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A Comparative Qualitative Study of Layers of Retina of Nocturnal and Diurnal Birds

Narasinga Rao B*, Pramila Padmini M

Department of Anatomy, Maharajah's Institute of Medical Sciences, Nellimarla

ABSTRACT

Vertebrates as is well known have been classified into Icthyopsida, Sauropsida and Mammals on the basis of structure of the eyes. Amongst, Aves like, Aquilla (Hawk), Bubo bubo (Indian Owl) were chosen for the study. The eye balls of Aquilla and Bubo Bubo were enucleated under anesthesia such as chloroform and fixed in 4% solution of formalin in 0.9% sodium chloride for 24 hours. Then the eye balls were subjected to histological protocol. Microscopic observations of retina of Aquilla revealed domination of duplex type cone and that of Bubo Bubo showed domination of rod. The cell domination of photoreceptors is purely dependent upon habitat of the animal. In the present study, in Hawks where highest acquity is required, maximum cone domination is observed whereas Bubo bubo having scotopic vision, domination of photoreceptors is towards rods, since rods are the ones, which are responsible for dark adaptation. In both retinas of Aquilla and Bubo Bubo, inspite of domination of photoreceptors consequent to the habitat of the animal it is found that the retinas are not purely cone dominated in aquila and not purely rod dominated in bubo bubo and in both minimum percentage of other variety of photoreceptors are found leading to a duplex type of retina. Duplex retina is thought to be the dictum of mammals till now. However, the finding of duplex type of retina in the birds leads to the change in the domination of single photoreceptor cell.

Keywords: Cones, Photoreceptors, Retina, Rods, Scotopic

***Corresponding author**
Email: rao.bhattam@gmail.com

INTRODUCTION

The essential constituents of the eye is the centinent layer retina that primarly serves the purpose of photo reception. Vertebrates as is well known have been classified into Icthyopsida, Sauropsida and Mammals on the basis of structure of the eye. The interesting thing is that the eye of each of their types has developed separately and independently [1]. No evolutionary sequence could be seen in the structure of the eyes of each one of them.

The Sauropsidian eye is the most efficient as an optical mechanism. Birds have the efficient focusing apparatus pectin, instead of retinal system of vessels and the retina has the highest visual acuity [1]. The eyes of mammals are not fully so developed as those of birds but their anatomical simplicity is more than compensated by the efficiency of central nervous organization of vision [1]. Because of the scintillating architecture of the retina, the present comparative study of Aquilla and Bubo Bubo has been taken for the study. Owl retinas have been examined histologically by a number of investigators [2-6]. All reported retinas with high concentrations of rods, as would be expected for basically nocturnal animals.

MATERIALS AND METHODS

The eye balls of Aquilla (Hawk), Bubo Bubo (Indian Owl). The samples were collected by the approval of institutional ethics committee. The eye balls have been enucleated under chloroform anesthesia and fixed in 4% solution of formalin in 0.9% sodium chloride for 24 hours. The eye balls were washed for 3 hours under running tap water and each of them was halved and thawed in distilled water for half an hour. Dehydration process of eye balls in 50, 70, 80, 90% grades of alcohol each for 4 hours and in absolute alcohol for 1 hour each with two changes were completed. The eye balls were subjected to clearing in Xylol for an hour each in two changes. Paraffin with melting point of 58 degrees centigrade was used for embedding. The prepared paraffin blocks were kept in deep freeze for uniform hardening of paraffin. Proper care is taken to avoid crystallization. 5-micron thickness sections were cut with rotary microtome. Rods and cones were stained with triple mallory for differentiation. Rods stained orange to red and cones stained blue. The layers were measured by using stage and ocular micrometer.

Abbreviations

PC-Pigment cells
PCL- Pigment cell layer
ONL-Outer nuclear layer
OPL-Outer plexiform layer
INL-Inner nuclear layer
IPL-Inner plexiform layer
GCL-Ganglionic cell layer
ELM-External limiting membrane

RESULTS

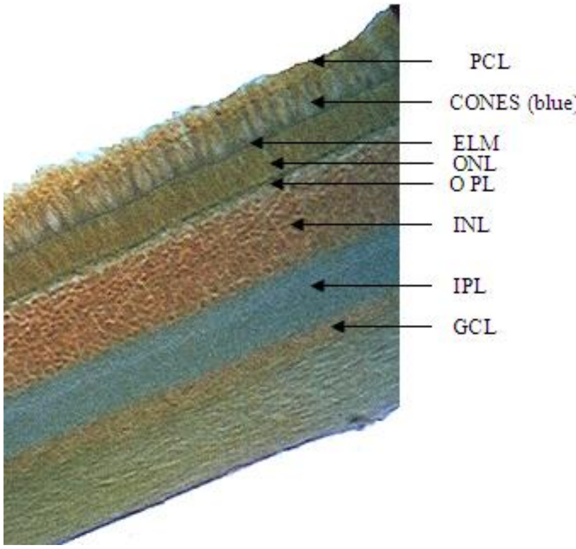

Fig. 1. Fig.1- Retinal layers of Aves Aquilla **(Hawk)**, Triple Mallory stain, 10X10

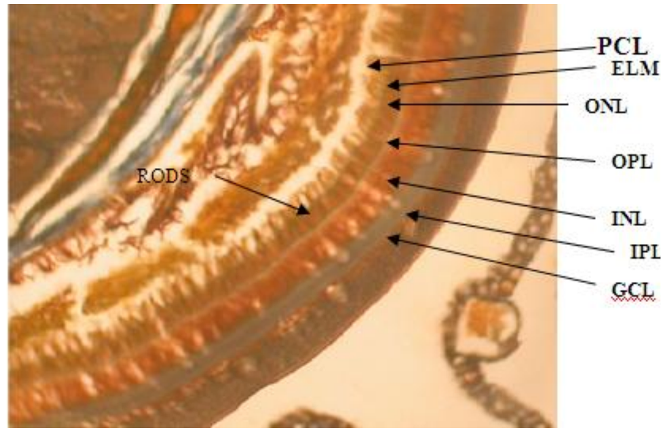

Fig. 2- Retinal layers of **Bubo bubo (Indian Owl)**, Triple Mallory stain, 40X10

Abbrev. ELM- External limiting membrane; PC-Pigment cells; PCL- Pigment cell layer; ONL-Outer nuclear layer; OPL-Outer plexiform layer; INL-Inner nuclear layer; IPL-Inner plexiform layer; GCL-Ganglionic cell layer.

In Aquilla Pigment cells (PC) were single layered and regular. Visual cells were slender. Cones seemed to be dominated and were closely packed. Outer nuclear layer (ONL) was 10 microns thick. External limiting membrane was very clear. Outer Plexiform layer (OPL) was stratified and thin in Aquilla. Inner nuclear layer (INL) was of 20 microns thickness and is formed by Bi-polar, Amacrine and horizontal cells which cannot be differentiated from each other under light microscopic picture. Inner plexiform layer (IPL) was reduced to 12-15 microns in Aquilla (Table-1). Ganglion cells (GC) were large and arranged in 1 – 2 rows in Aquillla (Fig.1).

Table-1 Comparision in the thickness of layers of nocturnal and diurnal birds in the present study

Retinal Layers	diurnal bird **<u>Aves</u>** Aquilla (Hawk)	nocturnal bird Bubo bubo (Owl)
Outer nuclear Layer	10μ	4μ
Inner nuclear Layer	20μ	8μ
Inner plexiform Layer	12-15μ	5μ

Retina of Bubo Bubo showed Pigment cell layer (PCL) which was single celled thick and was seen as separate layer. Visual cells were rods which were prominent and dominated the outer nuclear layer. Cones are scanty. Outer nuclear layer is 4 microns thick. Outer plexiform layer is thin. Inner nuclear layer was 8 microns thick. Bi-polar Amacrines and horizontal cells were closely packed (Table-1). Inner plexiform layer is 5 microns throughout and stratified in Bubo bubo. Ganglion cells were seen as uniformly placed unilayered row, closely packed (Fig.2).

DISCUSSION

The most notable feature of nocturnal animals is the size of their eyes. Large eyes, with a wider pupil, larger lens and increased retinal surface can collect more ambient light. For example, an owl's eyes fill over one half its skull. The retina of nocturnal animals is almost entirely composed of rods. The other type of vision cells, cones, are absent, leaving nocturnal animals with virtually no color vision [7]. Owl retinas have been examined histologically by a number of investigators [2-6]. All reported retinas with high concentrations of rods, as would be expected for basically nocturnal animals. However, Fite [5] and [4] pointed out that owl retinas did possess very small concentrations of cones, even in the most nocturnal species. Microscopic study of retina of Aquilla is cone dominated and duplex type. A duplex retina is a retina consisting of both rod cells and cone cells. In contrast to duplex retinas, pure rod and pure cone retinas have only rods or cones, respectively. [8]. The retinal photoreceptors of the red-tailed hawk (Buteo jamaicensis) consist of rods, single cones and double (unequal) cones present in a ratio of about 2:1:5 [9]. Single cone is the presence of only one cone cell where as Double cones (DCs) are two cone cells (colour detecting photoreceptors) joined together that may also be coupled optically/electrically. They are the most common type of cone cells in fish, reptiles and birds, and are present in most vertebrates [10, 11] compiled in his work on “owls eyes and vision” that the retina of an owl's eye has an abundance of light-sensitive, rod-shaped cells appropriately called "rod" cells. Although these cells are very sensitive to light and movement, they do not react well to colour. Cells that do react to colour are called "cone" cells (shaped like a cone), and an Owl's eye possesses few of these, so most Owls see in limited colour or in monochrome. In the present study all 10 layers were very distinct in both groups of birds. The retina of Bubo bubo was rod dominated with outer nuclear layer as thick as 4 microns where as retina of Aquilla was cone dominated with outer nuclear layer of 10 micron thickness.

In all nocturnal animals like Bubo Bubo rod domination is maximum to the extent of 94% of the total photoreceptor cell were rods. In cone dominated retina of Aquilla the cones were 98%.

It is inferred that the cell domination of photo receptors is purely dependent upon habitat of the animal. In Hawks where highest acquity is required maximum cone domination is observed whereas in Bubo bubo having scotopic vision the dominant photoreceptors are rods, since rods are the ones which are responsible for dark adaptation. In both retinas of aquila ad bubo bubo, inspite of domination of photoreceptors consequent to the habitat of the animal it is found that the retinas are not purely cone dominated in aquila and not purely rod dominated in bubo bubo and in both minimum percentage of other variety of photoreceptors are found leading to a duplex type of retina. Duplex retina is thought to be the dictum of mammals till now. However, the finding of duplex type of retina in the birds leads to the change in the domination of single photoreceptor cell

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