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ORIGINAL ARTICLE

Comparative Study between Brain and Optic Lobe of Falcon (Falco Columbarius) and Owl (Bubo Bubo)

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ABSTRACT

Background: In Iraq have been collected 10 Falcon (Falco columbarius) and 10 Owl (Bubo bubo) to obtain their brain (optic lobe) and histological comparative between them.
Method: In recent study have been collected specimens and used hematoxylin and eosin stain and used silver stain to compare between them.
Result: Our result show weight of brain of falcon was less than owl (4.2$^{\pm}$ 0.04830 , 4.7$^{\pm}$ 0. 05164) respectively while weight of optic lobe of falcon was more than owl (1.2$^{\pm}$0.05270 , 1.1$^{\pm}$ 0.05164) respectively. Optic lobe of falcon was consist of six layers with thickness (770.7 $^{\pm}$0.48305) while owl was consist of three layers only with (707.7$^{\pm}$0.48305).
Conclusion: brain weight of falcon is less than owl because of long distance which be fly and weight of optic lobe of falcon is more than owl because it has high vision more than owl.

INTRODUCTION

The term "raptor" comes from the Latin "rapere," which means "plunderer." When it comes to birds, it's interchangeable with "bird of prey." Historically, these designations have been ascribed to a wide range of species that were originally classed together based on their feeding preferences for other animals and the presence of hooked beak and sharply hooked claws. The name "raptor" refers to a group of birds classified into three orders based on their evolutionary origins, Falconiformes, Strigiformes and Accipitriformes (Jarvis et al., 2014).

The nervous system is a highly sophisticated component of an animal that transmits messages to and from many areas of its body to coordinate its actions and sensory information. The nervous system senses changes in the environment that affect the body and then works in concert with the endocrine system to respond (Aspinall, 2015).

The cerebral cortex, cerebellum, and medulla oblongata are the three primary regions of the brain. The cerebella and cerebral hemispheres of the birds are rather massive.In addition, the birds' optic lobes are big, while their olfactory bulbs are tiny (Husband, 1999).

Birds' brains are important for research because they influence physical gestures, the organism's homeostasis, muscle tension control, and brain function. The optic lobe on either side of the brain is a large and complex extension that interprets visual input from the eye as well as conducting other "higher" functions including memory and behavior initiation and control. (Alix et. al., 2017).

The cerebral, cerebellum, and medulla oblongata are the three primary regions of the brain. The cerebral hemispheres and cerebella of the birds are rather big, and they also have big optic lobes and smaller olfactory bulbs (Batah et. al.2012).

The cerebral hemispheres of birds are shaped like a pear. The two olfactory bulbs are located in the front portion of the cerebral hemispheres; the right and left hemispheres are divided by a median fissure, and the cerebral hemispheres are separated from the cerebellum by a transverse fissure (Sultan, 2005). While Gunturkum in (2000) found that the optic lobe in birds is very big owing to the significance of vision for most birds, the olfactory lobes are comparatively tiny due to weak smell perception in most birds.

It represents the middle brain, which is the second portion of the brain (Midbrain). The optic lobe grows in size as a result of distance migration (Al-Nakeeb and Jasim, 2018).

The optic lobe was big and well-developed, and it was positioned underneath the cerebrum, with the cerebellum jutting upward and forward(Martin et. al. , 2007).

Gray matter and white matter are the two components of an avian's brain. The gray matter is located on the outside, whereas the white matter is located on the inside (Al-Nakeeb, 2018).

The cerebral cortex is composed of six layers containing from outside to inside molecular layer, external granular layer, external pyramidal layer, internal granular layer, internal pyramidal layer, and multiform layer, while the medulla contains dense bundles of fibers and glial nerve cells, according to Pal et. al. in (2003).

MATERIALS AND METHODS

Sample Collection: 10 falcons and 10 owls (adult and healthy birds) were collected from the Baghdad (Ghazil market) ,Najaf desert and Babylon during one year (2020-2021).
Animal Anatomy: The birds were anesthetized with chloroform, and cut the feathers by using scissor then have be broken the skull by cutter, the skull bones were separated and removed very carefully, using fine forceps and sharp knife to cut the attached nerves with the brain and taken it.(Al-Nakeeb and Jasim, 2018).
Preparation of the solutions and stains
Harris' Hematoxylin stain: This stain prepared according to Kiernan (1988) as follow:
1. 1 gm of hematoxylin powder dissolved in 10 ml of absolute ethanol.
2. 20 gm of potassium alum ($KAl(So_4)_2.12H_2O$) dissolved in 200 ml distilled water and added to dissolved hematoxylin and boiling the mixture for 2 minutes.
3. 0.5 gm of mercuric oxide added to the solution.
4. coiled rapidly and added 5 ml of glacial acetic acid.
5. The solution filtrated before used.

Alcoholic Eosin: This stain was prepared according to Presnell and Schreibman (1997) as follow:
1. Add 1 gm of eosin powder to 100 ml of 70% ethyl alcohol.
2. Mixing and adding few drop of glacial acetic acid.

Slides preparation: According to Al-Attar et al.(1982) the slides were prepared as the following steps:
Fixation: After dissection, optic lobe, optic nerve and retina, each specimen was putted in labeled tubes filled with aqueous formaldehyde (4% for optic lobe and optical nerve, and 10% for eye).
Washing: The specimens were washed with 70% ethanol many times, then store in labeled tubes filling with 70% ethanol.
Dehydration: The specimens were immersed in increased concentration of ethanol (70%,80%,90%,96% and 96%) for 30 minutes.
Clearing: The dehydrated specimens were cleared with xylene for 30 minutes three times.
Infiltration and Embedding: The cleared specimens were immersed in mixture of xylene and paraffin wax (1:1) for 30

minutes in electrical oven at 60ºC and then infiltrated with pure paraffin (60ºC melting point) in the oven for 30 minutes three times and finally, the specimens were embedded with paraffin by '' L '' shaped templates for making a labeled blocks.

Trimming and Sectioning: The blocked specimens were trimmed by sharp scalpel, sectioned by using the rotary microtome (4-5 µm thickness), brought out to water bath 50ºC for flatting, putted on microscopic slides coating with thin layer of Mayers' albumin .

Staining: The staining was employed by routine stains for histological study and special stains for histochemical study as the following :

- Hematoxylin and Eosin (H&E):

This stain used for showing the general components of the tissues, according to Kiernan (1988) as the following procedure:

1. De-waxing with two changes of xylene for 5 minutes, rehydration the sections with decreased concentrations of ethanol (96,96,90,80,70 %) for 2 minutes and washing with distilled water.
2. Immersing with Harris' hematoxylin for 5 minutes .
3. Washing with tape water for 7-10 minutes for optimum blue.
4. Immersing with Eosin for 3 minutes.
5. Dehydration with ascending concentrations of ethanol (70,80,90,96, 96 %) for 2 minutes .
6. Clearing for 15 minutes by two changes of xylene.

Mounting: The prepared microscopic slides were mounting with Dextrin plastisyzer xylene (D.P.X.) and leaving them on the hot plate at 37º-40ºC for drying.

Preparation of samples for Silver stain

1 Impregnated specimens in 1.5-2.0% aqueous silver nitrate at 37 C 2 to 3 days.

2 Washed in distilled water about 20 minutes to 1 hour, with changed every 10 minutes.

3 Reduced in 4% aqueous Pyrogallol for 4 hours.

4 Dehydrated by ethanol (70%,80%,90%,96% and 96%) for 30 minutes for each concentration.

5 Cleared with xylene for 30 minutes.

6 Embedded in paraffin wax for 30 minutes in electrical oven at 60ºC in “L” shaped templates for making a labeled blocks.

5 Added Dextrin plastisyzer xylene (D.P.X.) and cover glass.

RESULTS

Morphological Description of brain of the two birds: Brain of falcon is hemisphere separated by fissure, consist of cerebrum, cerebellum, medulla and optic lobe which be part of midbrain. The optic lobe is large when compare with owl, its located on ventral side of brain, it was easy when its removed , Figure (1). The brain have been measured length (5.2± 0.04422) and its weight about (4.2± 0.04830). The optic lobe have been measured length (1.7± 0.02769) and its weigh (1.2±0.05270).

Brain of owl is hemisphere separated by fissure, consist of cerebrum, cerebellum, medulla and optic lobe which be part of midbrain. The optic lobe is large but its smaller when compare with falcon, its located on lateral_ventral side of brain and its attached tightly to other parts of brain, so its removed was hard while the optic lobe of falcon, was easy when its removed , Figure (2). The brain have been measured length (5.6± 0.03416) and its weight about (4.7± 0. 05164). The optic lobe have been measured length (1.7± 0.02494) and its weigh (1.1± 0.05164).

Our finding show brain of owl is more than falcon in length and weight while optic lobe length of both is equal somewhat, but they are different in weight, falcon optic lobe is more than owl optic lobe weight, Table(1).

Staining

Hematoxylin and eosin stain: In falcon: Cortex of optic lobe have thickness (770.7 ±0.48305 µm), Its consist of six layers: Molecular layer (40.7±0.48305 µm) consist of a few nerve cells , External granular layer (61.7±0.48305 µm) its thin layer consisting of numerous small, densely packed neurons, External pyramidal layer (148.7±0.48305 µm) consist of medium-sized pyramidal cells, Internal granular layer (64.7±0.48305 µm) consist of small, irregularly shaped nerve cells, Internal pyramidal layer (175.7±0.48305 µm) consist of large pyramidal cells and Multiform layer (99.7±0.48305 µm) consist of small polymorphic and fusiform nerve cells,(figure 2).

In owl: Cortex of optic lobe have thickness (707.7±0.48305 µm), Its consist of three layers: molecular layer (146.7±0.48305 µm) consist of a few nerve cells, pyramidal layer (388.7±0.48305 µm) consist of medium to large sized pyramidal cells and Multiform layer (155.7±0.48305 µm) consist of small polymorphic and fusiform nerve cells,(figure 3).

Table 1: describe length and weight (mean± std.) of brain and optic lobe of falcon and owl. We note weight of brain of falcon was less than owl brain beside length of falcon brain is shorter than owl brain, but length of two birds was equal while weight of optic lobe of falcon was more than weight of owl optic lobe.

	length of brain(cm)	Weight of brain(gm)	Length of optic lobe(cm)	Weight of optic lobe(gm)
Falcon	5.2± 0.04422	4.2± 0.04830	1.7± 0.02769	1.2±0.05270
Owl	5.6± 0.03416	4.7± 0. 05164	1.7± 0.02494	1.1± 0.05164

Table 2: show thickness (mean± std.) of cortex and theirs layer in falcon and owl. We note optic lobe of falcon consist of six layers which have different thicknesses, while optic lobe of owl consist of three layers. thickness of whole optic lobe of falcon is more than thickness of optic lobe of owl.

Falcon						Owl		
Thickness of cortex(µm)						Thickness of cortex(µm)		
770.7 ±0.48305						707.7±0.48305		
Molecular layer	External granular layer	External pyramidal layer	Internal granular layer	Internal pyramidal layer	Multiform layer	Molecular layer	pyramidal layer	Multiform layer
40.7±0.48305	61.7±0.48305	148.7±0.48305	64.7±0.48305	175.7±0.48305	99.7±0.48305	146.7±0.48305	388.7±0.48305	155.7±0.48305

We notes, thickness of optic lobe of falcon is more than owl optic lobe, also we found internal pyramidal layer and external pyramidal layer are largest layers in optic lobe of falcon, when compare it with owl optic lobe, pyramidal layer is largest one also, Table (2).

Silver stain: In falcon: we finding after taken cross section from optic lobe of falcon and staining with silver stain, showed high density of neurofibrils (brown to black color) and appears oligodendrocyte among them (dark color) compared with owl optic lobe, figure (4).

In owl: we found optic lobe low density of neurofibrils when compared with optic lobe of falcon, which appear in brown to black color beside to oligodendrocyte among them with dark appearance, figure (5).

Figure 1: Bain of falcon and owl and their optic lobes location, in falcon lie ventral location while in owl was lateral – ventral location.

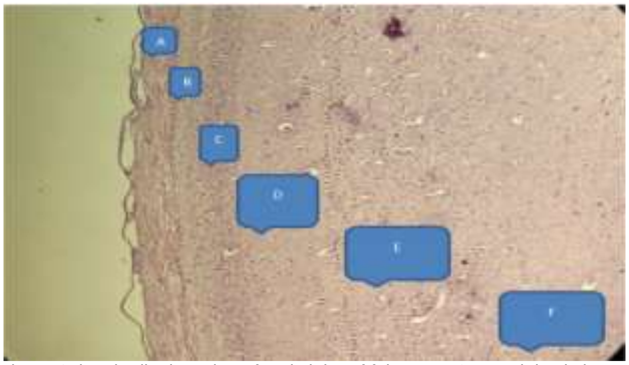

Figure 2: longitudinal section of optic lobe of falcon at 40X, explain six layers of optic lobe A: Molecular layer, B: External granular layer, C: External pyramidal layer, D: Internal granular layer, E: Internal pyramidal layer and F Multiform layer.

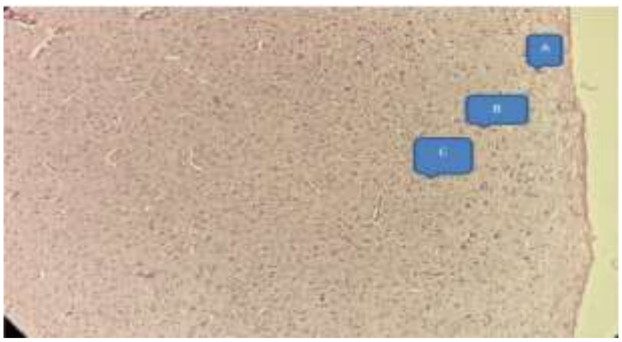

Figure 3: longitudinal section of optic lobe of owl at 40X, explain three layers of optic lobe A: Molecular layer, B: pyramidal layer and C: Multiform layer.

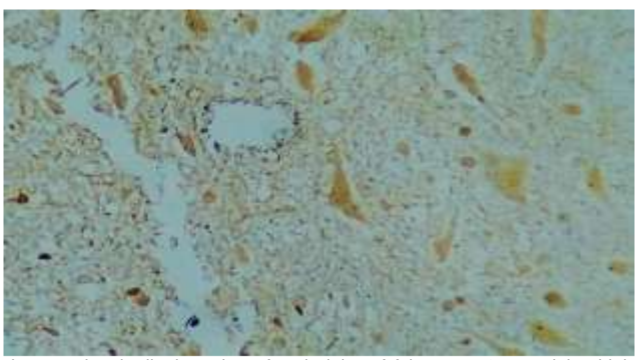

Figure 4: longitudinal section of optic lobe of falcon at 40X, explain high density of neurofibrils when compared with owl (brown to dark color) and oligodendrocyte (dark color).

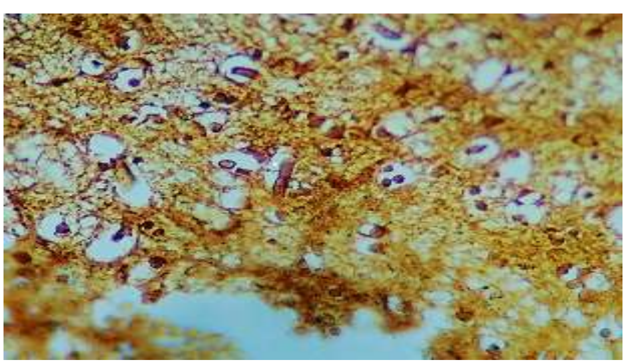

Figure 5: longitudinal section of optic lobe of owl at 40X, explain low density of neurofibrils when compared with falcon (brown color) and oligodendrocyte (dark color).

DISCUSSION

Birds' big and complex brains are unsurprising given their ability to engage in advanced cognitive, social, and motor behaviors. The cerebrum (ortelencephalon) and cerebellum of birds are very big and developed compared to many mammalian species (Reiner, 2005).

Birds' histological and physiological structure vary based on their lifestyle, nutrition, and environment, among other things. Long-distance travel has been shown to be advantageous. Compared to migratory and endemic species, short-distance migratory and endemic birds have smaller brains. The size of a bird's brain is impacted by its migration distance. The rise in the size of these birds, as well as the size of the height of the wings and the optic lobe, has an influence on the average migratory distance species within diverse birds (Vincze et. al., 2015). Under the cerebral hemispheres, the optic lobes were largely veiled(Gupta et. al. 2016).

In the recent study, we found different in weight and length of brain in falcon and owl which be they studded , maybe these differences refer to different distance which be migration to it, table (1) so falcon have less weight brain than owl because it migrated to long distance. Also optic lobe was effected by distance which be traveled, but in different way, in falcon which be migrated to long distance, optic lobe was bigger than optic lobe of owl.

We can't founded match study to our work, so our suggestion that falcon needs to high resolution of vision, so it need to high process these vision by developing optic lobe and that explain why weight of optic lobe of falcon more than owl. But we note length of optic lobe for each birds was same, and that is maybe return to location of optic lobe figure, (1). Each birds have optic lobe in midbrain and that's match to another studies.

In our study we found optic lobe of falcon consist of six layers like in mammals and optic lobe of owl have only three layers. optic lobes of falcon and owl have been taken as longitudinal section after removed from their brains, we note different between there, falcon optic lobe consist of six layers (Molecular layer, External granular layer, External pyramidal layer, Internal granular layer, Internal pyramidal layer and Multiform layer) when compare it with optic lobe of owl which be consist of three layers (pyramidal layer, granular layer and Multiform layer), that's mean optic lobe of falcon is more developed than owl by our opinion, figure (2). Because haven't been found relative research, we thought these different return to style of life, falcon belong to diurnal birds which need high ability vision and high process, in additional to migrate for long distance, so it have six developing layers.

These findings proved to other studies which refer to developing of optic lobe "The broad optic lobes of avian species are due to the fact that birds have a highly developed sense of vision" (Abd-Alrahman, 2018) .

Also in 2005; Jarvis et. al. display " in compared to reptiles, the cerebrum of birds is comparable to that of mammals. The increasing size of avian brains was once thought to be due to expanded basal ganglia, with the rest of the brain remaining primitive, however this theory has since been debunked".

In mammals, the input from distant regions enters the cerebral cortex primarily at a specific degree of cortical thickness, as it does in other cortices. Likewise, the output to other areas of the brain comes at a different level. The well-known laminar structure of the cerebral cortex is based on this division between input and output levels, as well as the levels where the majority of the cortex's internal traffic occurs. The most frequent differentiation is one of six levels, which are numbered from the top down (typically in Roman numerals) (from the free surface to the white matter). The following are the key distinguishing characteristics of the several levels in terms of input and output: Communication between distant portions of the cortex within or between hemispheres is handled by the higher layers, layers I to III. Layer IV is the level at which sensory input fibers end (relayed from the thalamus) or fibers primarily from other sections of the cortex relay such information directly. Fibers from Layer V are sent to the basal ganglia, as well as other areas of the brain and the spinal cord. Layer VI connects with the thalamus as well as the above levels(Schüz and Braitenberg, 2001).

In our study, have been found different in thickness of layers of optic lobe for both falcon and owl. we can't founded any match study to our work, so we suggest that different in histology section of optic lobe in falcon and owl belong to nature of life and ability to fly at high and long distance.

CONCLUSION

Falcon is flying for long distance which it be need to have low weight of brain and have high vision makes it possessing developing optic lobe when comparative with owl.

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