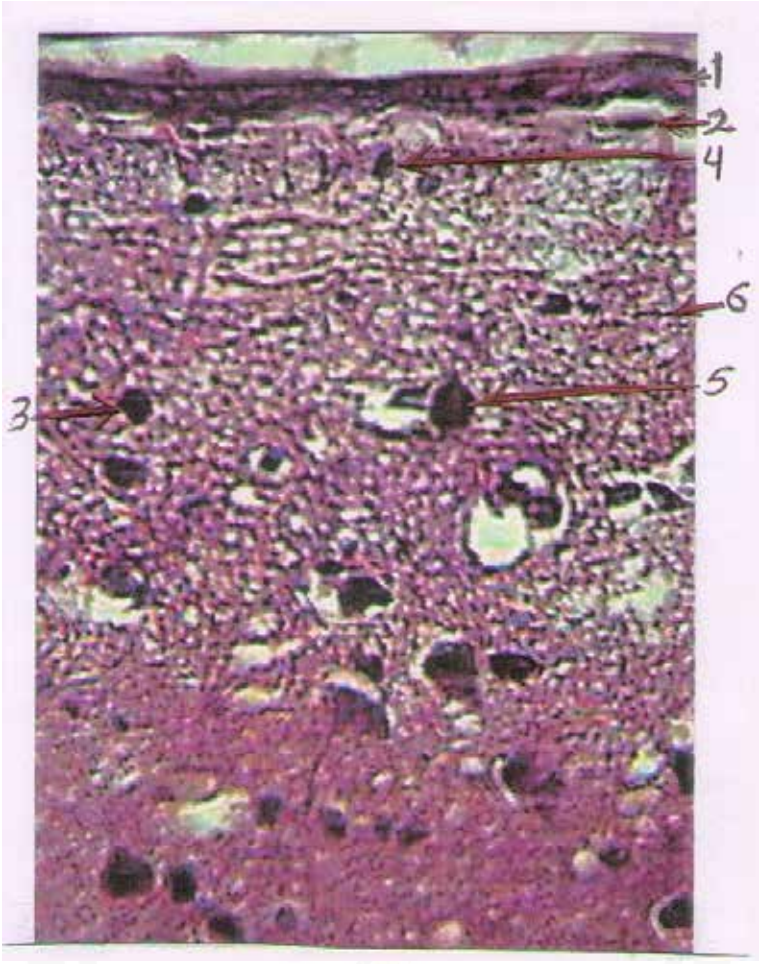


Fig. (6) A- Second coronal section through the cerebrum: (H&E) (10X) 1- meninges 2- dorsolateral corticoid area (CDL)



B- An enlargement of section A- (40X): 1- meninges 2- horizontal cell 3- spinous projecting neurons 4- aspinous local circuit neurons 5- stellate cell 6- spinous dendrites.

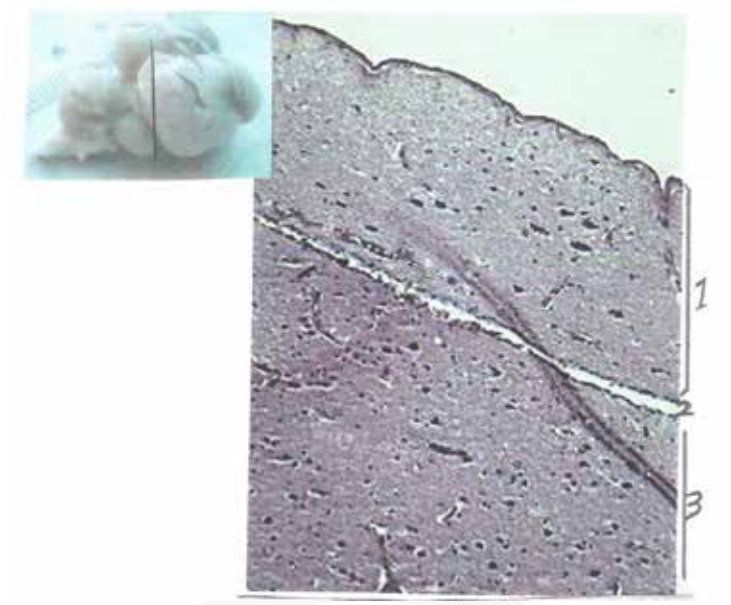
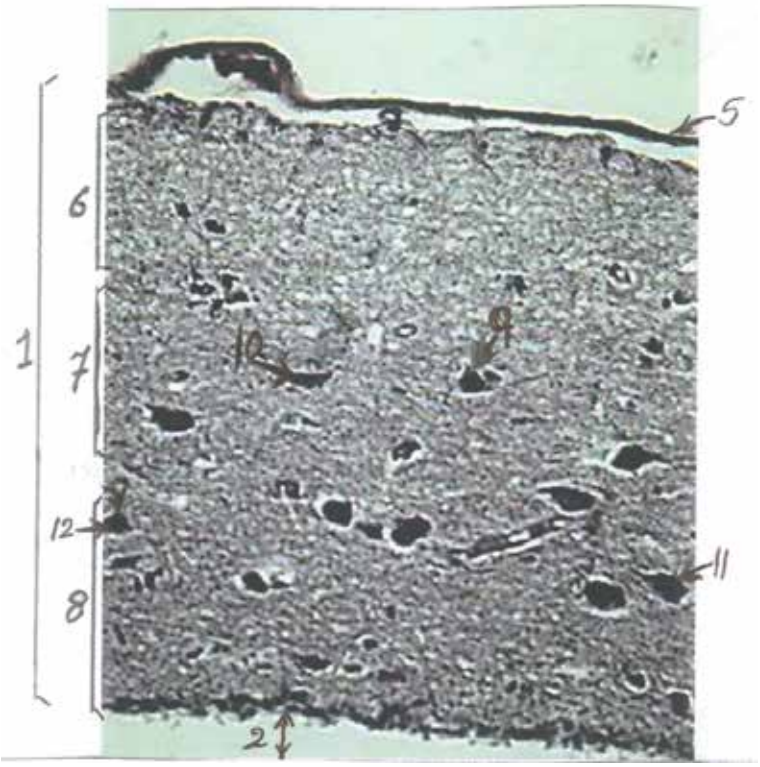


Fig. (7) A- Third coronal section through the cerebrum (PAS) (10X) 1- hippocampal complex 2- lateral ventricle 3- nidopallium (nest pallium).



B- An enlargement of section A- (20X): 2- lateral ventrical 5- meninges 6- dorsolateral parts (DL) 7- dorsomedial parts (DM) 8- ventral parts 9- pyramidal neuron 10- pyramidal like neuron 11- multipolar neuron 12- ovoid local circuit neuron.

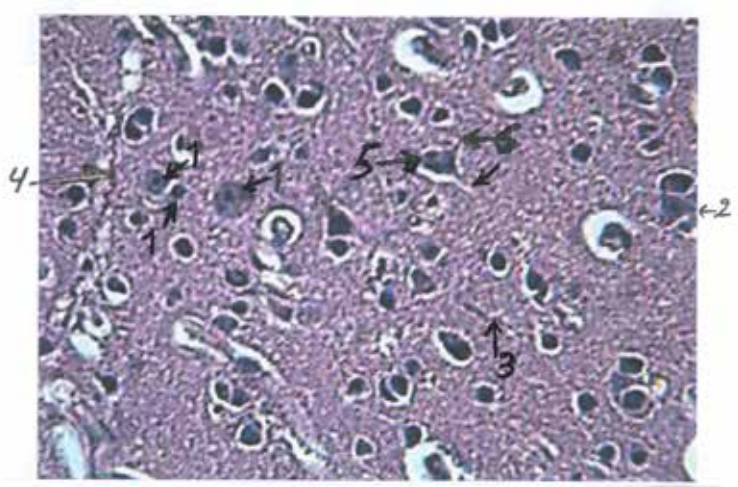


Fig. (8) Trasverse section through the mesopallium (middle pallium) (PAS) (40X)
1- heterogeneous neuron groups 2- pyramidal cells 3- spiny dendrites 4- axonal collaterals 5- apical Dendrite 6- basal dendrites.

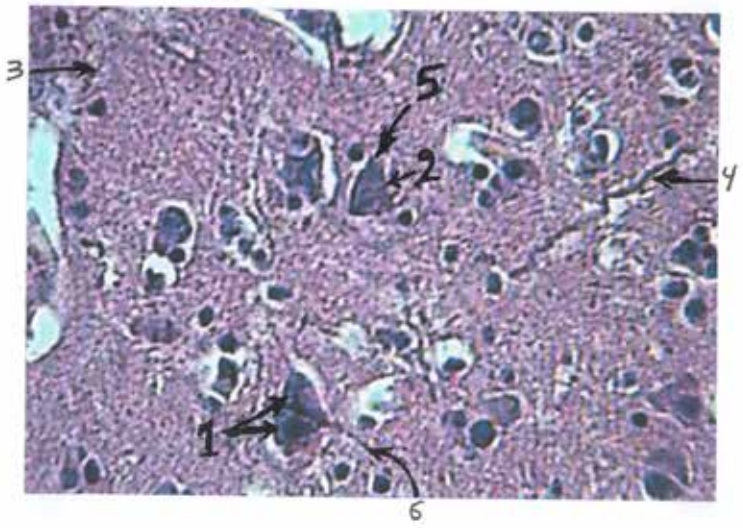


Fig.(9)Transverse section through the nidopallium (nest pallium) (PAS) (40X) 1- large pyramidal cells 2- somata of large pyramidal cells 3-spiny dendrites 4- axonal collaterals 5- apical dendrite of pyramidal cell 6- basal dendrites of pyramidal cell.

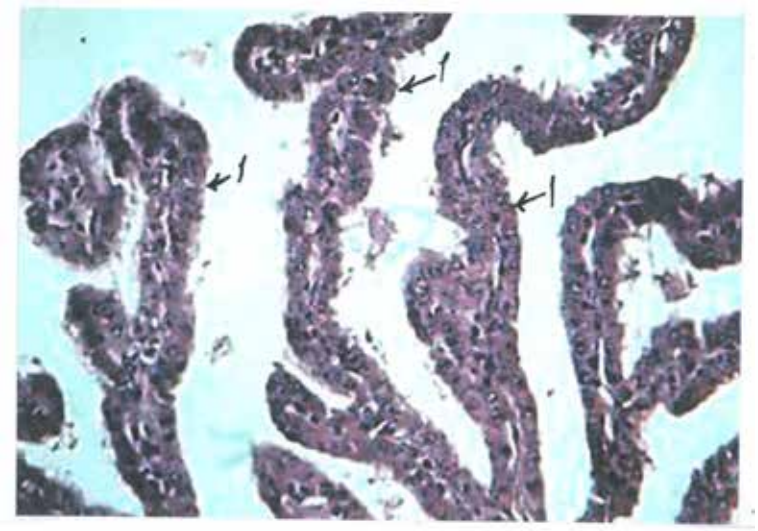
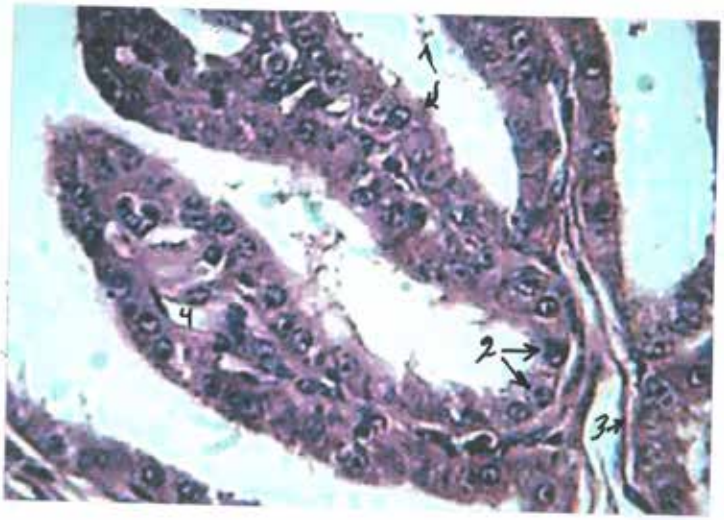


Fig.(10) A- Transverse section through the choroid plexsus (H&E) (10X) 1- villi.



B- An enlargement of section A- (40X): 1- villus 2- cuboidal ependymal cells 3- pia matter 4- capillary .

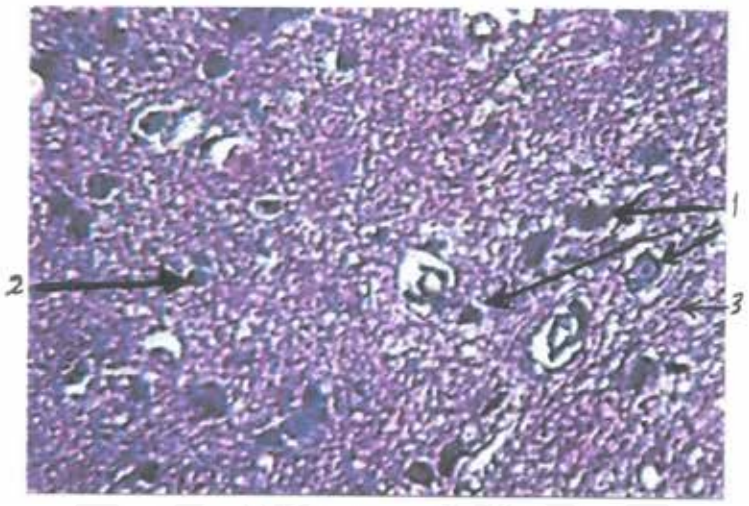


Fig. (11) Trasverse section through the striatum (PAS) (40X) 1-different neurons 2- mylinated axon 3- spiny dendrites

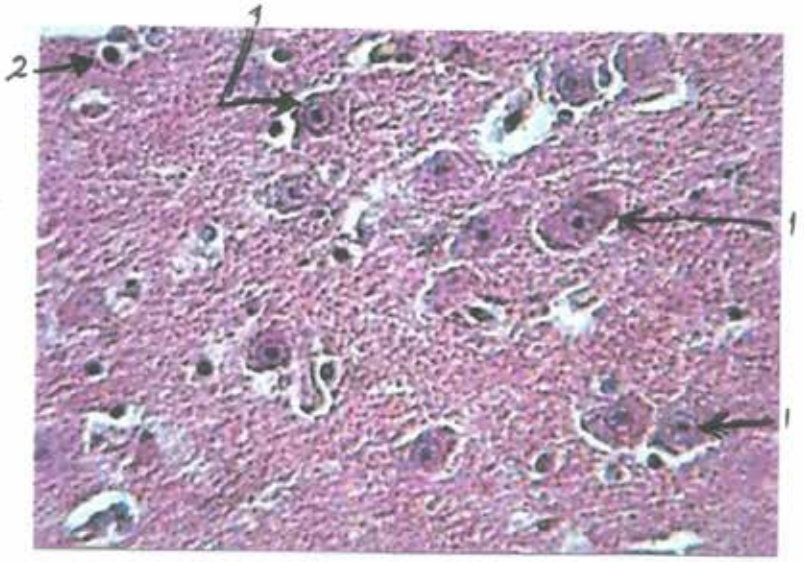


Fig.(12) Transverse section through the pallidum (H&E) (40X) 1- different neurons 2- mylinated axon .

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دراسة مظهرية ونسجية للمخ في نوع من الطيورالليلية(البوم البيضاء) *albaTyto*

شرمين عبدالله عبد الرحمن.
قسم علوم الحياة، كلية التربية ابن الهيثم ،جامعة بغداد
استلم البحث في: 22 نيسان 2012 قبل البحث في:12 ايلول 2012

الخلاصـــة

تناولت الدراسة الجوانب المظهرية والنسجية الخلوية لمخ طائر البوم (barn owl) للتعرف على حجم المخ وشكله كما وصف شكل مكونات مناطق المـخ ومواصفاتها عند فحصها بالمجهر الضوئي وباستعمال تقنية التلوين الهيماتوكســيلين- ايوسين و كاشف شف الدوري.اظهرت النتائج المظهرية ان المـخ كبير الحجم، والشكل مثلث المظــهر مستدق الاطراف كما لوحظ على سطحه وجود اخاديدغيرعميقة. اظهرت المقاطع السهمية موقع اقسام المخ اللحائية وتحت اللحائية وترتيبه و حجمه. اظهرت نتائج الفحص المجهري ان البروز السهمي الضخم والمتماســك عبـــارةعـن تركيب ذي طبقات متعددة ضخمة ومحددة وسميكة تعكس القابلية على الرؤية الليلية المجسمة الواسعة.تضمـــنت مساحات القشرة الظهرية الجانبية وجود ثلاث مجاميع خلوية مختلفة. تميزت السلسلة البطينية الظــهرية الجيدة التكوين باحتوائها اللحاء الوسطي،وعش اللحاء، واللحاء القديم وبكونـها عبارة عن كتلة من النوى الغزيــرة التي تضم العصبونات متغايرة الخواص و الخلايا الهرمية. كما لوحظ تواجد الخلايا الهرمية الكبيرة بكثافة عالية في منطقة عش اللحاء المحيطة بالبطين الجانبي الهلالي الشكل.اتسم المخطط بسبب بنيته النسيجية الخلوية بمظهر التخطيط. يعد الشاحب الاصـــغر و الاعمق بين اقسام المخ كما اتسم بالمظهر الفاتح بسبب بنيته النسيجية الخلوية.

الكلمات المفتاحية المخ ، الطيور الليلية، البوم.