Annals of R.S.C.B., ISSN:1583-6258, Vol. 27, Issue 1, 2023, Pages. 310 - 316
Received 25 December 2022; Accepted 01 January 2023.

Histological Study of Dorsal Retina in Eye of Brown Falcon, Iraq

Amal Ali Al-Taee [1], Rajaa Ali Moheiseen Al-Taee [2]
[1] Department of Biology, Collage of Science, University of Babylon, Babylon, Iraq
[2] Medical Department, Hammurabi Medical Collage, University of Babylon, Babylon, Iraq
Emails: sci.amal.ali@uobabylon.edu.iq [1], rajaa.altaie@uobabylon.edu.iq [2]

Abstract
The current research project aims to identify the histological structures of the dorsal retina in eye of brown falcon (*Falco berigora*). The results showed an existence of blood vessels in retinal tissues with presence a pair of layers in dorsal retina. The retina is comprised up double mainly layers; outer layer as a pigmented epithelium (PE) in addition to inner layer as neural layer that compromised of nine layers vision cells, which are constructed up of rods and cones and outer limiting membrane that contains External nuclear layer (ENL), External plexiform layer (EPL), Internal nuclear layer (INL), Internal plexiform layer (IPL), Ganglion cell layer (GCL), Optic nerve fiber layer (ONFL), and Inner limiting membrane (ILM). PE comprises the cells of cuboidal epithelium, and cytoplasmic extensions extend from its inner surface towards the optic cells. The visual cell layer contains rods and cones. Outer plexiform layer (OPL) is thinner than inner plexiform layer (IPL), and numbers of row of outer nuclear layer is less than those found in inner nuclear retinal layer of falcon. As a result, we conclude that difference in visual cell density has been linked to improved visual acuity and sensitivity to light intensity.

Keywords: Birds, *Falco berigora*, Histology, Rods and cones

Introduction

The preponderance of birds is diurnal and have accommodativeness for tetrachromatic color vision and supernormal visual acuity in glary light. Themorphology of their eye, types of receptors and visual pigment spectral tuning are completely uniform: cone photoreceptors largely outnumbered rod photoreceptors that are used for the vision in dimer light (Hart, 2001).

Birds outperform mammals when it comes to monitoring small objects moving quickly and recognizing targets in dimly lit environments. For instance, raptors may easily spot prey moving quickly on the ground while flying thousands of meters in the air (Fernandez-Juricic, 2012). For instance, eagles and falcons have twice the visual acuity of monkeys (Gaffney and Hodos, 2003).

Birds, like other vertebrates, have three primary visual pathways: The thalamofugal route connects the retina to the thalamic main optic nucleus (OPT) and the visual Wulst (Reiner *et al.,* 2005). When the eyes are located on both sides of the head, each eye sees the visual field facing it, giving binocular vision, as seen in several fishes, reptiles, amphibians, birds, and mammals (Saadatlou and Shahrouz, 2016).

Materials and methods

Samples

The brown falcon served as a model for carnivore birds in the current inquiry. It was anesthetized with chloroform, and the feathers were cut with scissors before the skull was smashed with a cutter. The skull bones were carefully separated from one another and removed. The associated nerves to the brain were also cut with fine forceps and sharp scissors (Al-Nakeeb and Jasim, 2018). The eye was removed from orbit, washed, and kept in petridish with filter paper (Taha and Hamid, 2020).

Annals of R.S.C.B., ISSN:1583-6258, Vol. 27, Issue 1, 2023, Pages. 310 - 316
Received 25 December 2022; Accepted 01 January 2023.

Histology

The specimens were processed for histological staining. The blocks were sectioned at 5µm thickness and stained with routine stain (Mayer's Hematoxylin and Eosin) for general features study (Bancroft and Stevens, 2010). The layer thickness of different layers of retina was done by using ocular micrometer after calibration.

Statistical Analysis

The findings were presented as Mean SE. According to the version 23 of the Statistical Package for Social Science (SPSS) software, the statistical analysis was conducted using the Analysis of Variance (ANOVA) test at least significant differences (Gharban *et al*., 2023).

Results and Discussion

The findings of histological study showed that the dorsal retina in eye of the brown falcon was vascular (Figure 1), as is the case in most birds, and this is what distinguishes the retina in birds (Al-Sheikhly *et al.*, 2014). It is supplied with oxygen and nutrition from a multi-fold hemoglobin structure rich in blood vessels, which locate upside optic nerve, extend to vitreous fluid called the "pectin oculi" of eye (Dayan and Ozaydin, 2013). This result was agree with the results found in *Gallus domesticus* (Abd and Abd Al Majeed, 2010; Shehan, 2012). While, the retina of humans and mice is characterized by vascular, complex tissue consisting of several layers of cells responsible for absorbing light and transmitting it in the form of signals to the brain (Treuting, and Dintzis, 2012). The retina in the falcon compose of two major layers: (the outer layer, the pigmented epithelial layerandan inner nerve layerthat divides into nine layers (Figure 2). Nine layers are the visual cells layer consisting of rods and cones; ENL, EPL, INL, IPL, GCL, ONFL, and ILM (Hassan, 2023; Szabadfi *et al*, 2015, She *et al*., 2014, Saenz-de-Viteri *et al*, 2014, Oliveira *et al*, 2014).

Figure (1): Longitudinal section illustrating the histological structure of pectine in eye of falcon. H and E. 10X

The pigmented epithelium layer is made up by unique cell rows of cuboidal epithelium and oval nuclei that are low and rest on a basement membrane. Numerous cytoplasmic elongations extend from the surface of the basement membrane between the visual cells, and the layer is distinguished by the presence of pigmented particles in the falcon (Figure 3), this layer absorbs the scattered light

Annals of R.S.C.B., ISSN:1583-6258, Vol. 27, Issue 1, 2023, Pages. 310 - 316
Received 25 December 2022; Accepted 01 January 2023.

passing through the neural layer and removes the roots, the free ones (Mescher, 2013; El-Beltagy, 2014).

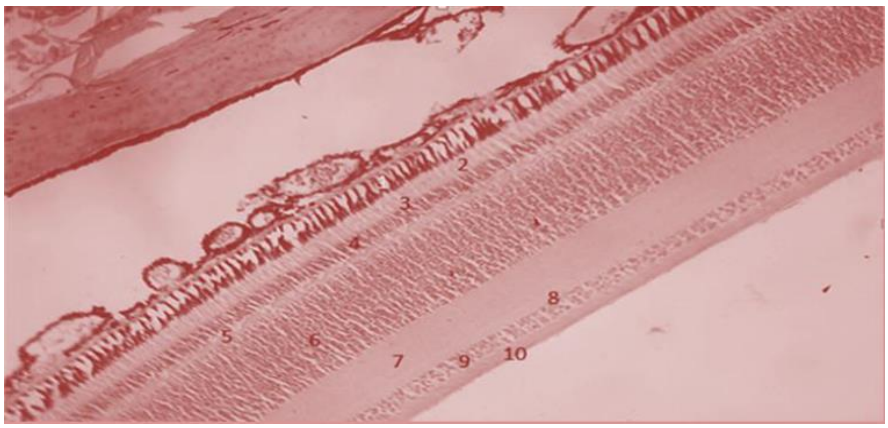

Figure (2): Longitudinal section in retina of *Falco berigora*, (1) epithelial pigment, (2) optic cell layer, (3) outer limiting epithelium, (4) outer nuclear layer, (5) outer plexiform layer, (6) inner nuclear layer, (7) inner plexiform layer, (8) ganglion cell layer, (9) optic nerve fiber layer, (10) inner limiting envelope, stained with hematoxylin-eosin. 40X

In neural retina, there were 9 layers; layer of visual cells (optic layer) composed from elongated cells of rods and cones, each one has outer piece overlaps and extension of pigmented cells of epithelium and inner part. Distributing of rods and cones differs depending on area, from one segment to another in the retina of a falcon bird, and outer pieces of cones are conic in shape and more extensive than rods that having cylindrically and thinner (Figure 3). It distinguishes birds with diurnal activity (Jones, 2007; Alix *et. al*., 2017). Therefore, the falcon has eagle-eyed day time, and this construes its ability to prey. In the neural retina of animals with nocturnal activity, the layer of visual cells consists of long, thin rods and no cones (Gali, 2014). The rods' sensitivity to low light levels is important when distinguishing between dark and light intensities (Mescher, 2013). The layer of outer limiting membrane is lighter in color and inconspicuous at particular regions to separate outer nuclear layer from visual cells layer (Figure 3). It consists of protrusions of Müller cells (Mescher, 2013). An outer plexiform layer lies between outer limiting membrane and outer nuclear layer (López *et. al*., 2008).

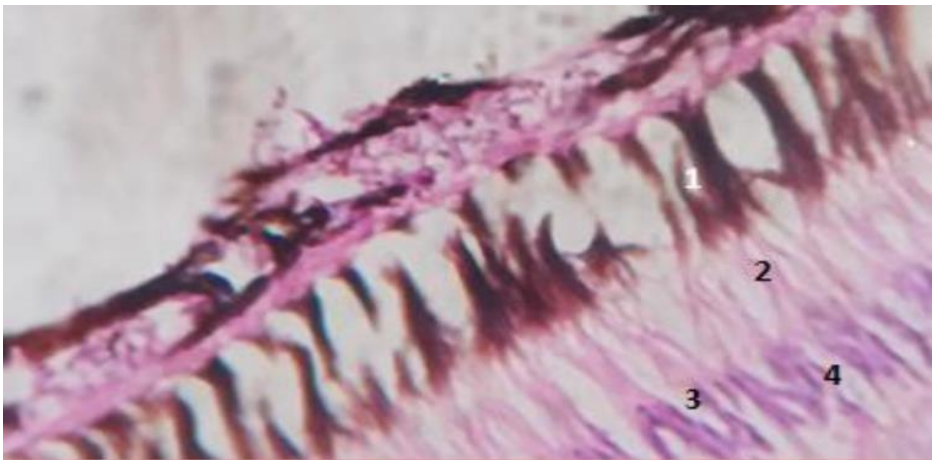

Figure (3): Longitudinal section shows retinal layers of falcon; (1) epithelial pigment, (2) visual cells layer, (3) outer limiting epithelium, (4) outer nuclear layer, stained with hematoxylin-eosin. 400X

Annals of R.S.C.B., ISSN:1583-6258, Vol. 27, Issue 1, 2023, Pages. 310 - 316
Received 25 December 2022; Accepted 01 January 2023.

As for the outer nuclear layer, it composes of bodies of visual cells, and number of rows of cells is 4 in the falcon bird (Figure 4), and this variation in the number of rows reveals a variation in the density of the visual cells (Treuting, and Dintzis, 2012; Alix *et al*., 2017); which perhaps because the falcon depends on the bright vision for feeding. Animals with nocturnal activity depend on low vision for feeding, and this is associated with the presence of many rods. The outer plexiform layer is arrow and axons of visual cells intertwine with dendrites of both bipolar cells and horizontal cells (Figure 5) and this is consistent with Mescher (2013). As for the inner nuclear layer, it is distinguished by its compact and variety cells, consisting of horizontal cells, bipolar cells and amacrine cells, and the number of rows ranges from 25 in the falcon (Figure 4), and this differs from the number in the retina of the kestrel, magpie and bird. The collared phalanx (Al-hamadany, 2012; El-Beltagy, 2014), and differs from its number in mice and humans (Treuting, and Dintzis. 2012). The inner plexiform layer (IPL) is thicker than outer plexiform layer (OPL), and includes a network of axons of each of cells without protuberances with ganglion cells and bipolar cells (Figure 5). It consists of bipolar and multitubercular cells with ganglion cell dendrites (Treuting, and Dintzis. 2012; Park *et. al.,* 2014). The ganglion cell layer consists of one row of ganglion cells, and its cells are distinguished by clear nuclei and their large size (Figure 5), this thickness depends upon denseness of cells in the outer and inner nuclear layers (Al-hamadany, 2012; Kim *et al.*, 2021). In ganglion cells, axons gather to constitute thelayer of nerve fiber, which increases in thickness as it back down to form the nerve that leaving eye to reaches brain. This is similar to that indicated by Mescher (2013) and the specific membrane layer. The inner layer that separates the vitreous fluid from retina, and is a basal plate of Muller cells that appear as large supporting cells extend within inner and outer limiting layers, with existence of nucleus situates at inner nuclear layer (Figure 5), and this is consistent with Treuting, and Dintzis (2012) and Beltagy (2014) in the Falcon. The morphological results of the thickness of the retinal layers showed that the inner nuclear layer is the thickest one (Figure 6).

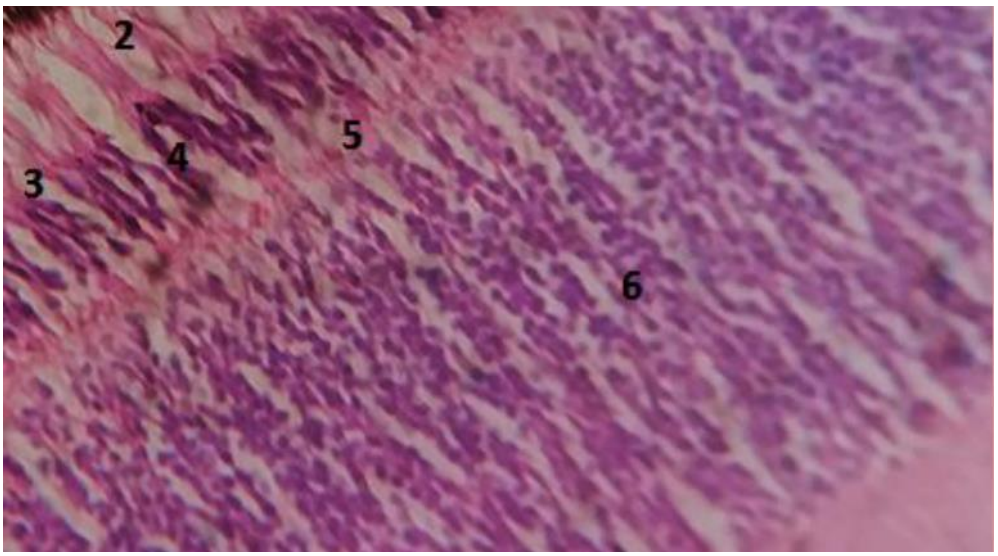

Figure (4): Longitudinal section shows retinal layers of eye in *Falco berigora* (2) optical cell layer, (3) outer limiting cover, (4) outer nuclear layer, (5) outer plexiform (6) inner nuclear layer, colored Hematoxylin-eosin. 400X

Annals of R.S.C.B., ISSN:1583-6258, Vol. 27, Issue 1, 2023, Pages. 310 - 316
Received 25 December 2022; Accepted 01 January 2023.

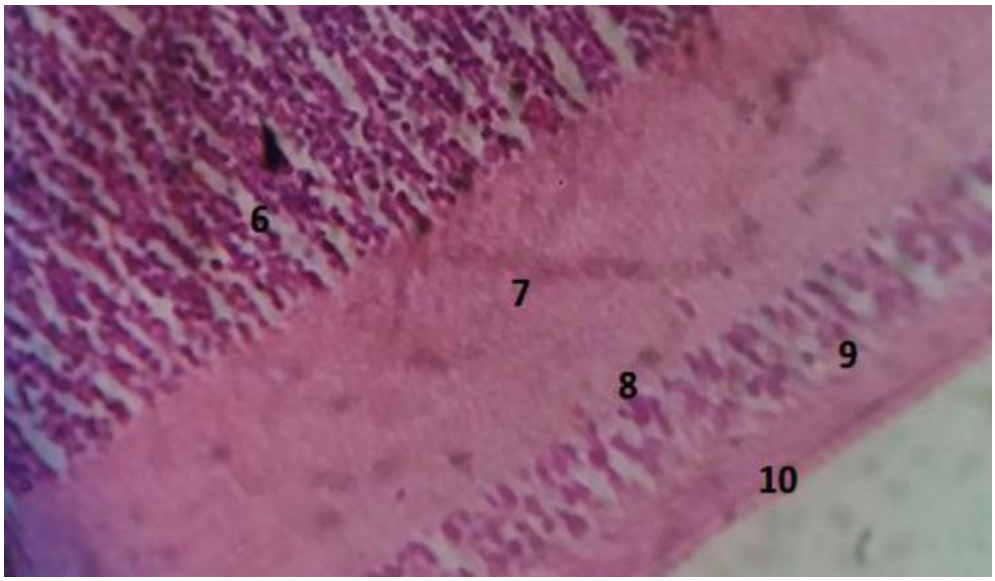

Figure (5): Longitudinal section shows retinal layers of falcon, (6) inner nuclear layer, (7) inner plexiform layer, (8) ganglion cells layer, (9) optic nerve fiber layer, (10) inner limiting envelope, Hematoxylin-eosin stain. 400X

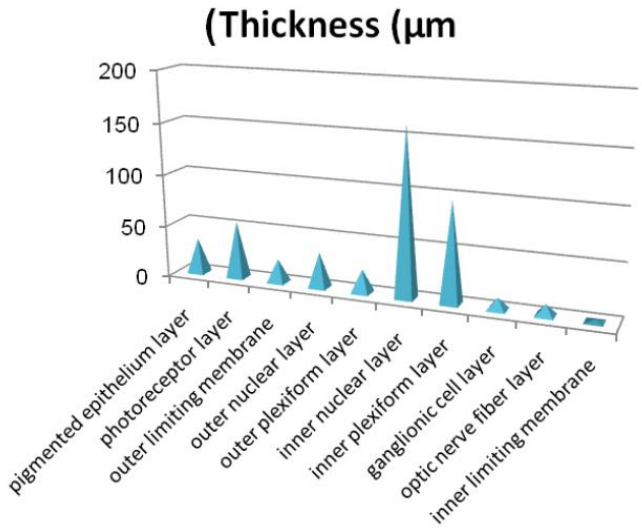

Figure (6): The thickness of the retinal layers (µm)in the brown falcon eye

Reference

1. Abd, A. A.;Abd Al Majeed,S.A. (2010). Anatomical, Histological Study Eye of the Bird Corncrake *crexcrex* J. of Al-Raffidian sience.21(4):6-21
2. Abed, A. A. ; Ahmed D. F. and H. M. Hamodi. (2010). Anatomical and histological study of eye structure in the Iraqi pin – tailed sandgrouse bird Pteroclesalchatacaudarus. Tikrit Journal of Pure Science. 15(2):246 – 260.
3. Al-hamadany, A. M. T. A. (2012). Comparative Anatomical, Histological with Developmental Study at Light and Electron Microscopic Level of Eye and Alimentary Canal for three Species of Birds which Differ in Nutrient Nature. pp: 82- 104,141-166.
4. Al-jaboori, Sh. A. A. (2014). Comparative Morphological and Histological Study of the Eye in two Species of Iraqi birds (Falco tinnunculus L. and Streptopeliadecaocto F.). M.Sc.

Thesis. College of Science for Women. Baghdad university. pp: 50-81,97-99.

5. Al-Robaae, S. J. M. ; Mirhish, Sh. M. and Rajab, J. M.. (2012). Histological studies on the ciliary body of the falcon "S Eye ball (Circus Cyaneus C.) under light and electron microscopy. The Iraqi Journal of Veterinary Medicine, 36(2):83 – 92 .
6. Al-Sheikhly, O. F. and M. Kh. Haba. (2014). The Field Guide to the Wild Mammals of Iraq. Faraaheedi house publishing and distribution / Baghdad . pp: 54 .
7. *Bonney, R.; Rohrbaugh, Jr., Ronald, (2004), Handbook of Bird Biology (2nd ed.), Princeton, NJ: Princeton University Press.*
8. Charng, J.;Nguyen, C.; Bui, B.V. and Vingrys, A(2011).Age-lated retinal function cha nges in albino and pigmented rats.Invest.,Ophthalmol,Vis,Sci.Vol.52(21):8891-8899.
9. Cuenca,N.;Pinilla,L.;Sauve,Lu.b.;wang,S. and Lumd,R.D. (2004).Regressive and reaction changes in the connectivity patterns of rods and cones pathways of rat retina.NeuroScience,127:301-317
10. Dayan, M. O. and Ozaydin ,T.. (2013). A Comparative Morphometrical Study of the Pectin Oculi in Different Avian Species. The Scientific World Journal. pp:1-5.
11. Fernandez-Juricic, E., 2012. Sensory basis of vigilance behavior in birds: synthesis and future prospects. Behav. Process. 89, 143–152.
12. Fleming, M.D.;Benca,R.M. and Behan,M. *(*2006).Retinal projectons to the subcortical visual system in congenic albino and pigmented rats.Neuroscience,143(3):895-904.
13. Gaffney, M. F., and Hodos, W. (2003). The visual acuity and refractive state of the American kestrel (*Falco sparverius*). *Vision Research, 43*(19), 2053–2059.
14. Gali, M. A. and Dauod, H. A. M.. (2014). Comparative Anatomy of Chordates, 2nd ed., Dar Al – Doctor the Administrative and Economic Sciences, Pp: 800 – 823.
15. Gharban, H. A., Al-Shaeli, S. J., and Hussen, T. J. (2023). Molecular genotyping, histopathological and immunohistochemical studies of bovine papillomatosis. *Open Veterinary Journal*, *13*(1), 26-41
16. Hart, N. S. (2001b). The visual ecology of avian photoreceptors. *Progress in Retinal and Eye Research, 20*, 675–703.
17. Harvey, A.(2004). The rat nervous system,Champ.32,Visual system,3d ed.Elsevier press.
18. Jones, M. P.; Pierce, K. E. and Ward, D. (2007). Avian vision: A review of form and function with special consideration to birds of prey. J. Exotic. Pet. Medicine. 16(2):69 – 87 .
19. Jones, M.P.; Pierce, K.E. Jr. and Ward, D.(2007). Avian vision: a review of form and function with special consideration to birds of prey. *J Exotic PetMed.*;16(2):69–87.
20. Kandel, E.R.;Schwart,J.H. and Jesel,T.M (2000). Principles of neural science. 4th.ed.Mc.Graw.Hill.NY,515-520.
21. Kardong, K. V. (2012). Vertebrates Comparative Anatomy, Function, Evolution, 6 th ed., McGraw – Hill . pp 681 – 690.
22. Kiama, S. G.; Maina, J. N.; Bhattacharjee, J.andWeyrauch, K. D. (2001). "Functional

morphology of the pecten oculi in the nocturnal spotted eagle owl (Bubo buboafricanus), and the diurnal black kite (Milvus migrans) and domestic fowl (Gallus gallus var. domesticus): a comparative study". Journal of Zoology. 254: 521–528.

23. Kim, K. H.; Puoris'haag, M.; Maguluri, G. N.; Umino, Y.; K.; Cusato Barlow, R. B. and de Boer, J. F.. (2008). Monitoring mouse retinal degeneration with high-resolution spectral-domain optical coherence tomography. Journal of Vision, 8(1):17, 1–11.
24. Mescher, A. L. (2013). Junqueira's basic histology Text and Atlas, 13th ed., McGraw Hill. pp: 489 – 494.
25. Oliveira, F. G.; Andrade, B. L. ; Cavalcante, J. S.; Silva, S. F.; Soares, J. G.; Lima, R. R. M.; Nascimento, Jr., E. S.; Cavalcante, J. C.; Resende, N. S. and Costa, M. S. M. O. (2014) . The eye of the crepuscular rodent rock cavy (Kerodonrupestris) (Wied, 1820) . J. Morphol. Sci., 31(2): 89-97.
26. Payne, B.R. and Rushmore,R.J.(2002). The special relation ship between β retinal ganglion cells and cat prmary visual cortex.561-607.
27. Reiner, A.N.;Yamamoto, K. and Karten,I.J.(2005):Organization and Evolution of the Avian Forebrain. The Anatomical Recoed Part A 287A:1080–1102.
28. Saadatlou,M.A.E. and Sahrouz,R. (2016).Histoanatomical study of the lens and ciliary body in ostrich eye. Veterinary Research Forum. 2016; 7 (3) 221 - 226
29. Saenz-de-Viteri, M. ; Heras-Mulero, H.; Fernández-Robredo, P.; Recalde, S.; Hernández, M.; Reiter, N.; Moreno-Orduña, M. and García-Layana., A. (2014). Oxidative Stress and Histological Changes in a Model of Retinal Phototoxicity in Rabbits . Oxidative Medicine and Cellular Longevity . pp: 1-10.
30. Samuelson, D.(1991). Ophthalmic anatomy. In: Gelatt KN, ed: *Veterinary Ophthalmology.* 3rd ed. Baltimore, MD, Lippincott Williams and Wilkins,;31–150.
31. Shaimaa, A., A.(2018). Comparative Histological Study of the Retina in the Two Types of Iraqi Vertebrates. International Journal of Science and Research,7(1): 2319-7064
32. She, Q.; An, Z.; Xia, C.; Kong, Y. and Chen, E.. (2014). Study on comparative histology of retinas in Ctenopharyngodonidella, Cynopsorientalis, Bufobufogargarizans, Gekko japonicas and Columba livia. Internationa journal of Morphology, 32(3):918-922.
33. Shehan, N. A. (2012). Anatomical and histological study of eye in local chickens (*Gallus domesticus*) at Basrah city. AL-Qadisiya Journal of Vet.Med.Sci. Vol.11. No.2.
34. Szabadfi1, K. ; Estrada, C.; FernandezVillalba ,E.; Tarragon, E.; Setalo, Jr. G.; Izura, V.; Reglodi, D.; Tamas, A.; Gabrie, R. and Herrero, M. T.. (2015). Retinal aging in the diurnal Chilean rodent (Octodon degus): histological, ultrastructural and neurochemical alterations of the vertical information processing pathway. Frontiers in Cellular Neuroscience. 9 (126): 1-14.
35. Treuting, P. M. and Dintzis ,S. M.. (2012).Comparative Anatomy and Histology A Mouse and Human Atlas, 1st ed., Elsevier Inc. pp: 403 – 405. 22.