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Research Articles

A lens-like specialization for photic input in the pineal window of an Indian catfish, *Heteropneustes fossilis*

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Summary. An unusual lens-like structure is reported in the pineal window of the Indian nocturnal catfish *Heteropneustes fossilis*. This is the first report of its kind for the pineal window of fishes. This structure, coupled with a pineal fossa and a pineal window, forms a specialization that apparently serves to concentrate the photic input to the intracranially situated pineal organ. This structure may play a significant role in the photoneuroendocrine function of the photosensitive pineal under conditions of low light intensity, controlling the fish's circadian rhythmic activities.
Key words. Pineal window; lens-like tissue; pineal photosensitivity; catfishes.

Vertebrate photoreceptive systems operating through extraretinal[2] (extraocular[3]) photosensory inputs include the superficial dermal receptors, the epithalamic pineal sense organs, and the deep diencephalic photoreceptors. While the eyes serve primarily for visual function, pineal sense organs control photoneuroendocrine events[4], for which they are also endowed with photoreceptor cells and photopigments resembling those found in the retina. The vertebrate photoreceptive systems control circadian and reproductive rhythmic activities. As far as the pineal is concerned, light has an indirect effect, producing inhibition of melatonin synthesis. In tetrapods, light can reach the pineal (situated superficially, though intracranially), by penetrating through the skin and the skull, though its intensity may be attenuated while passing through these tissues. This is also the case in most fishes which lack a pineal foramen. As the amount of light reaching the pineal is dependent, on the one hand, on the nature of the tissues overlying it[5] and, on the other hand, on the light conditions of the species' habitat[6], fishes

inhabiting habitats with poor light (such as caves, pelagic regions, or the deep sea) have developed additional morphological adaptations for light transmittance to the pineal gland. A pineal spot or a pineal window[5,7] is a specialization of this kind found in certain fishes and it presumably allows more light to reach the pineal organ[8,9] than is possible in fishes without this specialization (Matty's[10] category of fishes with opaque tissue overlying pineal). Little is known about the precise structure of the pineal spot or window, except for the role of melanophores[7].

Catfishes are endowed with a pineal window, and also have the distinction of combining it with a pineal foramen[11,12] which recalls the persistence of the primitive character of early vertebrates (ostracoderms, placoderms)[13]. A pineal fontanelle[14] occurs in related characids. Although the occurrence of a pineal window has been reported for a number of catfishes, the detailed structure is not known except for gross morphology[12,15,16]. The present paper describes the preliminary histological findings on the pineal window of *Heteropneustes fossilis*.

Material and methods

Twenty live specimens of *H. fossilis* were locally procured. For histological preparations, the pineal window was fixed in Bouin's fixative and 6–8-µm serial paraffin sections were stained with hemotoxylin-eosin and Azan Mallory triple stain. Whole mounts of the skin of the region of the pineal window were also made for determination of the melanophore-index (MI) according to Hogben and Slome[17]. For this a total of ten specimens were maintained for a week under normal L/D conditions in a plastic pool, open above, with a diameter of 90 cm. Five specimens were sampled at 12 noon, one each day, for MI determination during photophase (light period of normal day cycle), and the other 5 specimens were sampled at 23.00 h, one each day, for MI determination during scotophase (dark period of normal day cycle). A total of about 1500 melanophores were counted in each preparation.

Results

For a description of the gross morphology of the pineal window, the reader is referred to Srivastava and Srivastava[16]. The histological composition of the wide-type[16] pineal window of *H. fossilis* shows a thin (3–4 layer) epidermis with a layer of melanophores underlying it; elsewhere on the head the epidermis is thick (8–10 layers). The dermis is devoid of the typical organization of collagen into fibrous layers found elsewhere, and it is represented by simple connective tissue. Much of the space of the fossa in the skull bones is occupied by an unusual 'tissue' (cf. Srivastava and Srivastava[16]) which follows the contours of the fossa below and the epidermis above, so acquiring a plano-convex shape (fig. 1). This tissue is vascular and is supplied with blood capillaries. It presents a lamellar configuration – a number of layers stacked in a pile (fig. 2). No nuclei are discernible, neither is there any sign of distinct cell boundaries, so that it is a 'lens-like tissue' whose convex side is directed towards the pineal foramen. The melanophore preparations show an MI of 4–5 (according to Hogben and Slome[17]), that is, the pigments were maximally dispersed during both scotophase and photophase of the normal daily cycle under laboratory conditions.

Discussion

The findings are summarized in figure 3. The wide-type[16] pineal window of *H. fossilis* has a lens-like tissue overlying the pineal foramen. The plano-convex shape of

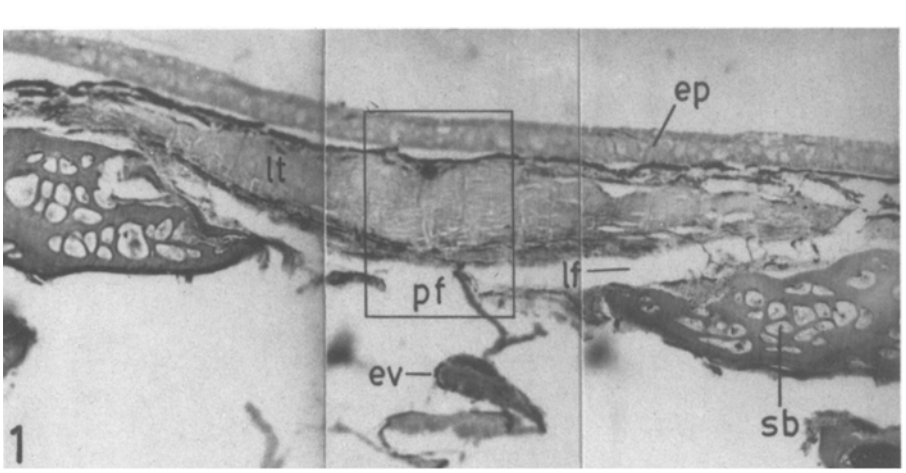

Figure 1. Transverse section of the skull roof passing through the region of pineal window of *Heteropneustes fossilis* showing the organization of tissues in the composition of the pineal window. Hemotoxylin-eosin stain, x 125. Note the presence of a conspicuous plano-convex lens-like tissue over the pineal foramen. ep, epidermis; ev, end vesicle, lf, lenticular fossa, lt, lent-like tissue; pf, pineal foramen; sb, skull bones.

Figure 2. Magnified view of a portion, enclosed in rectangle of fig. 1, showing lamellar disposition of the lens-like tissue. Hemotoxylin-eosin stain x 500.

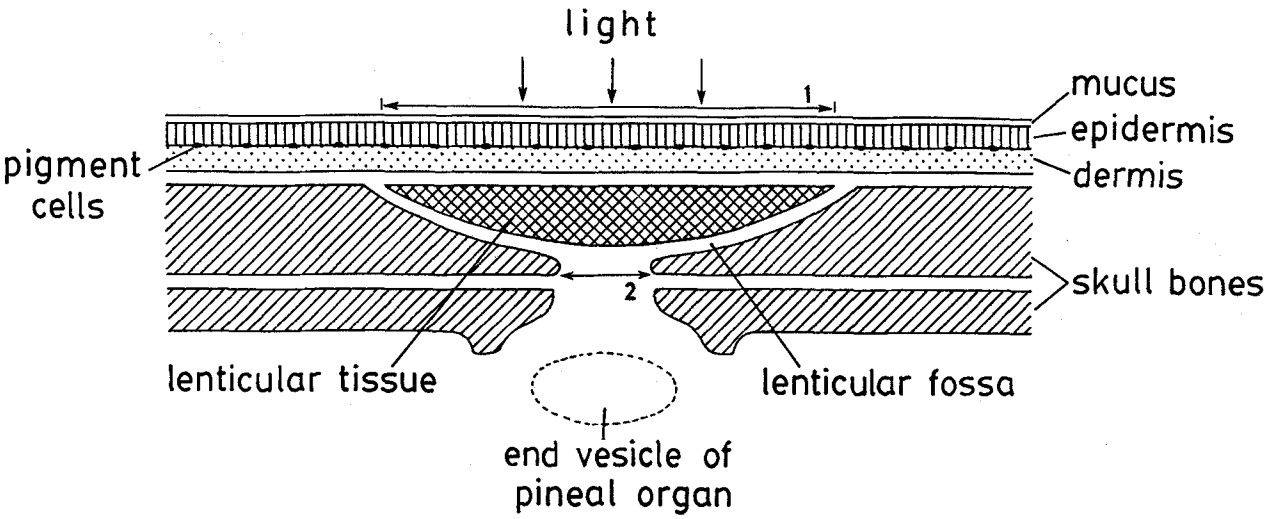

Figure 3. Schematic drawing of the organization of the pineal window of *Heteropneustes fossilis*. 1: Pineal window; 2: Pineal foramen.

this tissue, coupled with a thin epidermis and maximally dispersed pigments in the melanophores above it, and a large pineal foramen underneath it, suggest that it is a remarkably specialized form of pineal window, hitherto unknown, which is meant for concentrating light input into the pineal end vesicle situated underneath the pineal foramen. This device will minimise any losses due to scattering and absorption during the passage of light through the tissues of the pineal window. Such a pineal window may help catfish to detect the length of the photoperiod. The pineal window apparently serves to enhance the transmittance of extraretinal light to the pineal when the catfish is in its habitat at the bottom of a river or pond, where low light intensity prevails. Experiments to evaluate the effect of capping or shielding of the pineal window will be necessary to confirm this.

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