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A Pulsing-Mirror Eye in a Deep-Sea Ostracod

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Abstract. In the deep sea, it is unknown how eyes that use concave mirrors to focus can distinguish between the small bioluminescent lights of their prey and those larger lights of more distant predators. Beyond 1000 m depth, where sunlight is no longer perceptable, the deep sea contains a continuous field of (mostly) blue, bioluminescent lights. Here, some predators, such as the ostracods of the genus *Gigantocypris*, famed for their gooseberry-like appearance, are attracted to their prey through the prey's bioluminescence. The enigmatic eyes of *Gigantocypris* spp. focus light using large, parabolic mirrors. Here, I show that the mirrors flex, pulsing continuously, so causing large, distant light sources to pass in and out of focus while small, nearby light sources remain in focus with each pulse cycle. This distinguishes predators from prey and constitutes a new type of eye.

Introduction

Species of the "giant" myodocopid ostracod (Crustacea) genus *Gigantocypris* Müller, 1895, are pelagic crustaceans with shrimp-like bodies enclosed within spherical, bivalved "shells", 10 to 32 mm in diameter, and are emblematic of the deep sea. They live between about 600 and 2,300 m depth world-wide and use a pair of oar-like antennae to swim and hunt small, bioluminescent, pelagic animals such as copepods and small fish (Land, 1984; Land & Nilsson, 2002). Species of *Gigantocypris* are characterized by a pair of large (naupliar) eyes, which, rather than using convex lenses to focus light onto a retina, use concave, parabolic mirrors about 3 mm wide, appearing like car headlights (Land, 1984). These are considered the parabolic reflecting eye type, one of the 10 fundamentally different types of eye (Land & Fernald, 1992).

Each retina of *Gigantocypris* sp. is not a flat sheet, as is usual for an eye, but condensed into a light-bulb shape (Land & Nilsson, 2002). The curvature of each mirror in the horizontal and vertical planes is different, which means that the image of a point source will be astigmatic: a line at right angles to the mirror (Land & Nilsson, 2002). The retina is also elongated in this direction (about 750 microns long), and "so may have some capacity to resolve these linear images" (Land & Nilsson, 2002). At a depth of 1000 m there is no remaining sunlight (Denton, 1990; Herring, 2002), so the function of these eyes has been assumed to assist predation by tracking down the bioluminescent organisms, which are common at such depths (Land & Nilsson, 2002). However, our current understanding (Land & Nilsson, 2002) cannot account for this required function.

In a deep field of bioluminescence produced by very different animals from large fish to tiny planktonic shrimps, a predator such as *Gigantocypris* sp. must distinguish between the light of a large predator at distance and a small prey animal nearby. Although the former light emerges from a larger and brighter source (photophore), if the small prey animal is closer to an observer's eye, both lights may appear equal. Indeed, small prey that are conspicuous may be afforded protection through "mimicry" as a result of this phenomenon. A discovery made from examining *living* specimens of an unidentified species of *Gigantocypris* revealed another, critical character of the *Gigantocypris* eye that enables it to distinguish its prey.

Keywords: eye function, new type of eye, predation, bioluminescent light, concave mirrors, Crustacea, Ostracoda
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