THE VISUAL CELLS OF *PLANCTERUS KANSAE* (GARMAN)

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By

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Bachelor of Science

Oklahoma Agricultural and Mechanical College

Stillwater, Oklahoma

1946

Submitted to the Department of Zoology

Oklahoma Agricultural and Mechanical College

In Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

1947

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ACKNOWLEDGMENT

The author is indebted to Dr. Gordon L. Walls, Associate Professor of Physiological Optics and Optometry of the School of Optometry, University of California, for valuable suggestions and examination of mounted materials.

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The plains killifish, a common and widely distributed cyprinodont of the Great Plains Region, is remarkably adapted to wide differences of habitat. This species is known to inhabit waters ranging from fresh to quite saline condition in clear brooks and also in muddy rivers. The very plastic nature of this form would indicate that a highly diversified retina could be expected. Wherever it occurs this killifish is abundant and in apparently good condition. Although occurring naturally in stream situations it does reproduce in ponds. Unlike many of its relatives Plancterus seldom swims at the surface of the water and, on the other hand, is not a bottom fish.

The purpose of this study was to examine the visual cells in order to determine the various types present, their structure, size, mosaic arrangement, and relative numbers. An attempt was made to study three retinal regions, namely: the area centralis and those portions above and below it.

The literature contains few references to the visual cells of cyprinodonts. Eigenmann and Schafer (1900) demonstrated a definite arrangement of twin and single cones in Fundulus notatus (Rafinesque). Butcher (1938) found double and single cones, but no twins, in Fundulus heteroclitus (Linnaeus).

The material for this work was light or dark adapted before the whole fishes were fixed in Kolmer's or Perenyi's fluid, and the heads were imbedded by Walls' (1932) hot celloidin method. Tangential sections of the upper and lower portions of the retina and the area centralis were cut from the same specimen. The sections were bleached in Janders fluid, and stained in Mallory's connective tissue stain or Heidenhain's iron hematoxylin. The measurements given are maxima in microns since other measurements would include dimensions of cell fragments. Counts of the cells were made from tangential sections in the region of the fundus by means of a micrometer grid. The following abbreviations are used: UR for upper retina, LR for lower retina, and AC for area centralis.

The retina is divided into two distinct areas, an upper two--thirds and a lower one-third, by a narrow crescentic area centralis similar to that of Fundulus (Butcher, 1938). A fovea-like depression extends across the area centralis directly below the optic nerve head which is slightly ventrad and nasad to the fundus.

Throughout the retina there are five types of visual cells: two being single cones, herein designated as types "A" (Fig. 1) and "B" (Fig. 2); two designated as types "C" (Fig. 3) and "D" (Fig. 4) are conjugated and are considered as unequal twins of Walls (1942: 586); and, one type is a rod (Fig. 5).

Each cone possesses a conical foot-piece with its base in the outer plexiform layer and its apex extending to the nucleus. There is an elliptical granular body within the foot-piece. The elliptical nucleus (UR 12x4.5; LR 12x5; AC 12x4.5), directly opposite its corresponding ellipsoid, contains a reticular chromatin network and lies near, or sometimes extends through, the outer limiting membrane. The nucleus is connected through the outer limiting membrane with the ellipsoid by a myoid which, in the dark-adapted eye, appears to be connected with the limiting membrane by several minute strands.

TYPE "A" CONE. The chromophillic ellipsoid (UR 13x6; LR 10x3.5; AC 12x2) is greater in diameter at the distal end and contains one large spherical body staining bright red in Mallory's and dark blue in Heidenhain's. Surmounting the ellipsoid, and separated from it by a clear intermediate plate, is the conical outer segment (UR 11x2.3; LR 11x1.3; AC 8x1), containing a double myeloidal spiral and a centrally located fiber presumed to be the fiber of Furst. This latter structure was only occasionally observed and therefore was omitted from the illustrations.

TYPE "B" CONE. This type appears to be nearly identical to type "A". The ellipsoid (UR 11x6; LR 8x3; AC 9x2.3) is larger at its proximal end and contains a variable number (usually two) of distally located bodies which stain in a manner similar to the single body in type "A". The outer segment (UR 10x2.3; LR 10x1.3; AC 7x1) also contains a double myeloidal spiral. Type "B" further differs from "A" in its photomechanical reactions in that it contracts to a greater extent in the light-adapted state.

TYPES "C" AND "D". The unequal twins consist of two members that are alike in size and shape, and retain the same relative positions, one to the other, in both contracted and extended (light- and dark-adapted) conditions. The footpieces, nuclei, and myoids are similar and indistinguishable from those of the single cones except by correlation with positions or attached ellipsoids. The ellipsoids (UR 14x5; LR 17x3.5; AC 13.5x2.5) are alike in size and shape, but quite different in their inner structure. In type "C" the ellipsoid is an irregular, elongate body which does not stain as deeply as the single cone ellipsoids. At the distal end of the ellipsoid there is a darker, elliptical body, similar in position to the bright red body in type "A" but not staining red in Mallory's. The ellipsoid of type "D" possesses a somewhat spherical body appearing gray in Heidenhain's, similar in position to the one in "C", and surrounded by a clear area which is crossed by thin strands, thus presenting a vacuolated appearance. Proximal to this structure the ellipsoid is comparatively clear and contains irregular structures more distinct distad and becoming indistinct proximad. The conical outer segments (UR 13x2.4; LR 13x 1.8; AC 14x1.2) of both "C" and "D" contain only one myeloidal spiral.

ROD. The single type of rod is relatively large and has a barrel-shaped ellipsoid (UR, LR, AC, 4x3) grading into the myoidal attachment. The cylindrical outer segment (UR 28x2; LR 18x2; AC 40x2) contains one myeloidal spiral and occasionally a centrally located fiber is seen.

The rod nuclei are about two-thirds as large (UR 8x4; LR 6x4; AC 8x3.5) as the cone nuclei and are in about three layers in the outer nuclear layer. The rod foot-piece seems to vary in shape depending on the position of the nucleus in the outer nuclear layer. Those nuclei that lie near the outer plexiform layer have short and thick foot--pieces and those farthest from the outer plexiform layer are long, slender and end in a knob-like structure. The nuclei of intermediate position have foot-pieces intermediate in shape.

The rod myoids are connected with the outer limiting membrane so as to present the appearance of two cones (one above and one below) with their bases in the outer limiting membrane.

The cone mosaic pattern (Figs. 6 and 7) remains the same throughout the retina. The difference in relative sizes of the cones, and the slight change in shape of the geometric figure formed by the cone elements, results in superficial differences. This is essentially the same mosaic as in salmonids (Ryder, 1895; Eigenmann and Shafer, 1900; Furst, 1904) except that in Plancterus the mosaic is composed of two types of single cones and one unequal twin in contrast to the one type single and one twin cone, mentioned as unequal twins in Salmo gairdneri irideus (Gibbons) and S. trutta fario (Linnaeus) by Walls (loc. cit.).

No regular rod mosaic was observed, but these cells occupy available space between the cones.

The numbers of the various types of visual cells per square millimeter of retinal area are approximately as follows: each type of cone in UR 6,000, in LR 11,000, in AC 15,000; rods in UR 66,000, in LR 110, 000, in AC 120,000. Thus the ratio of cones to rods is different in the retinal areas: 1:2.75 in the UR, 1:2.50 in the LR, 1:2.00 in the AC.

The visual cells vary in size in accordance with their location in the retina. The largest cones occur in the upper retina and the smallest ones in the area centralis. It is of special interest that the rods of the area centralis are larger than elsewhere.

The cone-rod ratio is apparently unusual since Arey (1932: 1256) gave a ratio of 1:4.5 in bright-light forms. This paucity of rods coupled with a fovea-like structure in the area centralis indicates that this species should be considered a bright-light form.

Arey (loc. cit.) and Wunder (1925) stated that fishes have the same size and frequency of cones in the upper and lower retina. Plancterus definitely has smaller and more numerous cones in the lower retina than in the upper.

During the course of these investigations some sections of eyes of Fundulus olivaceus (Storer) were available. A preliminary examination of this material shows that olivaceus has visual cells very similar to those described for Plancterus. This is of particular interest in view of the fact that Butcher (1938) described a double cone for Fundulus heteroclitus and Eigenmann and Schafer (1900) considered the conjugated cones as twins in Fundulus notatus (long confused with F. olivaceus and undoubtedly very closely related).

Another interesting circumstance is evident when the habits of these cyprinodonts are considered. Both notatus and olivaceus are surface swimmers while Plancterus is never seen at the surface and heteroclitus is described (Jordan and Evermann, 1896: 640) as "......a bottom species often burying itself in the mud".

Fundulus olivaceus and notatus could be expected to possess very similar visual cells and it would seem that Plancterus should be intermediate between the surface swimmers and the bottom-inhabiting heteroclitus. The striking similarity between the cones of olivaceus and Plancterus is therefore surprising.

More studies of the visual cells of cyprinodonts are needed and such studies could be expected to indicate relationships not now apparent.

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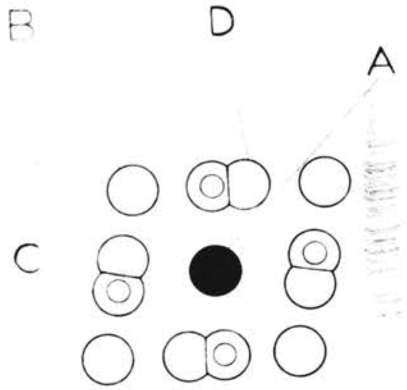

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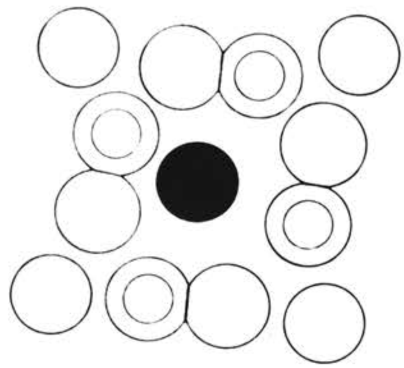

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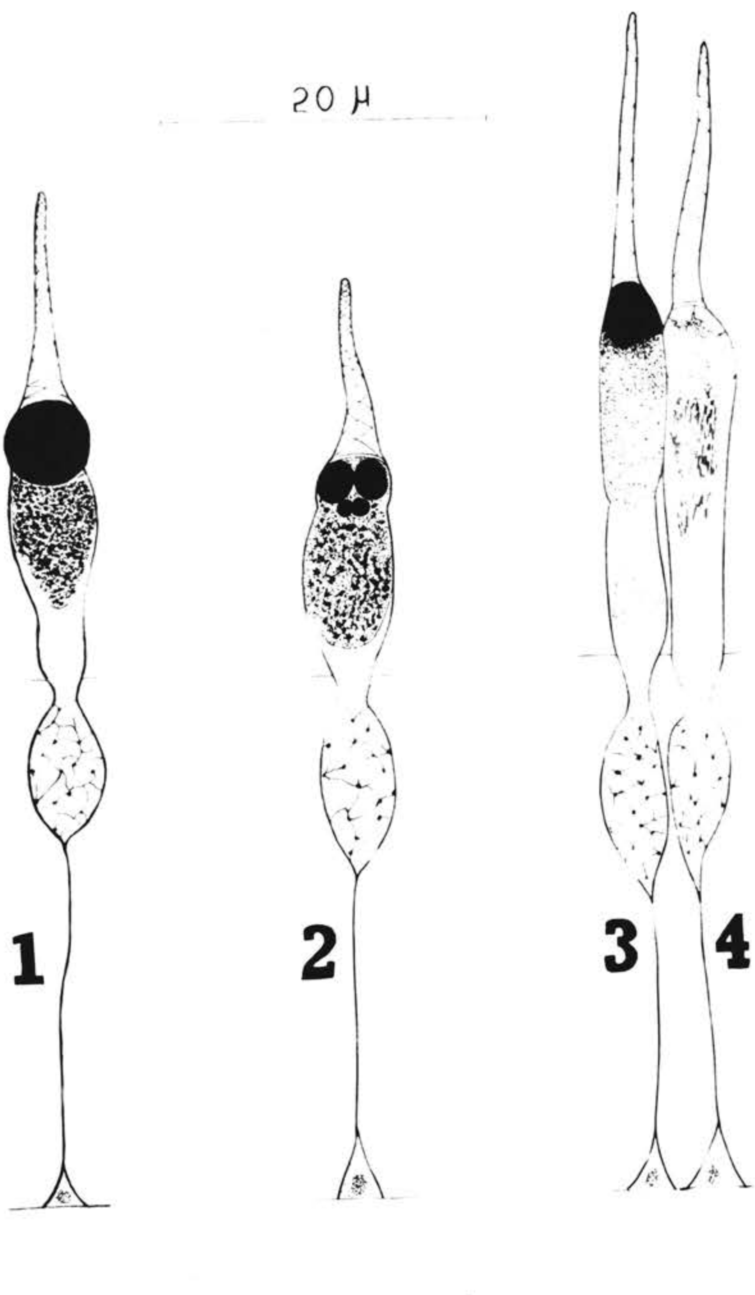

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