Chapter-9

FUNCTIONAL STRUCTURES OF THE EYE LENS OF
Anabas testudineus, AN AIR BREATHING
TELEOST OF FRESHWATER HABITAT.

INTRODUCTION

The photo-environment in fish live is probably more varied when compared with that of any vertebrates. Some of them are inhabitants of clear streams water and the surface of water bodies, where penetration of light is quite high. Some are bottom dwellers or inhabitants of turbid water bodies with poor illumination, while some change from an environment of very low light levels to that with a very high light intensity. Due to their exposure to very different light conditions fish adapt themselves to great extent, which give rise to diversity in structure and physiology of visual system. Like any other ocular tissue the refractive structures (cornea and lens) also shows chemical specialization as well as structural modifications in response to photo-adaptation and also may act as an interference filter in the eye, reduce reflection at the eye surface, help in the reflection of specific wavelengths from regions behind the receptive cells and play a role in selective light absorption (Bernhard et al., 1965; Kennedy and Milkman, 1956; Somiya, 1976; Lythgoe, 1972; and Dey et al., 1994).

Unlike terrestrial vertebrates, the principal refractive structure in the fish eye is the lens, since little refraction takes place at the cornea whose refractive index is approximately equal to that of water. Hence in fish, specialization in the dioptric apparatus in response to photo-adaptation is expected more in the lens than in cornea. However structural specialization in response to optical phenomena other than refraction has been described in some fish cornea (Lythgoe, 1972).
Several studies on the specialization of the dioptric apparatus in response to photo-adaptation in fish exist in published literature. However very few investigations have been carried out in air breathing fish. The present work reports the occurrence of some spherical particles in the lens of the air breathing teleost *Anabas testudineus*, which may act in the scattering of light according to Rayleigh (1911).

**AIMS AND OBJECTIVES**

Although many studies have been carried out on lens of fishes yet very less investigation is carried out in air breathing fishes, so with a view to study the lens of air breathing fish the investigation has aimed at the following:

1. The shape and sizes of the lens of the air breathing fish *Anabas testudineus*.
2. Organization and the nature of the lens.
3. Nature and density of some granules or particles observed in the lens of this air breathing fish.
4. The size of these particles, their distribution pattern and function.

**MATERIALS AND METHODS**

**Scanning electron microscopy:**

The lenses were excised from the eyes and were cut with a fine razor blade and secured horizontally to a brass stub (30 mm diameter x 20 mm high) with the help of double adhesive tape. The samples were placed, with the cut surface facing the electron beam of the microscope. A thin electroconductive metal coating was applied to each specimen using gold as a target metal in an ion sputter coater, JFC 1100 (Joel). Observation were made with a scanning electron microscope JSM-35CF (Joel) using the secondary electron emission mode at an accelerating voltage of 15 kv and at a working distance of 15 mm. Twenty individual fish representing both males and females were used for study.
**OBSERVATION**

**Scanning electron microscopy:**

The cut surface of the lens is examined by *scanning electron microscopy* (SEM), which shows that the lens is spherical in shape and is about 2mm in diameter (Fig 9.1). The medulla and cortex are well organized. Crystallinity of the lens fiber is prominent in both medulla and cortex. The magnified lens fiber contained densely packed spherical granules randomly distributed throughout the lens. The density is found to be ~ 5,000 per mm², and is more or less the same for all twenty individual fish examined. The granules are 0.02 to 0.65µm in diameter (Fig 9.2). A comparison of the size of the spherical bodies detected in the lens of *Anabas* indicates that they can scatters incident radiation of wavelengths 0.5µm or less, i.e UV-visible radiation (Table 9). Furthermore, the particles are 1.0 to 1.9µm apart from one another.

**Figure:** 9.1. Showing the spherical shaped lens of *Anabas testudineus.*
Figure: 9.2. Showing numerous granules of varying sizes in the lens of *Anabas testudineus*. Bar = 10.0 μm

Table: 9. A comparison of particle size in *Anabas testudineus* lens with the suggested upper size limit (Stroble, 1973) of particles responsible for scattering at different wavelengths.

<table>
<thead>
<tr>
<th>Incident radiation: Wavelength (μm)</th>
<th>Spectral region</th>
<th>Upper size limit of particles responsible for scattering (μm)</th>
<th>Range of particle size in lens (μm)</th>
<th><em>Anabas</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Infrared</td>
<td>15.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td>Visible</td>
<td>0.15</td>
<td>0.20-0.15</td>
<td></td>
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<tr>
<td>0.001</td>
<td>X-ray</td>
<td>0.002</td>
<td></td>
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DISCUSSION

Lens of Anabas testudineus, an air breathing teleost is spherical in shape and is about 2mm in diameter. The medulla and cortex are well organized. Crystallinity of the lens fiber is prominent in both medulla and cortex. The magnified lens fiber shows presence of some granules of sizes 0.02-0.65μm in diameter indicates presence of some spherical scatters. The density of the granules is about 5000 per mm sq.

The size of the spherical particles (0.02-0.65μm) and their pattern of distribution in the lens indicated that they might act in spherical scattering of the light (Rayleigh, 1911). The size of the particles and their distribution pattern suggested they functioned in spherical scattering of light. The presence of these spherical granules indicates that since reflection usually does not take place by the lens, some portion of the light is scattered from the lens to regulate the quality and quantity of light entering the retina of the air-breathing teleost Anabas testudineus. The physical principle of scattering suggests that like reflection and refraction, scattering has its origin in the induced secondary emission of light from particles, which lie in the path of radiation. However, scattering takes place only when the dimensions of the particles are equal to or smaller than the incident wavelength, and the refractive indexes of the particles are different from that of the medium where they are randomly distributed. We have reported the lens studies of some more freshwater fish. In our earlier studies in Acrossocheilus hexagonolepis (Goswami et al., 1998 & 2000).

If the dimensions of the particles are larger than the wavelength of the incident radiation, the lateral rays originating from the secondary emission of atoms mutually cancel through destructive interference leaving only a reflected and refracted beam. Incident radiations are reflected from those particles whose dimensions are greater than 2λ whereas scattering is caused by particles whose dimension are smaller than 3λ/2. It is known that in a collection of particles of different sizes the scattering efficiency will be higher for larger particles. However, if the size of the particles is larger than incident wavelength, or if the particles are brought closer together, there will be lateral destruction, which will
give rise to a more clearly defined transmitted beam. Thus, there will be no scattering and an ordinary situation of a single refracted beam will result (Strobel, 1973).

In the present study, it was observed that the size of the spherical bodies in each lens is not larger than the incident wavelength and also the particles are not closely juxtaposed. This suggests that the particles may act as spherical scatters in the lens. The possibility which exists for light rays incident on transparent structures like lenses are that small percentage of the radiation may be absorb in the system, other rays will be reflected or scattered and the remainder will be transmitted.

Reflection usually does not take place from ocular refractive structures (cornea and lens), except for a very small percentage from the surface in the region of a sharp transition in the refractive index (Miller, 1979). Therefore, it is logical that the part of the incident light rays, which escape from the lens of air breathing fish, is through scattering.

The classical analysis of scattering by Rayleigh (1911) showing that the blue colour of sky was due to the scattering of sunlight by air molecules, and this is also applicable to ocular media has not been investigated in detail, Fischcher and Horstman (1971) recorded the occurrence of densely packed spherical granules in the core of the crystalline cone of many arthropods. The granules were small with respect to the wavelength of light, and their numbers were high. On the basis of their dimensions and large numbers, it was suggested that the theory of Rayleigh scattering was applicable to these structures. Similar structures were found in the gull cornea by Miller (1979). The dimensions and dense numbers of the spherical particles described in the lens of Anabas testudineus were comparable with those observed in the core of the arthropod crystalline cone and the cornea of the gull.

The present study provides the first report on the occurrence of spherical scatters in air breathing fish. *A. testudineus* is an inhabitant of swampy turbid water so the spherical scatters in the lens may be an adaptive feature to regulate the quality and quantity of light entering its retina.
SUMMARY

1. Lens of *Anabas testudineus*, an air breathing teleost is spherical in shape and is about 2mm in diameter.

2. The medulla and cortex are well organized.

3. Crystallinity of the lens fiber is prominent in both medulla and cortex.

4. The magnified lens fiber shows presence of some granules (0.02-0.65μm) in diameter indicates presence of some spherical scatters.

5. The density of the granules is about 5000 per mm sq.

6. The size of the particles and their distribution pattern suggested they functioned in spherical scattering of light.

7. The presence of these spherical granules indicates that since reflection usually does not take place by the lens some portion of the light is scattered from the lens to regulate the quality and quantity of light entering the retina of the air breathing teleost *Anabas testudineus*. 