Photoreceptor Fine Structure in the Goldeye (*Hiodon alosoides*) (Teleost)

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**Summary.** The retinal photoreceptors of the goldeye (*Hiodon alosoides*) are arranged in large bundles of 40–50 cells optically isolated from other bundles by the retinal epithelial cells. Within each bundle are found both rods and cones in roughly equal numbers. Rod photoreceptors show marked retinomotor responses to project beyond the photoreceptor bundle in light-adaptation and to lie entirely within the bundle in dark-adaptation. In all stages of the light cycle cone outer segments remain at the apex of the photoreceptor bundle. In light-adaptation, rod inner segments display an apical ellipsoid separated from a basal ellipsoid by the greatly elongated myoid. In dark-adaptation the rod inner segment is much the same diameter throughout its length. In both rods and cones, profiles of rough and smooth endoplasmic reticulum and Golgi zones are present in a supranuclear location. The nuclei of rods display little heterochromatin and are located vitreal to the external limiting membrane in light-adaptation, whereas in dark-adaptation more heterochromatin is noted and the nuclei lie scleral to the external limiting membrane. Cone nuclei display the same changes in chromatin pattern as rods but they show changes in nuclear location opposite that of the rods. Throughout its length, the rod photoreceptor cytoplasm is more electron dense than that of the cone. The synaptic spherule of rods displays 2–3 invaginated synaptic sites while the cone pedicle is larger and presents 8–10 invaginated synaptic sites. Both rods and cones also appear to have superficial synaptic sites. Membrane specializations are found along the length of the inner segments where rods and cones are contiguous. These may act as sites of intercellular communication and the whole photoreceptor bundle may therefore be considered as a macroreceptor.

**Key words:** Photoreceptor – Retinomotor Responses – Circadian Changes – Teleost

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Introduction

Retinal photoreceptors are the first neurons in the visual pathway and for this reason have been investigated both structurally and functionally in a variety of species (Rodieck 1973; Nilsson et al. 1973; Braekevelt 1973, 1975). While species variations are noted, a basic structural plan appears to be common to all vertebrate photoreceptors, with the “typical” photoreceptor consisting of an outer segment, connecting cilium, inner segment (often divided into ellipsoid and myoid), nuclear region and synaptic ending (Hogan et al. 1971; Cohen 1972; Rodieck 1973).

While teleosts in general have photoreceptors constructed on the basic vertebrate plan outlined, several species have been reported to have their photoreceptors grouped in bundles of 30–60 cells. These bundles are optically isolated from one another by large retinal epithelial cells containing abundant reflective material which forms a retinal tapetum lucidum (Engstrom 1963; Munk 1966, 1977; Locket 1970; Ali and Anctil 1976).

The goldeye (*Hiodon alosoides*) is amongst those teleosts which have previously been noted to possess such grouped or bundled photoreceptors (Moore 1944; Wagner and Ali 1978; Best and Nicol 1979). This investigation deals with the fine structure of these bundled photoreceptors and with morphological changes of both the rods and cones in light- and dark-adaptation. A previous report described the fine structure and intimate relationship of the retinal epithelium to the grouped photoreceptors of this species (Braekevelt 1982).

Materials and Methods

For this study the eyes of 8 healthy adult specimens (average length 25–30 cm) of the goldeye (*Hiodon alosoides*) were examined by both light and electron microscopy. The fish were obtained locally from the Red River. Light-adapted fish (5) were collected and sampled between 12 noon and 1 pm. Dark-adapted fish (3) were held for 3 days on a 12 h light: 12 h dark cycle (lights on 6 am: lights off 6 pm) and sampled at 12 midnight under dim red light.

The fish were decapitated, the eyeballs removed, opened at the equator and fixed for 5 h at 4°C in 5% glutaraldehyde buffered to pH 7.3 with 0.1 M Sorensen’s phosphate buffer. The posterior half of the eyeball was then removed, washed in 5% sucrose in 0.1 M Sorensen’s buffer (pH 7.3) and cut into pieces less than 1 mm². The material was then post-fixed for 2 h in 1% OsO₄ in the same phosphate buffer (pH 7.3) dehydrated in graded ethanols to propylene oxide and embedded in Araldite.

Pieces of plastic-embedded tissue were reorientated by using a wax mount, and thick (0.5 μm) and thin sections (500–600Å) were cut on an LKB ultramicrotome. Thick sections were placed on glass slides, stained with toluidine blue and examined by light microscopy. Thin sections were mounted on copper grids, stained in aqueous uranyl acetate and lead citrate and examined by transmission electron microscopy.

Results

The retina of the goldeye (*Hiodon alosoides*) contains both rods and single cones arranged in bundles of 40–50 cells. Each bundle contains both rods and cones in roughly equal proportions. The relationship of the retinal epithelial cells to the photoreceptor bundles is such that each bundle is