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Research Report

Spatial distribution of a fusiform cell in the optic tectum of *Pantodon buchholzi*, the African butterfly fish (Teleostei, Osteoglossomorpha)

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ABSTRACT

Pantodon buchholzi, the African butterfly fish, inhabits an ecological niche just below the water surface. At that position, each eye necessarily views into the air through the surface of the water and into the water. Since *Pantodon* is an obligatory surface feeder, the ventral retina viewing the aerial environment provides all visual information for prey acquisition. The visual pathway of this fish reflects the divided visual field with structural differences in the retina and brain corresponding to the different views. In this study, we describe a specific type of neuron in the tectum that, due to its intrinsic structure, likely integrates visual and mechanoreceptor inputs. Because of its spatial distribution, this type of neuron is a candidate as a basic element in a network involved with prey acquisition.

1. Introduction

The visual field of actinopterygian fishes maps the retina onto the optic tectum in a retinotopic manner (see reviews: Meek, 1983, 1990). The superior visual field, seen by the ventral third of the retina, is represented in the dorsomedial optic tectum while the inferior visual field, seen by the dorsal retina, is represented in the ventrolateral optic tectum. Some species of fish show individual variations in the topological details reflecting specific adaptations to their ecological situation (Collin and Shand, 2003). One of the more unusual of the latter is the teleost fish, *Pantodon buchholzi*, the African butterflyfish. Its visual system is notably divided so that its superior visual field in its normal posture is largely a representation of Snell's window (Saidel and Braford, 1985). Snell's window is an aperture at the surface of the water within which light rays from the entire aerial hemisphere are seen by an eye underwater (Jenkins and White, 1976; Lythgoe, 1979), and the entire aperture is seen by the ventral part of the retina. The visual field is geometrically tripartite in that adjacent to the representation of Snell's window on the retina is a representation of the reflection from the underside of the water surface (which is largely occluded by a falciform process, see below) and adjacent to that is a view of the aquatic environment as seen by the dorsal retina (Schwartz, 1971; Lythgoe, 1979; Saidel and Braford, 1985; Saidel, 2000). This geometry is a consequence of the fish's unique subsurface habitat (Fig. 1).

Pantodon has been described as an obligatory surface feeder (Sterba, 1983; Moyle and Cech, 1996; Bleckmann et al., 1989; Froese and Pauly, 2008). The discrete partitioning of its visual field by its retina permits the visual system of *Pantodon* to independently convey stimuli from the different visual

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regions. A prey target seen by the ventral hemiretina initiates feeding behavior; the same target seen in the water column (or by the dorsal hemiretina) does not. One would consequently assume that some aspects of the aerial visual pathway might differ from the aquatic visual pathway in this fish because some biologically-relevant behaviors related to feeding differ when the stimuli are presented in the different parts of its visual world.

Various aspects of *Pantodon*'s visual nervous system correlate with this analysis. The retina is horizontally bisected by a black-pigmented septum (Fig. 1, insert, a falciform process, Hanyu, 1959; Schwartz, 1971) to form the distinct dorsal and ventral regions (Schwartz, 1971; Saidel and Braford, 1985; Saidel, 1987, 2000). More centrally, a diencephalic nucleus rostrolateralis receives both direct retinal afferents from the ventral retina (Saidel and Butler, 1991) and direct tectal afferents from only the dorsomedial tectum, the region of the tectum receiving afferents from the ventral retina (Butler and Saidel, 1992; Saidel and Butler, 1997).

The optic tectum is a single neuroanatomical structure, but its heterogeneity in structure and function has been recognized within the recent past. For instance, different regions of the teleost optic tectum connect with different regions of the teleost central nervous system (Grover and Sharma, 1979; Pérez-Pérez et al., 2003). Functionally, electrical stimulation produces a different type of eye and tail movement from different tectal regions. (Salas et al., 1997; Herrero et al., 1998).

In this report, we identify a tectal component of the visual pathway associated with the ventral retina. It is a particular type of fusiform cell found in the stratum griseum centrale (SGC); and it possesses apical and basal dendrites appropriately layered to integrate visual and mechanoreceptive information. These cells are distributed with a degree of regularity within the region of optic tectum processing aerial visual information and rarely found in the region of optic tectum processing aquatic vision.

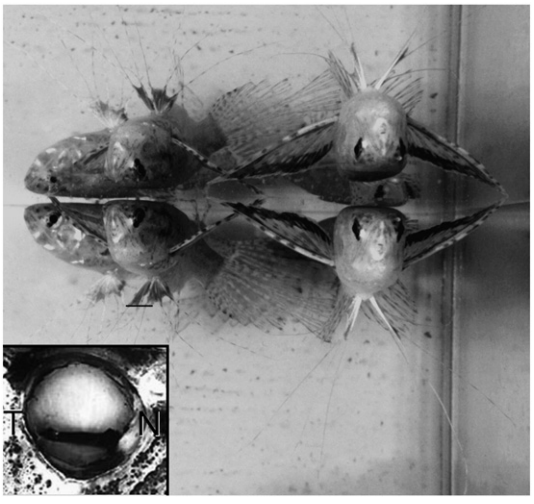

Fig. 1 – *Pantodon buchholzi* is a surface feeding fish whose visual field subtends aquatic and aerial portions. *Pantodon* are positioned in their usual posture adjacent to the surface. (Insert) The fundus of the eye is divided by a horizontal falciform process.

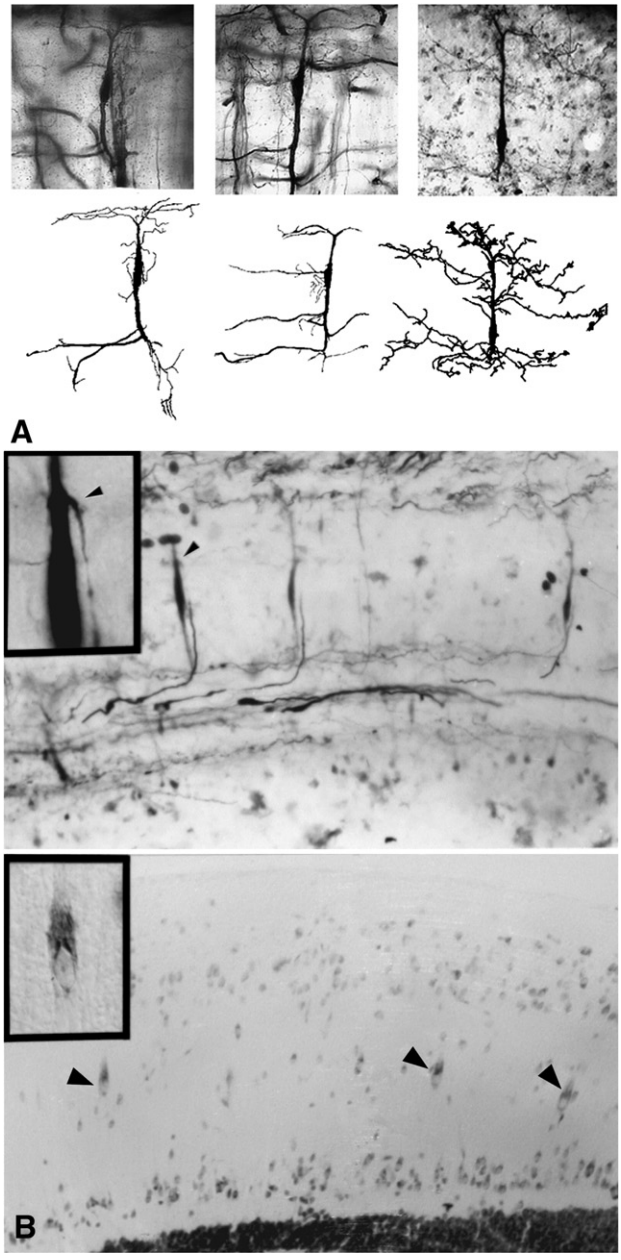

Fig. 2 – (A) Illustration of 3 types of fusiform-like cells in SGC. The left cell is the cell of interest in this study; the middle cell possesses an eccentric soma; the right cell has a short basal dendritic shaft (B) The somata of the fusiform cells can be identified in two different preparations: Two preparations illustration two adjacent cells and a third with one cell missing in its expected position. Above are three retrogradely labeled (with horseradish peroxidase) fusiform cells; beneath are three fusiform cells identified in cresylechtviolet stained tissue. Inserts: above—the axon emerges from the base of the apical dendrite; below—the asymmetric Nissl stain in which the apical cell compartment contains intense accumulations of Nissl substance compared with the basal cell compartment below the nucleus.