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Morphological and Histological Study of the Forebrain (Cerebrum) in a Wild Bird Species *(Columba livia domestica)* (Gmelin, 1789)

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Abstract:

The present study deals with the morphological and histological aspects of the forebrain(Cerebrum) in the *Columba livia domestica* (Gmelin, 1789) to identify the histoarchitecture of its layers. This bird' has a large head found as perpendicular to the longitudinal axis. The morphological results reveal that for brain (Cerebrum) pear shaped, its outer surface is smooth without folds or deep grooves. Cerebrum is made up of two regions, the Pallium and the Subpallium. The Cerebral cortex includes four layers of hyperpallium (Wulst) , Dorsolateral corticoid area (CDL), Hippocampus, Piriform cortex. The internal cortex of cerebrum consists of Dorsal Ventricle ridge which includes the mesopallium, nidopallium, and archospallium. All these regions includes Pyramidal cells, which have different sizes and densities, as well as many other neurons and Neuralgial. The Subpallium is divided to Striatum which is consisted of nerve fibers of nerve cells and the Palldium, which is the deepest part of the brain with light- color.

Keywords: Cerebrum, *C.l.domestica*, Homing dove.

Introduction:

Birds vary in histological, physiological and physiobiological structure according to the different nature of life, nutrition and the environment, as well as having more advanced brains than in the less developed vertebrates (such as amphibians and reptiles). It has been observed that long-distance migratory birds possess smaller brains than short-distance migratory and endemic birds. The size of the brain in the birds depends on migration distance of these birds; also the increase in the size of the optic lobe and the height of the wings affects on the average distance of migration within different bird species(1). The molecular, anatomical and chemical studies confirm that birds and mammals possess the largest brain compared to other vertebrates. It was observed that the central region of the dorsal telencephalon is the dorsal ventricular ridge(DVR) called the Pallium, in the mammals called neocortex, Piriform lobe nuclei and striatum as well as the presence of amygdala (2).

Studies show that the forebrain of the crowes is consisted of Hyperpallium and Pallium which is divided into the mesopallium and the nidopallium, as well as the lateral striatum. This plays a role in the different functions of these birds. The histoarchitecture control the functions of emotion, as well as the functions of perception, so the crowes have advance neurological systems to recognize and respond to different behaviors by the presence of certain areas in the brain such as thalamic and amygdalar, which work to integrate the received information and interpreted them as nerve signals. In mammalian all these functions are controlled by Neocortex. (3).

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Material and Methods:

Five specimens of adult and healthy birds were collected from the Ghazil market and the specimens were disceted according to the Hymen method(4) by making cut from occipital region toward the frontal region . The skull bones were separated and removed very carefully, using fine forceps and sharp knife to cut the attached nerves with the brain. Preparation of tissue sections: histological sections prepared according to the (5) specimens were fixed with formalin solution 10% for 24 hours and then washed with running water and put in serial concentrations of the absolute alcohol ranging from 70% to 100% for 45 min. Each was clearing with (Xylene) for 45 min., and then placed in a mixture of xylene and paraffin wax at 58C° for infiltration for 15 min. The samples were embedded in waxy molds for blocking and cut by rotary microtome, and using routin stain (hematoxylin&eosin).

Photography: The slides were photographed with a Meije compound microscope with a camera.

Results:

Morphological description of brain

Columba livia domestica has a large head found as perpendicular to the longitudinal axis of the body (Fig. 1). Morphologically, the brain appeared as a pear shape and has two large cerebral hemisphere separated by (Fissure). And surrounding by meninging, which protect the brain from external shocks and effects. The outer surface of brain smooth and without Wrinkles or deep grooves (Fig. 2). The brain is divided into three regions: the forebrain, which consists of two parts, the anterior is Telencephalon, which consists of the cerebrum, the thalamus, the hypothalamus and the posterior part is Diencephalon from optic vessels arises, (Pineal Body found in the dorsal surface but the (pituitary Gland) found in the ventral surface, while the second part is the middle brain (Midbrain), from which Optic Lobes arises, and Hindbrain, which consists of two parts, the frontal part called Metencephalon the origin of the Cerebellum and Myelencephalon which give (Medulla Oblongata) (Fig. 3). The cerebrum is divided into two areas: the pallium and the subpallium, which are formed by the outer cortical area, called the hyperpallium as well as the presence of the dorsolateral corticoid area (DCA), the piriform cortex, the hippocampus, while the inner cortical area called the dorsal ventricle ridge (DVR), which appears to be developed in birds, consisted of three regions, the first one was located in the middle of the medial pallium (mesopallium) the second, nidopallium (Nest pallium), as well as the archopallium (arched pallium), while the second region subpallium, which divided to the striatum and the pallidum, Figure(4).

Histological structure of the cerebrum

The cerebellar cortex of the forebrain of the bird show that it was surrounded by two layers:

Arachnoids matter

Is a thin fibrous membrane consisting of connective tissue rich in collagenous fibers and appear bundled of elastic fibers and many fibroblast cells in the cerebral cortex, followed by pia matter region, the subarachnoid space (SAS) filled with cerebrospinal fluid (CSF), with many blood vessels (Fig. 5).

Pia matter

Consisting (Loose connective tissue), collagenous fibers interspersed with fibroblast cells, as well as elastic fibers, and surrounded by simple squamous epithelial tissue, while the inner layer consists of a network of reticular and elastic fibers separated from the neural tissue beneath it by a layer of neuralgial cells (Fig.6).

The cerebrum is divided into two regions: the pallium and subpallium. The pallium consists of several layers, which are the area above the hyperpallium. The outer cortex is composed of several layers (Fig.7).

Reticular layer: reticular fibers, horizontal cells, glial cells, spherical cells, and fusiform cells are few in number,(Fig.8).

Hyperpallium apical (HA): It is composed of different types of neurons such as spherical cells and pyramidal cells small, medium and large as well as glial cells (Fig.9).

Hyperpallium apical Interstitial (IHA): is dominated by pyramidal neurons, axons and dendrites of pyramidal cells) as well as glial cells, (Fig.10:A).

Dense cell hyperpallium (HD): it contains different of types of neurons, which include pyramidal cells, fusiform cells, glial cells, satellite cells, and nerve fibers, (Fig.10: B) (Fig.11).

Dorsolateral corticoid area(CDL), which is the surface area of the cortex, the piriform cortex(Fig.12:A,B) and the hippocampus is divided to: Midoventral V-shape(MD) and Dorsal medial region (DL), lateral ventricle,(Fig.13) contain many different types of neurons, such as the pyramidal, fusiform cells and satellite cells that appear around the entire neuron called peripheral satellite cells as well as types of Myliented fibers.

Subpallium includes the striatum(Fig.14) and Palladium(Fig.15). This region is dark color because it contains the Axons of neurons and oligodendrites cells and a lot of Spiny dendrites as well as the presence of astrocytes cells.

Figure 1. Head region in *Columba livia domestica*

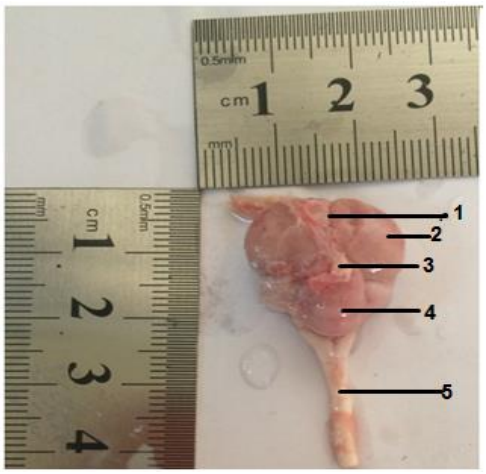

Figure 2. Dorsal view of (*C.L.domestica*) brain shows: 1:Fissure, 2: Cerebrum, 3: Meninges, 4: Cerebellum, 5: Spinal cord

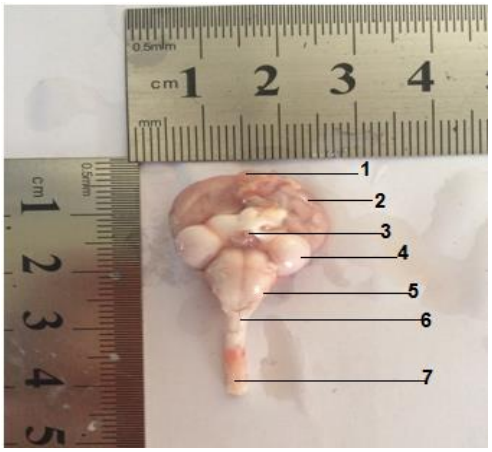

Figure 3.Ventral view of (*C.L.domestica*) brain shows: 1: Olfactory lobe, 2: cerebrum, 3: Optic chiasma, 4:Optic lobe, 5:cerebullum, 6:Medulla oblengata, 7: Spinal cord.

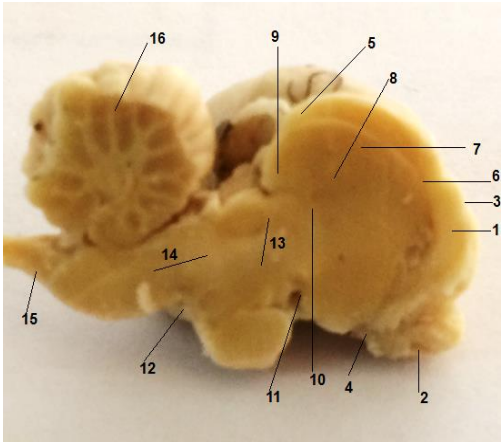

Figure 4. Sagittal section through the brain of (*C.L.domestica*) shows: 1: Hyperpallium, 2: olfactory bulb, 3: Dorsolateral corticoid area, 4: Piriform cortex, 5: Hippocampus, 6: Lateral ventricle, 7: Nidopallim, 8: Mesopallium, 9: Archopallium, 10: Palladium, 11: Striatum, 12: Optic chiasma, 13: Diencephalon, 14: Midbrain, 15: Medulla oblongata, 16: Cerebellum.

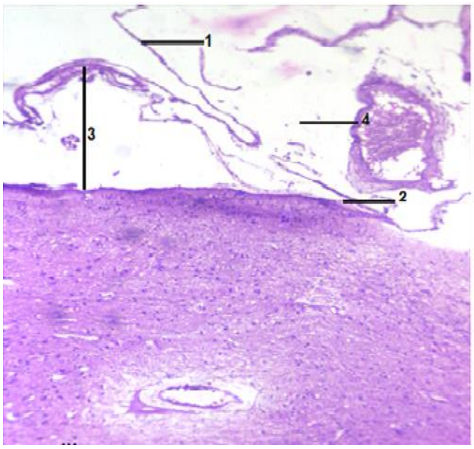

Figure 5. Cross section through for Cerebral cortex of forebrain for *(c.L. domestica*) shows: 1: Arachnoids matter, 2: Pia matter, 3: Subarachnoid space (SAS), 4: Blood vessel. (4X), (H&E).

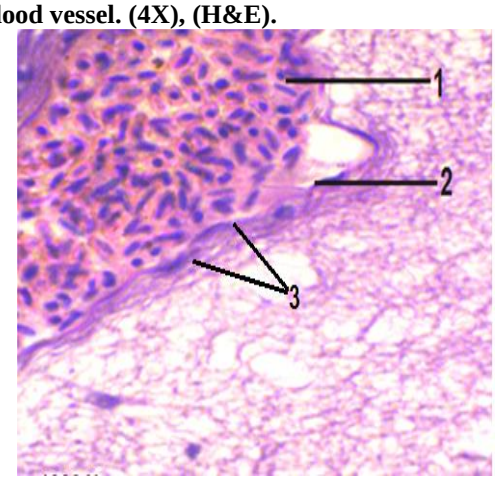

Figure 6. Cross section through for Cerebral cortex of forebrain for *(C.L. domestica*) shows: 1: Blood vessels, 2: Pia matter, 3: Fibroblast cell, 4:Simple squeomous tissue. (1000X)(H&E).

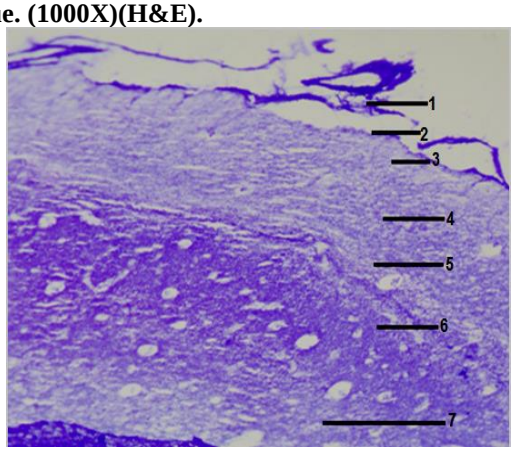

Figure 7. Cross section through the Cerebral cortex of forebrain for *(C.L. domestic*) shows: 1: Meninges, 2: Hyperpallium, 3:Reticular layer, 4:Hyperpallium Apicale (HA), 5: Interstitial Hyperpallium Apical(IHA), 6: Densocellular Hyperpallium(DH) (4X)(Luxal Fast Blue-Cresyl Violet).

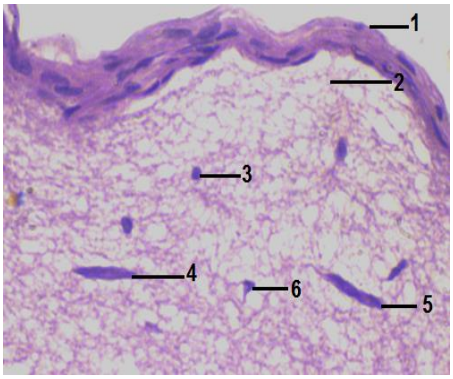

Figure 8. Cross section through the Reticular layer for Cerebral cortex of *(domestic*) shows: 1: Pia matter, 2: Reticular layer, 3: Glial cell, 4: Fusiform cell, 5:Horizontal cell, 6: Pyramidal cell. (1000X)(H&E).

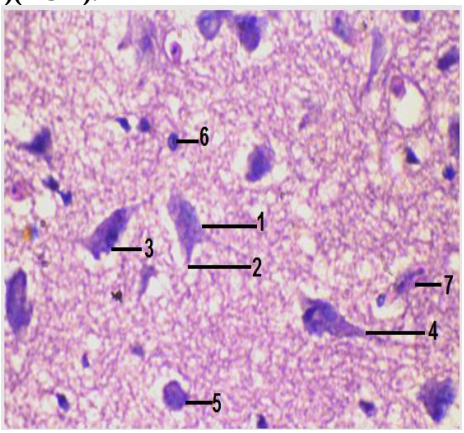

Figure 9. Cross section through the Hyperpallium Apical(HA) for Cerebral cortex for *(C.L.domestica*) shows: 1: Multipolar neuron, 2: Dendrites of neuron, 3: Fusiform cell, 4:Axon of Pyramidal cell, 5: Spherical cell, 6:Glial cell, 7: Blood vessels. (1000X)(H&E).

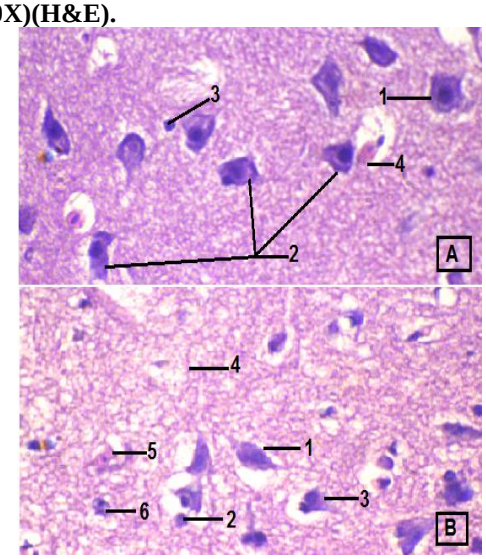

Figure 10. A: Cross section through the Interstitial Hyperpallium Apical (IHP) for Cerebral cortex for *(C.L.domestica*) shows: 1: Multipolar neuron, 2: Pyramidal cell, 3: Glial cell, 4: Blood vessels.(1000X)(H&E).B: Cross section through the Denscellular Hyperpallium (DH) for Cerebral cortex of *(domestic*) shows: 1: Fusiform cell, 2: Satellite cells, 3: Pyramidal cell, 4: Myliented fiber, 5: Blood vessel, 6: Glial cell.(1000X)(H&E).

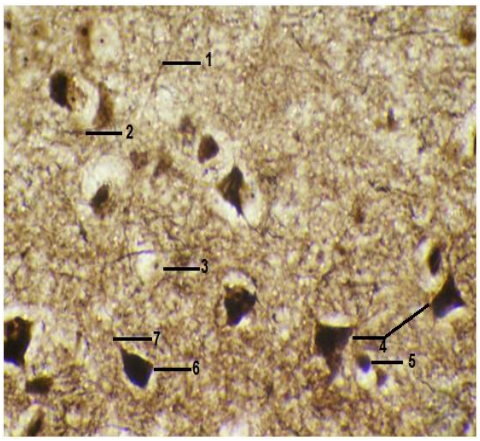

Figure 11. A: Cross section through the Interstitial Hyperpallium Apical (IHP) for Cerebral cortex for *(C.L.domestica*) shows: 1: Nerve fibers, 2: Axon of Multipolar neuron, 3: Blood vessels, 4: Multipolar neuron, 5: Glial cell, 6: Pyramidal cell, 7: Axon of pyramidal cell. (1000X) (Silver nitrate).

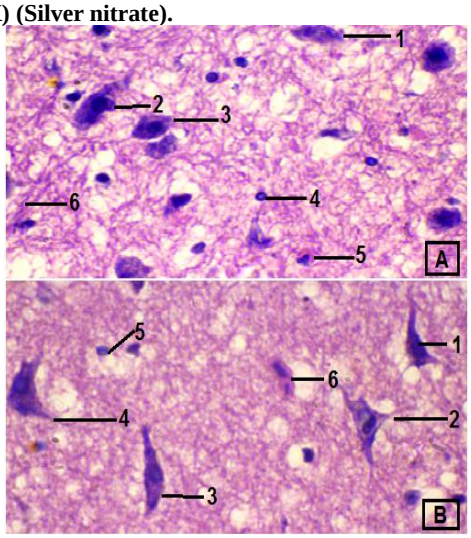

Figure 12. A: Cross section through the Dorsolateral corticoid area(CDL) for Cerebral cortex for *(C.L.domestica*) shows: 1: Horizontal cell, 2:Pyramidal cell, 3: Fusiform cell, 4: Glial cell, 5: Blood vessel 6:Nerve fibers. (1000X) (H&E). B: Cross section through the Piriform cortex for Cerebral cortex of *(domestic*) shows: 1: Pyramidal cell, 2: Multipolar neuron, 3: Fusiform cell, 4: Axon of Pyramidal cell, 6: Blood vessel.(1000X)(H&E)

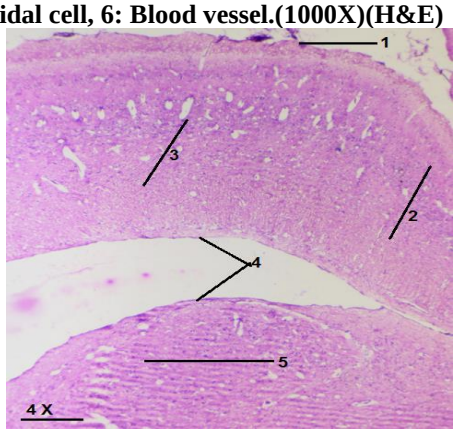

Figure 13. Cross section through the Hippocampus for Cerebral cortex for *(C.L.domestica*) shows: 1: Pia matter, 2: Midoventral V-shape(MD), 3: Dorsal medial region (DL), 4:lateral ventricle, 5: Nidopallium.

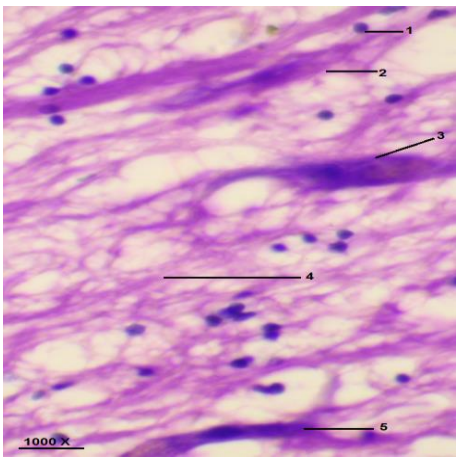

Figure 14. Cross section through the Striatum of Subpallium for Cerebral cortex for *(C.L.domestica*) shows: 1: Neuroglial cell, 2: Multipolar Neuron 3: Pyramidal cell, 4: Nerve fibers, 5: Horizontal cell.(1000X)(H&E).

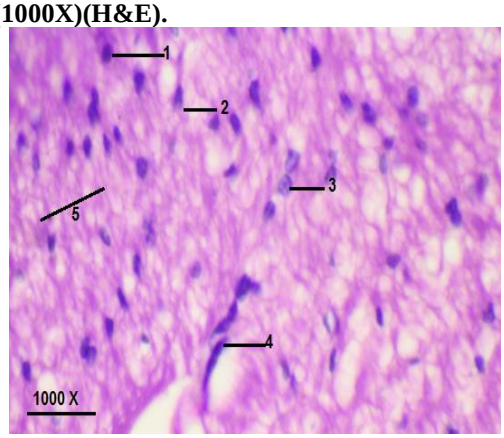

Figure 15. Cross section through the Palladium of Subpallium for Cerebral cortex of *(domestic*) shows: 1: Neuroglial cell, 2: Astrocyte, 3: Oligocytes, 4: Horizontal cell, 5: Nerve fibers. (1000X) (H&E).

Discussion:

The results of this study deals with the morphological and histological description of the (*Columba livia domestica*) (Gmelin, 1789)

The brain in vertebrates shows a wide variation between the taxonomic hierarchies as well as the differences within the same species. *C.L. domestica* one of the wild migratory bird which migrates for long distances so it has large head found as perpendicular to the longitudinal axis of the body. The brain pear- shaped consists of two large lobes separated by fissure and covered by cerebral membranes(Meninges) that protect the brain from shocks and external influences. Its outer surface is smooth without deep wrinkles or grooves. The brain is divided into three portions: the forebrain which consists of the cerebrum, the thalamus, the hypothalamus, the dorsal surface of the pituitary cavity. The mid brain, and the hind brain consists of two parts: the cerebellum and the medulla oblongata. The results agree with Karkoura (6) who pointed out of the morphology of African Ostrich brain (*Struthio camelus*) and its divisions and how to arrange parts as they pointed out that the largest parts in the brain is the cerebrum because ostrich is poultry bird unable to fly.

The brain consists of two regions: the Pallium and the Subpallium. The pallium consists of the external cortex, which includes the Hyperpallium, the dorsolateral corticoid area (DCA), the Hippocampus complex and the Piriform cortex, while the inner cortex consists of the dorsal ventricle ridge, consisting of the mesopallium, the nidopallium, the primary cortex. The subpallium is divided into the striatum, which consists of the nerve fibers of the nerve cells and the palladium, the deepest part of the brain.(7) revealed the same results when they study European falsev, (*Sturnus vulgaris*) which is one of the migratory birds to Iraq, with the advantage of the brain as an oval to pear-shaped with a smooth surface thin because it lacks of holes and peaks as well as the disappearance of gyri and deep canyons.

The results of Karten (8) study shows that the organization of the forebrain in birds and reptiles is very different from that occurred in mammals because it does not contain the Neocortex. The telencephalon is divided into two basic areas: the basal ventricular edge and the dorsal ventricle ridge. The telencephalon in the non-mammalian is the molecular analyses forebrain as well as the test about physiological characteristics showed that only a small part of brain is similar to mammalian brain. The remaining areas (DVR) and subpallium as well as nidopallium contains the same types of neurons with different number and density.

The histological study of the cerebrum shows that all vertebrates have brain of them either covering to protect against external influences and strong shocks (9). This fact is confirmed by the results of the present study, cerebrum in the *(C. l. domestica*) being surrounded by several layers. First: the Arachnoids matter is considered as thin fibrous sheath consists of connective tissue rich with bandles of collagenous fibers, elastic fibers followed by pia matter that separates them by a space called the sub-arachionid space that fills the spinal fluid and permeates with many blood vessels. Second: the pia matter, that is composed of a losse connective tissue which is composed of collagenous fibers, fibroblast, elastic fibers and bandles of reticular fibers, neuroglial, separated from the nervous tissue beneath it by a layer of neuroglial cells. The present study show that the brain in the *(C. l. domestica*) consists of two areas: the pallium and the subpallium. The pallium is made up of hyperpallium and the dorsolateral corticoid area large size, in contrast to kiwi, and poto, this area is usually very small, or reduced (10). This layer is

divided into several sublayers, consisting of reticular fibers sub layer that is composed of retinal fibers, horizontal neurons that appear to predominate in this layer, neuroglial cells and spherical neurons, and few numbers of fusiform cell the layer appicale hypopallium. (IHA) consists of different types of neurons such as spherical neurons and pyramidal cells, which vary in sizes from small to medium and large size as well as the nerve cells and (IHA) consisted of predominate satellite cells, pyramidal cells, and their axon and dendrites and glial cells and dense hyperpallium which appear dark due to presence of different types of neurons and ventral medium hypopallium called lateral pallium current of few pyramidal cells with their spinal dendrites as well as spherical cells and big multipolar neurons. These results agree with Abd-Alrahman (11) when studying the (bran owl) the structure of the layers and the types of neurons while(*C. l. domestica*) the neurons are the biggest sizes and perhaps this bird is a migratory bird while the barn owl is raptor bird, depending on hearing and vision to hunt its prey.

The histological structure of dorsolateral corticoid area (DCA), the hippocampus complex and the piriform cortex, in the (*C. l. domestica*) similar to (12) who studying on Strawberry finch (Estildamandava), it was found to be similar to the current study. The corticoid complex in birds is similar to the lateral cortex of (the reptiles and the mammalian) cortex as indicated by Srivastava (12).

The hippocampus complex is of great importance in the body of the organism because it is responsible for memory and storage of information. The current study of the hippocampus region shows that it consists of two regions: which agrees with Belgard and Tompol (13)(14). When studying chicken and Homing pigeon, it consists of a network of nerve fibers as well as the presence of nerve cells (15). The study shows that two species of birds migrated long distances, such as the semipalmated sandpiper (*Calidris pusilla*), and the second migrated to short distances as spotted sandpiper (*Actitis macularia*). There is a difference between the two species as the birds migrating for distances are characterized by a large size of the hippocampus and an increase in the number of neurons and neuroglial. This variation in area size and differences in neuron specialties are assistant with orientation and navigation strategies.

The subpallium consists of two regions: the first is called striatum, and this name is due to its appearance, Histo arrangement which appeared as a result of the entanglement and arrangement of the nerve fibers in bundles and interspersed with scattered nerve cells like pyramidal cells that are different in size and fusiform cells. The pallidium is pale in color because it contains axons of neurons as well as the presence of nerve cells such as dendrites cells, satellite cells (16)(17).

Conflicts of Interest: None.

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دراسة مظهرية ونسجية للدماغ الامامي(المخ) لنوع من الطيور البرية (حمام الزاجل) (*Columba livia domestica*) (Gmelin, 1789)

غزوة درويش النقيب **نور نعيم جاسم**

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الخلاصة:

تناولت الدراسة الحالية معرفة الجوانب المظهرية والنسجية للدماغ الأمامي Forebrain المتمثل بالمخ (Cerebrum) لحمام الزاجل *Columba livia domestica (*Gmelin1789) لتشخيص الطبقات النسجية، اذ يمتاز الطائر بكبر حجم الدماغ ويكون الراس عمودي على المحور الطولي للجسم، إذ أكدت النتائج المظهرية بكون المخ كمثري الشكل ويتألف من منطقتين اللحاء وتحت اللحاء، اذ تتميز القشرة المخية للحاء من أربعة مناطق متمثلة بمنطقة فوق اللحاء ألقمي، والباحة القشرية الظهرية الجانبية ومعقد الحصين والقشرة الكمثرية، بينما تتألف القشرة الداخلية للمخ من الحافة الظهرية البطنية والتي تتألف من ثلاث مناطق تتمثل باللحاء المتوسط وعش اللحاء واللحاء البدائي، اذ تتألف هذه المناطق من خلايا هرمية متباينة الإحجام والخلايا العصبية الساندة، بينما تتألف منطقة تحت اللحاء من منطقتين المخطط التي تمتاز باحتوائها على الخلايا والألياف العصبية ومنطقة الشاحبة اذ تعد من أعمق المناطق وذات لون باهت وشفاف.

الكلمات المفتاحية: المخ، الطيور البرية، الحمام المنزلي.