

Anatomical and Histological Study of the Cerebrum in large brain modern bird species (gold – capped parrot)

Mahmoud M. Mahmoud** and Shermean Abdullah Abd.Alrahman*

* College of Education – Ibn Alhaitham, University of Baghdad.

** College of Pharmacy/ University of Al Mustansiriya

خلاصة

تناولت الدراسة الجانبين (الشكلي والنسيجي) للمخ في (gold- Capped parrot) حيث تم تصنيف مناطق وطبقات المخ وتسميتها بأسلوب جديد طبقاً لما أعلنته المنظمة العالمية المهمة بدراسة الجهاز العصبي للطيور. أظهرت نتائج الشكليات كبر حجم المخ وسيادته على بقية اجزاء الدماغ الأخرى وتميز سطحه بكونه أملس خالٍ من الأخاديد والطيّات، كما وتميز البروز السهمي wulst بكونه ضخّم ومتماسك، وتميز باتخاذ الموقع الظهري لمقدمة سطح نصفي المخ واما عن الحافة الجانبية له فكانت محددة بالأخدود .Vallecula. أظهرت نتائج الجانب النسيجي وجود منطقتين الأولى ظهريّة الموقع تعرف لحاء الدماغ Pallial والثانية قاعدية الموقع وتضم المنطقتين الـ Pallidal والمخططة Striatal. تمثل السلسلة البطنية الظهرية (DVR) Dorsal Ventricular ridge (DVR) المادة السنجابية للمخ، وتعد الأجرد نمواً في هذه النماذج .

Abstract

Morphological and histological aspects on the cerebrum of gold- capped parrot was studied to describe the cerebrum regions which classify and named a cording to the new standard nomenclature of the international consortium of avian neuroscientists.

The results of morphological aspects (the gross anatomy) revealed that the cerebrum was the largest and the dominant part of the brain, the surface of each cerebral hemisphere was smooth and without gyri and sulci. The wulst was found as a bulge on the dorsum of each hemisphere, it was massive. The lateral border of the wulst was demarcated by vallecula groove. The results of histological aspects indicated the presence of two regions: the dorsal (pallial), and the basal (striatal and pallidal) regions. The dorsal ventricular ridge (DVR) was the best developed representing the gray matter.

Introduction

Bird has relatively large brain, which is dominated by the telencephalic hemisphere (Cerebrum) ^[1,2,3]. Among birds the largest brains for body size are seen in modern birds – diurnal species such as (perching birds, woodpecker, parrots, corvides) ^[4,5], nocturnal species such as oilbirds ^[6]. The brain of modern birds was larger (6-11) times than brain of vertebrates that have the same body size ^[7,8]. Cerebrum is a great organized integration center that involved consciousness, thinking, learning and emotions ^[9].

An international consortium of neuroscientists has reconsidered the traditional, 100 year old terminology used to describe the avian cerebrum. The intelligent modern birds brain requires a new terminology that better reflects of these functions and homologies between avian and mammalian brains ^[5,9].

Anatomical studies of this structure has been undertaken by ^[10,11,12] in various birds.

This current research paper aims to give a more recent finding about gold-capped parrots cerebrum structure according to the new nomenclature of the international consortium of avian neuroscientists.

Materials and Methods

Healthy gold-capped parrots were utilized in this investigation, the brain was extracted from the skull by careful dissection, and the whole brains were submersion fixed in 10% buffered formalin.

The brain was bisected in the sagittal plane to examine the gross anatomy of cerebrum. For histological observation 5-6 microns thick sections were cut with the help of rotary microtome, the sections were stained with Heamatoxylin and Eosin (H&E), and periodic acid schift regent (PAS), as per standard procedure, the tissue sections were washed, dehydrated, cleared and mounted as per usual method ^[13,14].

Results

The Cerebrum: Gross Anatomy:

Cerebrum was covered by meninges (i.e. pia mater and dura mater) Fig.1&2 shows that the cerebrum is the largest and the dominant part of the brain, which was occupy wide area of brain, and completely hide the underlying midbrain. Cerebrum consists of two cerebral hemisphere connected by the anterior commissure.

The surface of cerebrum was smooth and without folds gyri and sulci (Fig.1). There is a definitive bulge on the dorsum of the hemisphere that reaches the frontal pole of telencephalon named the wulst. The lateral border of wulst was demarcated by the vallecule. The vallecule was a groove that houses a large blood vessels (Fig. 3).



Fig.1: Dorsal view Parrot brain of Parrot brain

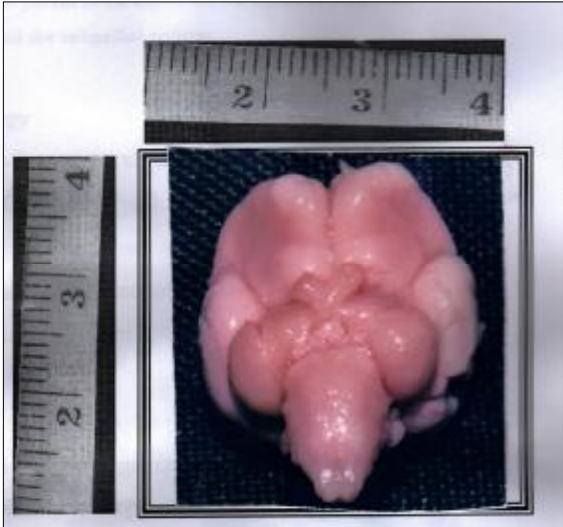


Fig. 2: Ventral view of Parrot brain

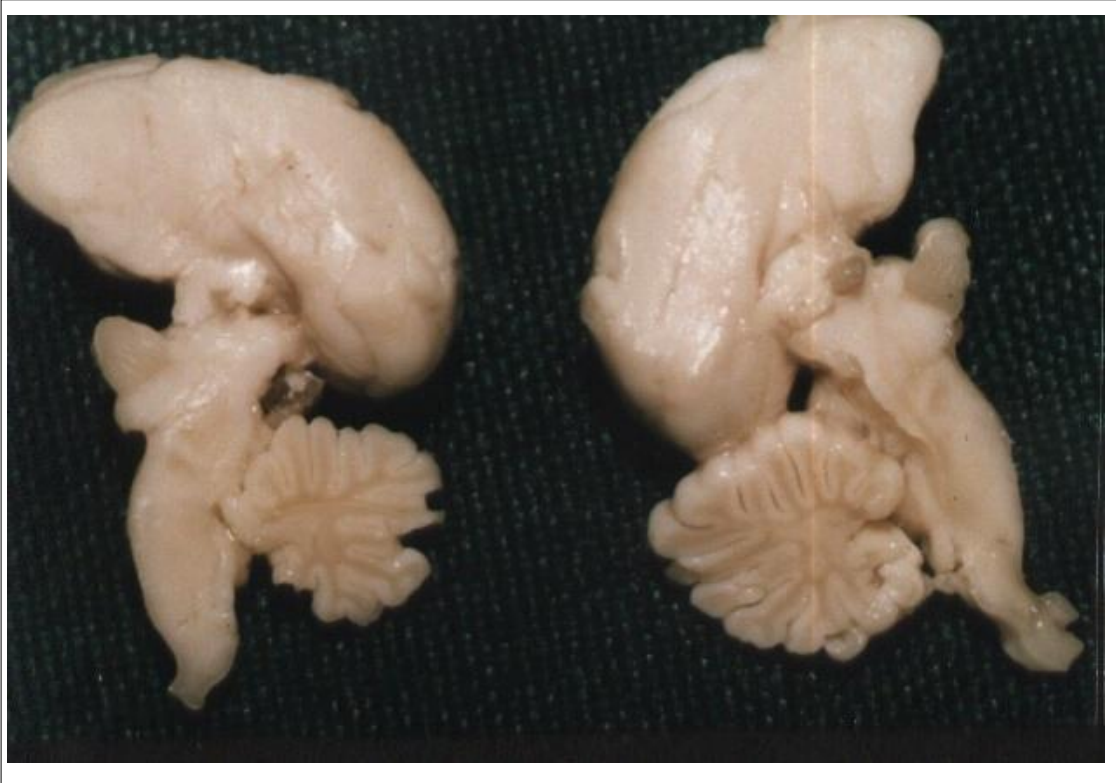


Fig. 3: Longitudinal sagittal section of parrot brain shows the six layers of the Pallial subdivision and the subpallial regions

The Cerebrum: Histomorphology:

The cerebrum consisting of two cerebral hemisphere, each one consisting of two regions:

1 - Dorsal regions (pallial).

2 - Basal regions (sub pallial). Pallial regions organized into four main subdivisions: Hyper pallium (hypertrophied pallium), Mesopallium (middle pallium) Nidopallium (nest pallium), Archopallium (arched pallium) are shown in (Fig.4,5,6).

The anterior cellular masses of nuclei of hyperpallium representing “the wulst”. The hyperpallium has a unique organization which was contained two layers: Hyperpallium Apicale (HA), Hyperpallium Intercalatum (HI) are shown in (Fig.4).

There was a thin lateral cortex of hyperpallium which contains (dorsal lateral corticoid area (CDL), Hipocampus Hp, reduced (piriform cortex)).

The remaining subdivisions of pallial: Mesopallium, Nidopallium, Archopallium which contains several different neural populations named the dorsal ventricular ridge (DVR). The Mesopallium consisting of two-layers: Mesopallium dorsalis (MD), Mesopallium ventralis (MV), Fig.5 shows that the Mesopallium ventralis layer was the larger in size, contains several different nuclei, while Fig.3 shows the Mesopallium ventralis was surrounding the next regions.

The Nidopallium is the greatest part of the hemisphere, which extends from the rostral to the caudal part of pallial are shown in Fig.3 while Fig .6 shows that the limit of nidopallum and subpallial regions which was marked by a fiber lamina lamina medullaris dorsalis.

The archopallium occupy the caudal parts of pallial, the posterior part of the archopallium named: the amygdaloid complex. The subpallial regions (striatal, pallidal) are the actual parts of the basal ganglia.

Fig.7 shows the straital region which was larger in size than the underneath pallidal regions.

There are many nerve tracts within the anterior commissure, which connecting the graymatter of cerebral hemisphere, most of them are extending to straital, pallidal, but a less of fibers extending to the pallial parts. The cerebrum enclosed cavity named lateral ventricle.

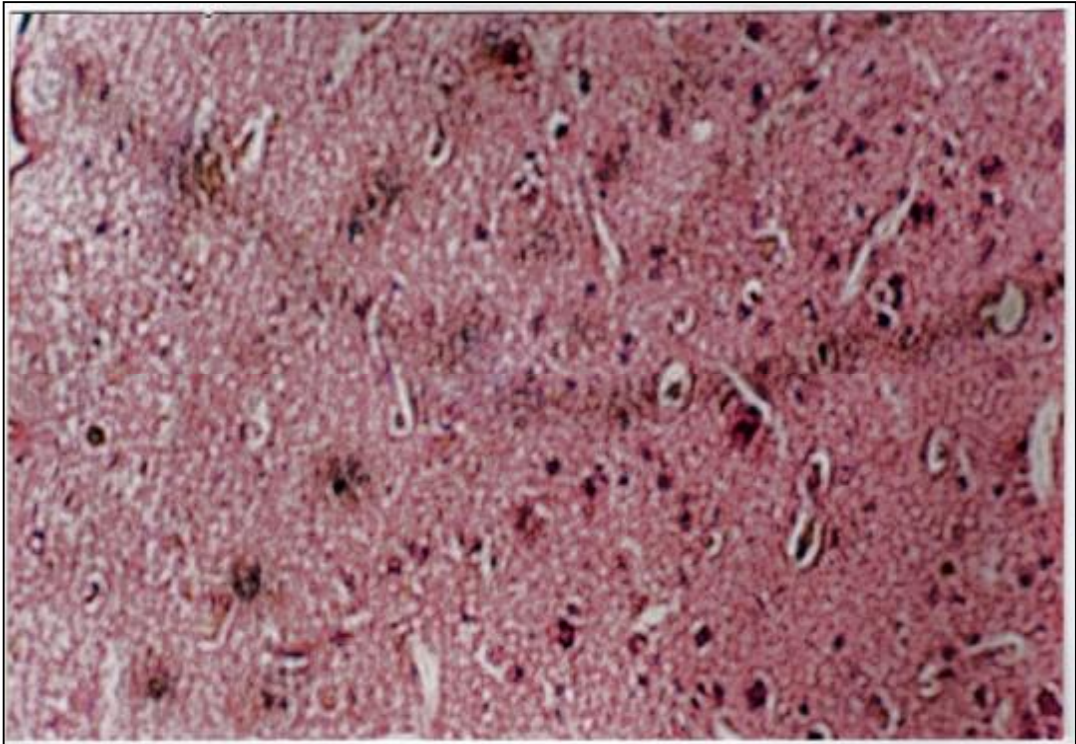


Fig. 4: The two layers of Hyperpallium (HA, HI ,and MD) H& E stain (100 x)

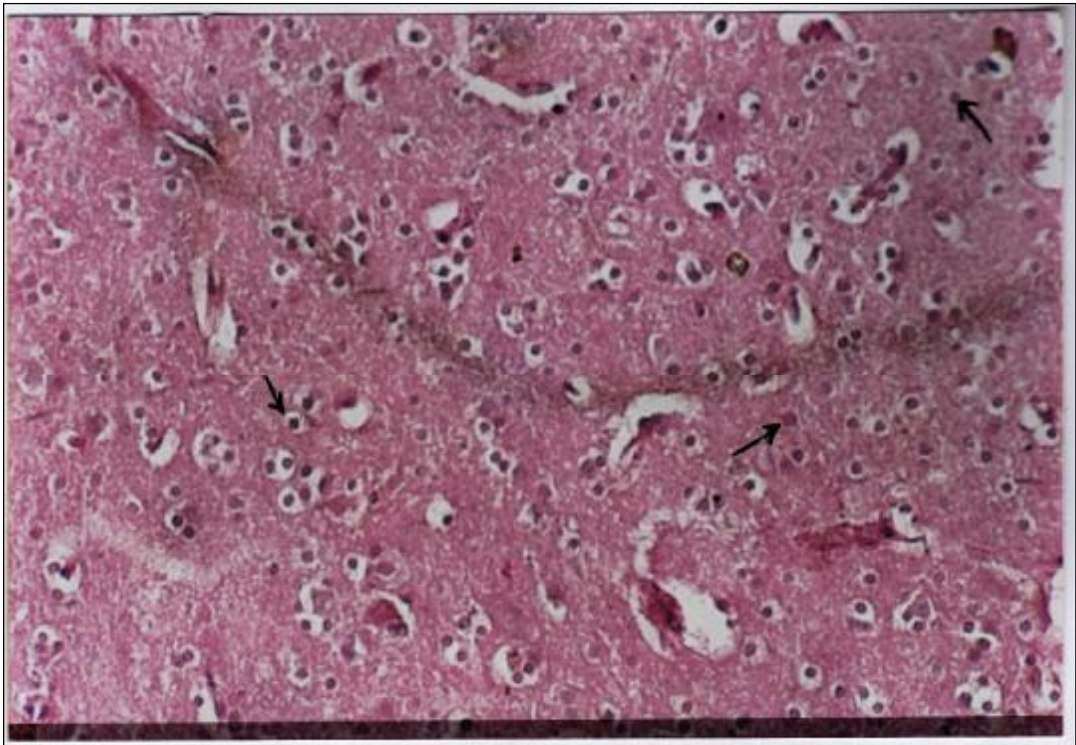


Fig. 5: The Mesopallium layer (MV)→different nuclei PAS stain(200x)

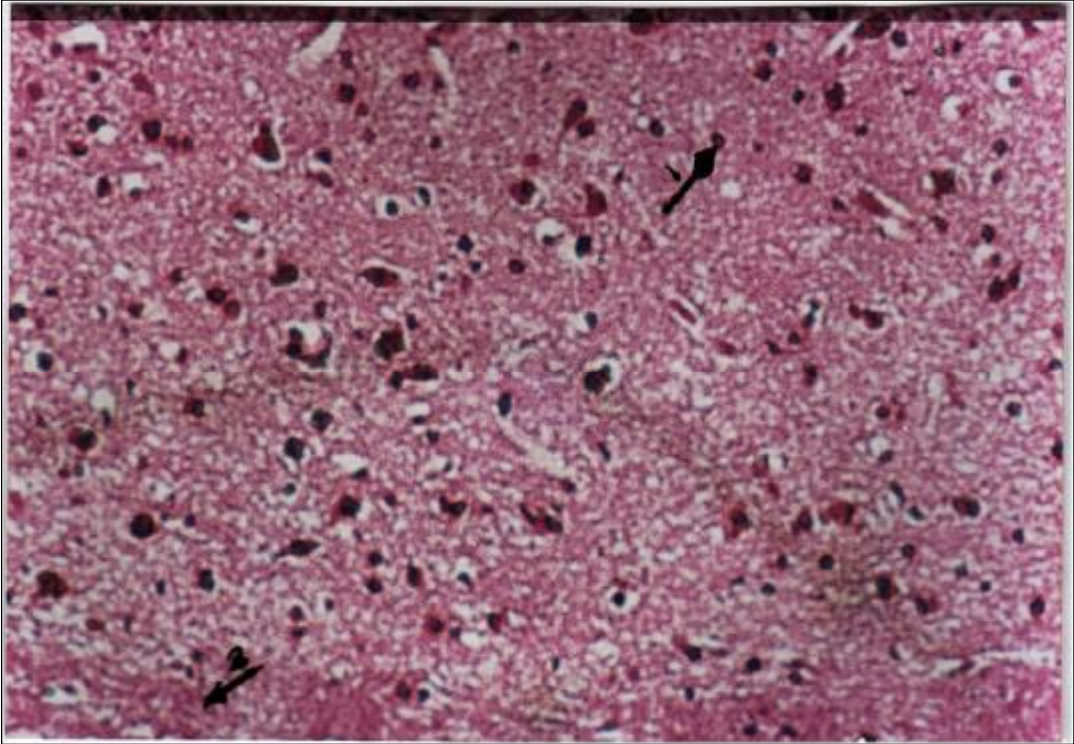


Fig. 6: The Nidopallium layer (NP) PAS stain (200x) —1→ different population —2→ fiber lamina.

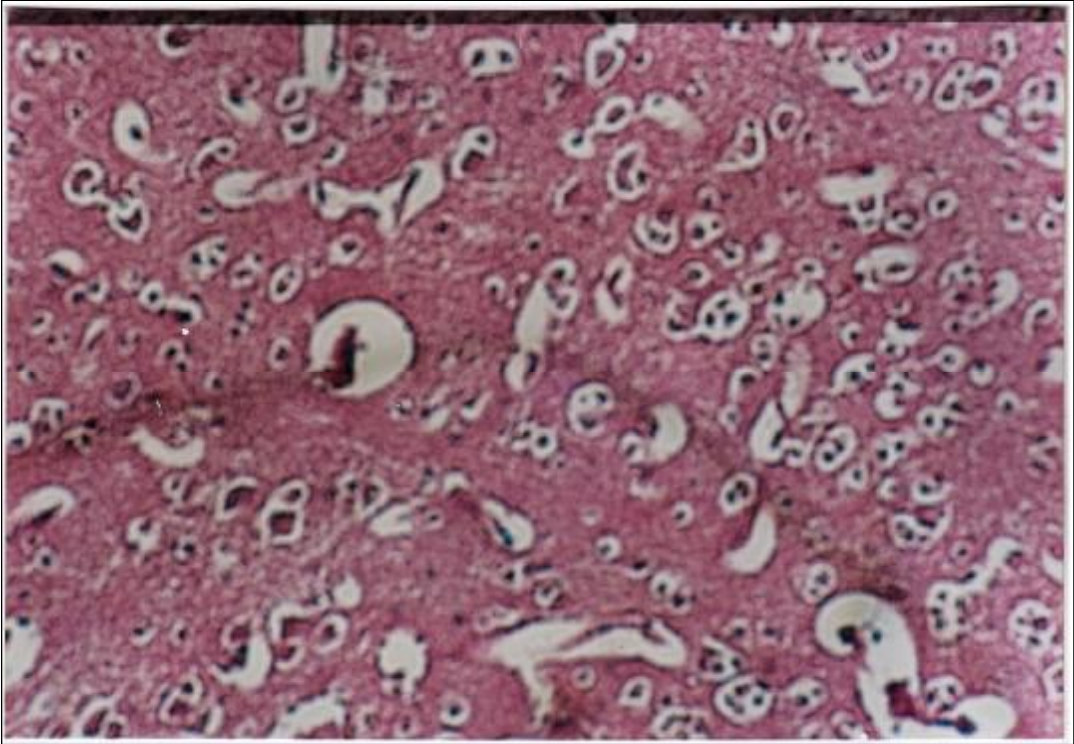


Fig. 7: The straital region of the subpallidal PAS stain (200x)

Discussion

The results indicate that gold-capped parrots have large brain dominated by cerebral hemisphere (cerebrum), the latter was completely hide the underlying midbrain, these finding is different with the statement in apodiforms, camprimulgiforms, gillaforms, pigeons^[4], and in migratory birds^[15]. Parrots and corvids have advanced cognitive abilities and also similar brain size and composition with primates^[4].

The gold-capped Parrots have three major cerebral regions (pallial, striatal and pallidal). The largest region was the pallial, the latter consist of six layers :HA, HI, MD, MV, NP, and AP , which is named a cording to ^[5], they were introduced the modern view of nomenclature. The latter based on the assumption of similarity and homology between songbirds and human cerebrum, also they observed that pallial regions which means mantle or covering comprises about 75% of telencephalic volume. Bird pallial regions (neocortical regions) had the same function of mammalian cortex^[9]. The thin lateral cortex in gold- capped parrot, were observed also in songbird by ^[5], and in sparrow by^[10].

Kiwi had a very much reduced wulst and shallow vallecule^[16], these finding is different in parrots, it has massive wulst, demarcated by a vallecule groove.

In saggital sections of the gold - capped parrot brain it was found that the (DVR) was the best developed, while in pigeons, doves, quail and domestic chicken it were less developed ^[5,12].

The expansion of the cerebral hemisphere in parrots is due to the expansion of neocortical regions; this type of expansion is typical in primates and adontocate whales ^[4].

The results indicate that the greatest part of hemisphere, that extends from the rostral to the caudal pole, was the nidopallium, these results was inagree with^[8] who observed that the equivalent of the human prefrontal cortex in the avian nervous system is a structure called the nidopallium caudolaterale.

The ‘amygdaloid complex’ occupy the posterior part of the archopallium, similar observation was by ^[5] in songbirds, ^[9] stated that the posterior part of the archistratum (renamed arcopallium) has been renamed to the posterior pallial amygdala.

References

- 1 - Ede, D. A. (1964). Bird Structure: An approach through evolution development and function in the Fowl. Agricultural Research Council, Poultry Research Center, Edinburgh.
- 2 - Pettingill, O. S. (1970). Ornithology in Laboratory and Filed, Cornell university Ithace, NewYork.

- 3 - Kent, G. (1987). *Comparative anatomy of Vertebrates*, 6th ed., John Wiley, New York.
- 4 - Iwaniuk, A. N. (2003). *The evolution of brain Size and Structure in birds* unpublished PHD thesis, Monash University, Clayton, Australia.
- 5 - Jarvis, E. D. D. ; Gütürkün, L. ; Bruce, A. ; Csillag, H. ; Karten, W. ; Kuenzel, L. ; Medina, G. ; Paxinos, D.J. ; Perkel, T. ; Shimizu, G. ; Striedter, M. ; Wild, G. F. ; Ball, J. ; Dugas Ford, S. ; Durand, G. ; Hough, S. ; Husband, L. ; Kubi Kova, D. ; Lee, C. V. ; Mello, A. ; Powers, C. ; Siang, T.V. ; Smulders, K. ; Wada, S.A. ; White, K. ; Yamamoto, J.Yu.; A. Reiner and B. Butler. (2005). Avian brains and a new understanding of Vertebrate brain evolution. *Nature Reviews Neuroscience* 6: 151 – 159.
- 6 - Iwaniuk, A.N. and Wylie, D.R.W. (2006). The evolution of stereopsis and the Wulst in Comprimulgiform birds : a comparative analysis . *J . Comp . physiol A* 192 : 1313 – 1326.
- 7 - Northcutt, R.G. (2002). Understanding Vertebrate brain evolution . *Integrative and comparative biology* , Vol . 42 , N . 4 PP .743 .
- 8 - Emery, N.J. (2007). *Cognitive Ornithology: The evolution of avian intelligence* , The Royal Society Bio science .
- 9 - Reiner, A.D.J.; Perkel, L.L.; Bruce, A.B.; Butter, A.; Csillag, W.; Kuenzel, L. ; Medina, G. ; Paxinos, T.; Shimizu, G.; Striedter, M.; Wild, G.F.; Ball, S.; Durand, O.; Gütürkün, D.W.; Lee, C.V.; Mello, A.; Powers, S.A.; White, G.; Hough, L.; Kubikova, T.V.; Smulders, K.; Wada, J.D.; Ford, S.; Husband, K.; Yamamoto, J.; Ya, C. and Siang, E.D. Jarvis. (2003). Revised nomenclature for avian telencephalon and Some related brainstem nuclei . *J . Comp. Neurol* ., May 31: 473 (3) : 377.
- 10 - Kappers, C.U.A. ; G.C. Huber and E.C. Crosby (1967). *The Comparative anatomy of the nervous System of Vertebrates including man* , VOL . 2 . Hafner Publishing Company New York .
- 11 - Marshall, A.J. (1961). *Comparative Physiology of birds* , Monash university , Victoria , Australia.
- 12 - Jarvis, E. (2005). *Bird Brain*, Nova Science now, North California
- 13 - Humanson, G.L. (1972). *Animal Tissue Technique*. 3th ed . W. H. Freeman, and Company San Francisco .
- 14 - Drury, R.A. and E.A. Willington (1980). *Carleton's histological technique* 5th Oxford, New York Toronto.
- 15 - Pravosudov, V.V.; K. Sanford and T.P. Hahn. (2007). On the evolution of brain Size in relation to migratory behaviour in birds . *Animal Behaviour*, Vol. 73, PP. 535.
- 16 - Martin, G.R.K.J.; Wilson, J.M.; Wild, S.; Parsons, M.; Fubke, F. and Corfield, J. (2007). Kiwi Forego Vision in the guidance of their nocturnal activities. *Plos one* 2: e 198.