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Suckers as light organs

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Light-emitting suckers in an octopus

Squids and cuttlefish often have light organs on different parts of their bodies that consist of a complex arrangement of lenses, mirrors, irises, light guides, coloured filters and shutters¹. These extraordinary features are rare in their sister group, the octopods, in which light organs have been reported only in breeding females of two genera¹. We have discovered that blue-green light is emitted from the suckers of a deep-sea finned octopod, *Stauroteuthis syrtensis*. The light organs have characteristics of both simple photophores and suckers, suggesting that they could have evolved from suckers. The function of the light is unknown, but it may be related to the non-bioluminescent sucker signalling used by shallow-water octopods², or act as a lure for prey³.

The existence of bioluminescence in the suckers of finned octopods has been considered before but never verified. The blind, finned octopod *Cirrothauma murrayi* has small bodies that have been suggested to be light organs⁴ or nerve ganglia⁵, but no luminescence has been observed.

When stimulated, the suckers of *S. syrtensis* (Fig. 1a) emit moderately bright, blue-green light with a maximum wavelength of 470 nm (Fig. 1b), which can last for up to 5 min. Individual light organs either glow dimly and continuously, or blink on and off brightly every 1–2 s. These organs could be capable of luminescence, and no other part of the body emitted light. The suckers were unable to attach to surfaces, indicating that, unlike typical octopod suckers, they have no adhesive function.

The light organs of *S. syrtensis* are arranged in a single row along the length of the oral surface of each arm. The overall appearance of the light organs is similar to that of octopod suckers⁶. They are button-like structures raised above the surface of the arm but are not supported on stalks or peduncles.

Like suckers, the organs consist of an outer collar of columnar epidermal cells surrounding a cup-like depressed region called the infundibulum (Fig. 2a). At the centre of the infundibulum, a pore opens into the acetabulum, which, in *S. syrtensis*, is a narrow channel situated within the organ. The cells of the epidermal collar, infundibulum and acetabulum are covered by a cuticle (Fig. 2a,c). At the outer rim of the infundibulum, the cuticle is elaborated to form a circle of hook-shaped denticles (Fig. 2b). Each light organ is supported by a sub-acetabular ganglion (Fig. 2c) that connects with the main brachial nerve cord.

The overall morphology is typical of octopod suckers⁶, but ultrastructural examination shows that the radial, circular and longitudinal muscles of the infundibulum

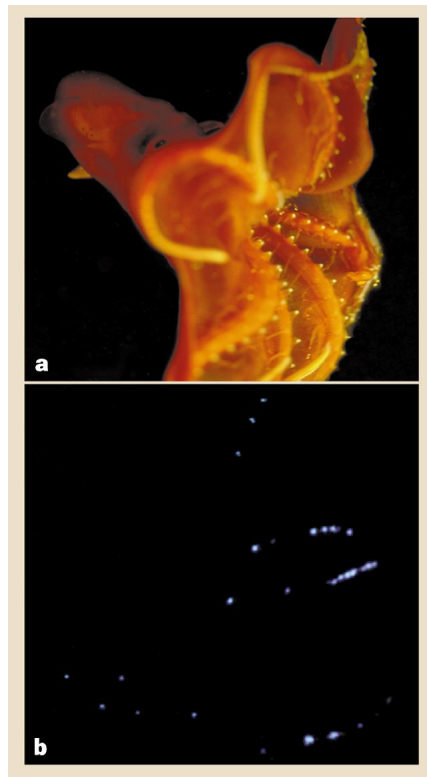


Figure 1 Views of *S. syrtensis* showing the light organs. **a**, Light organs can be seen where suckers are normally found. **b**, Digitized frame from an intensified video showing the bioluminescence. Because the video camera is monochromatic, the image has been colourized to match the actual colour of the emitted light. The views in **a** and **b** are not aligned.

and acetabulum, which are typically well-developed in suckers, are greatly reduced. The muscles are replaced by light-producing cells, or photocytes, limiting the mechanical function of the organ.

Although bioluminescence is ubiquitous in the ocean, study of its evolution has been hindered by the absence of a fossil record⁷. Light organs that retain structural traits indicative of a previous function therefore offer a rare view of their evolutionary history. The duality of sucker and photophore traits in this finned octopod supports the idea that the light organs are modified suckers. This transition of function may have occurred during colonization of the pelagic deep sea from the shallow-water benthos.

We propose that these modified suckers may have two functions: communication, and attraction of potential prey. Visual communication is almost universal in cephalopods⁸, and the suckers of some shallow-water octopods may be used in (non-bioluminescent) sexual signalling². Because the organs' wavelength of peak emission is close to that of maximum light transmission in the ocean (475 nm), they

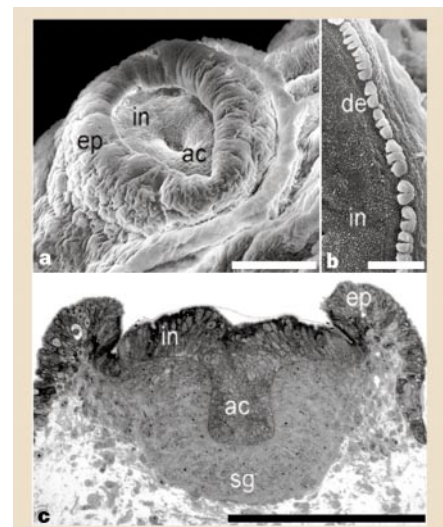


Figure 2 Micrographs of the light organs of *S. syrtensis*. **a**, Scanning electron micrograph of a whole light organ. The epidermis (ep) forms a collar around the cup-like infundibulum (in) and acetabulum (ac), which extends into the body of the organ. **b**, Scanning electron micrograph of the denticles (de), which encircle the outer rim of the infundibulum. **c**, Light micrograph of a longitudinal section through a light organ. The epidermis associated with the collar, infundibulum and acetabulum is composed of columnar cells covered by a cuticle. Presumably, light is produced by cells of the infundibulum and acetabulum. Each light organ is supported by a subacetabular ganglion (sg). The central canal of the acetabulum is not visible here. Scale bars: **a**, **c**, 100 μ m; **b**, 10 μ m.

are well suited for deep-sea communication. This matched spectrum, coupled with the common arms-spread posture of *S. syrtensis*⁹ and the location of the light organs, suggests that they may act as lures. *S. syrtensis* may trap small crustaceans in mucus produced near the mouth⁹, but as the shape of the arm web precludes any flow-through feeding current, so prey cannot be filtered from the water column, they must somehow be attracted to the mucus. Because many crustaceans are attracted to bioluminescent food sources¹⁰, the light organs may provide the attracting stimulus.

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