Research Articles

Amphibious vision in *Coryphoblennius galerita* L. (Perciformes)

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Abstract. The morphology of the ophthalmic cornea in the blenniid fish *Coryphoblennius galerita* (Teleostei) shows adaptation to the amphibious life. Amphibious vision is provided by a flattened area within the cornea. Eyes of other, non-amphibious blenniids are compared with those of *C. galerita.*
Key words. Blenniidae; corneal anatomy; amphibious vision.

Coryphoblennius galerita is a small blenniid fish living on rocky shores of the Mediterranean Sea and in the tidal zone of the European Atlantic. It is known to live as a semi-amphibious animal[1]. In the Mediterranean Sea it inhabits the surf zone. In addition, nocturnal emersions up to 50 cm above the water level have been described[2,3], and during the day the fish frequently moves out of the water for a short time if it is disturbed from below. Soljan[1] also describes amphibious feeding behavior. On the Atlantic coast of Brittany (F) *C. galerita* is usually found in tidal rockpools during low tide. Breeding males can be observed lying in narrow crevices fully exposed to the air, others outlast the low tide among boulders and gravels. Therefore *C. galerita* spends a significant part of its life out of the water. The problem of vision both underwater and in air gives rise to functional-anatomical questions.

Morphological adaptations to amphibious vision in fishes are known in several groups of teleosts. *Anableps*, the 'four-eyed fish', uses an aspherical lens and two pupils for amphibious vision. This division of the eye into two functionally separated areas allows the fish to accommodate in water as well as in air[4]. In contrast, in other groups it is the cornea that shows amphibious adaptations. The amphibious clinids *Dialommus fuscus*[5] and *Mnierpes macrocephalus*[6], which inhabit tropical tidal zones, have flattened corneas to reduce the refraction in air. The Atlantic flying fish *Cypselurus heterurus* uses a prism-like cornea[7].

The present study investigated the eyes of the European semi-amphibious blenny *Coryphoblennius galerita.*

Material and methods

Specimens of *C. galerita* were collected in Banyuls (France, Mediterranean Sea) and Erquy (France, Atlantic coast of Brittany) during March and September 1990. They were kept in Basel (Switzerland) in tidal aquariums of 170 liters. Eyes were examined on living, anesthetized (MS 222) animals using a stereo microscope. Reconstructions and drawings were made by using a Wild/Leitz M5 stereo microscope equipped with a drawing mirror.

Results and discussion

The cornea of *C. galerita* shows specializations analogous to those of *Mnierpes macrocephalus.* The frontal upper part of the cornea is strongly flattened; it lies in the frontal part of the field of vision (figs 2, 3 and 4). The dorsal view of the eye (figs 2 and 3) demonstrates the shape most clearly: the rostral part of the cornea is flat (arrows), whereas the caudal part shows a regular spher-

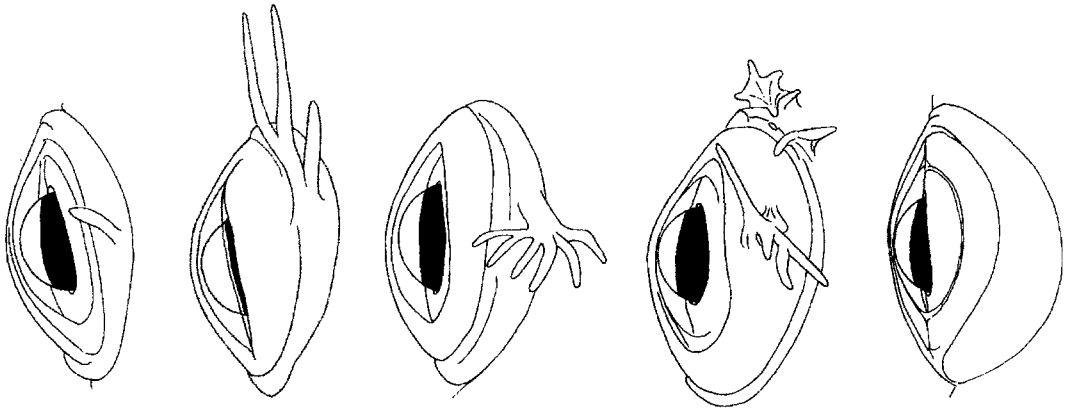

Figure 1. The eyes of *Lipophrys pavo, Parablennius rouxi, P. sanguinolentus, P. zvonimiri* and *Pomatoschistus microps* (left to right).

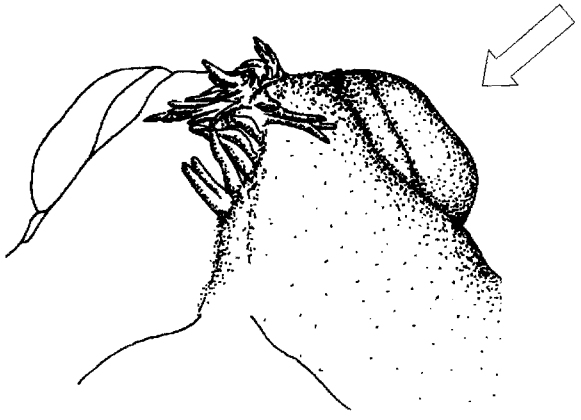

Figure 2. The eye of *C. galerita* (dorso-caudal view, 50°).

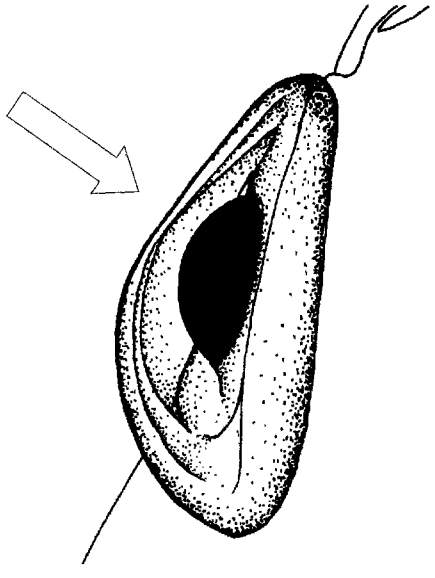

Figure 3. *C. galerita*, dorsal view (90°).

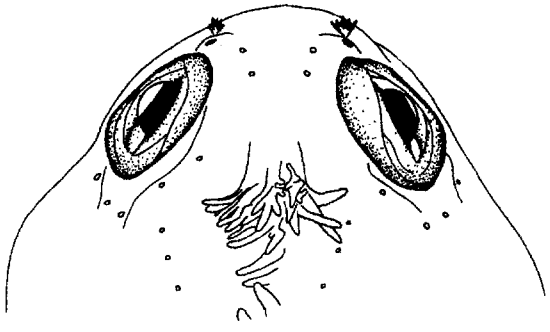

Figure 4. Dorsal view of the head of *C. galerita*.

ical shape. The cornea conjunctiva is strong and relatively thick. This could provide protection against desiccation during the terrestrial sojourns of *C. galerita*[8].

In general, the eyes of aquatic vertebrates differ strongly from those of land-dwelling animals. In land-living vertebrates the cornea is the main structure involved in refraction. In the human eye, for example, the refractive power of the cornea is up to 40–45 diopters[9]. This strong refraction is the result of the spherical interface between air and cornea with their strongly differing refractive indices. The lens itself focuses with a refraction of an additional 13 diopters[10].

On the other hand the teleostean eye is characterized by its rigid spherical lens, which cannot be deformed for focusing. Focusing can usually only be carried out by moving the lens along the optical axis of the eyeball. Underwater, the refraction at the water-to-cornea interface is almost neutralized by the absence of different refractive indices.

Therefore the shape of the cornea plays only a minor role in refraction in exclusively aquatic fish eyes. Its form is mostly adapted to optimizing the hydrodynamics of the fish. On the other hand, if the eye is exposed to air, the curved shape of the cornea gives rise to a strong refraction and the fish becomes heavily myopic. The optical error can reach more than 20–30 diopters[7]. To avoid or eliminate this effect, there are various possibilities: 1) The lens is not spherical and/or is heavily deformable (in seabirds we find the best accommodation for amphibious vision, with an adjustment of up to 48 diopters[11]); 2) the lens is extremely movable for accommodation, or 3) the cornea is partially or fully flattened and therefore plays no role in accommodation. Overlap of these mechanisms may occur.

This last mechanism is found in *C. galerita*. A flat cornea allows amphibious vision, because there is no refraction at the air-cornea interface. The shape of the cornea does not change, i.e. no alteration of the flattening was observed, either in water or in air. Thus the flat zone has no negative effect on the strong optical orientation of the fish in water. In air, the visual faculties are retained through a diminution of the myopy occurring in spherical corneas.

No flattened corneas were found in other, non-amphibious blennies or in the goby *Pomatoschistus microps* (fig. 1), except for *Lipophrys pholis* L. whose eyes show an analogous morphology (study in process).

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