

## Commentary

# The Mystery of the Vampire Squid

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Evolutionary biologists believe that polar bears evolved unusual adaptations to enable them to survive in the harsh Arctic environment, such as their white coat; hair on the soles of their feet, a sense of smell (the best in the world) to locate seals under the ice; the ability to build dens in the snow, etc., etc. While all that is true, extreme adaptations are not unique. The shark, it is often said, is “perfectly adapted to its environment,” because it has remained unchanged for 300 million years. First of all, there is no such thing as “the shark” – there are more than 400 species – and over those 300 million years, they have changed enormously. In the past, there have been sharks with antlers, sharks with teeth on top of their heads, sharks with circular-saw teeth, and carnivorous sharks 50 feet long. By definition, every living animal on earth is perfectly adapted to its environment. If it wasn’t – also by definition – it would be extinct. The terrestrial dinosaurs, flying reptiles, ichthyosaurs, plesiosaurs, trilobites, and thousands of other creatures failed to adapt, and they have all been relegated to fossil history.

The vampire squid (*Vampyroteuthis infernalis*) – more about that name in a minute – is the very definition of an animal that has developed a suite of characteristics that have enabled it to survive for hundreds of millions of years in a most inhospitable environment. The size (and color) of a small football, *Vampyroteuthis infernalis* was named by a 19<sup>th</sup> century German biologist who saw only a dead one brought up from the depths of the West African Atlantic Ocean. It was black, with what looked like a cape, and had (he thought) red eyes, so he named it *Vampyroteuthis infernalis*, “the vampire squid from Hell”. (*Vampyroteuthis* means “vampire squid,” and *infernalis* means “from the infernal depths.”) It’s not actually a squid (and not an octopus either), but a cephalopod so special that it’s been placed in its own order. The other orders of cephalopods are squid, octopuses, cuttlefish,

and nautilus. Squid and cuttlefish have eight arms and two feeding tentacles; octopuses (the correct plural; forget “octopi”) have eight arms, and the nautilus, the only cephalopods with an external shell, have around a hundred. The reason that Vampy is not a squid and not an octopus is the presence of two filamentous feeding tentacles in addition to its eight arms, which it uses in a manner heretofore unknown, except perhaps in Jellyfish (Figure 1).

*Vampyroteuthis* lives in all the world’s temperate oceans, at a depth of around 3,000 feet. To survive in this virtually lightless environment, Vampy has evolved the largest eyes relative to its size of any animal on earth: a ten-inch-long specimen has eyes an inch across, the size of those of a labrador retriever. The gigantic eyes of the vampire squid are cornflower blue. In addition, *Vampyroteuthis* has an assortment of light-emitting organs, unlike those of any other cephalopod – unlike those of any other creature. *Vampyroteuthis* is equipped with a pair of fin-based, quarter-sized photophores on its body that can be switched on and off, pulsed, dimmed, and increased in intensity, and even closed with “eyelids.” It has organs on the ends of its arms that can light up and release the microscopic particles that form a glowing cloud. The eight arm-tip light organs are always turned on *en suite*, and can flash or glow steadily, but rarely for more than a minute, and can be “masked” by curling them inside the web. Its body is peppered with what appear to be tiny photophores, but they have never been seen to luminesce. The pair of large, composite organs, located at the level of the eyes, do not luminesce, and are not photophores at all, but *extra-ocular photoreceptors*, composed of closely-packed clusters of small white nodules, covered by a clear window. The actual function of the extra-ocular photoreceptors is not clear, but as they are found in all octopuses and all squids,



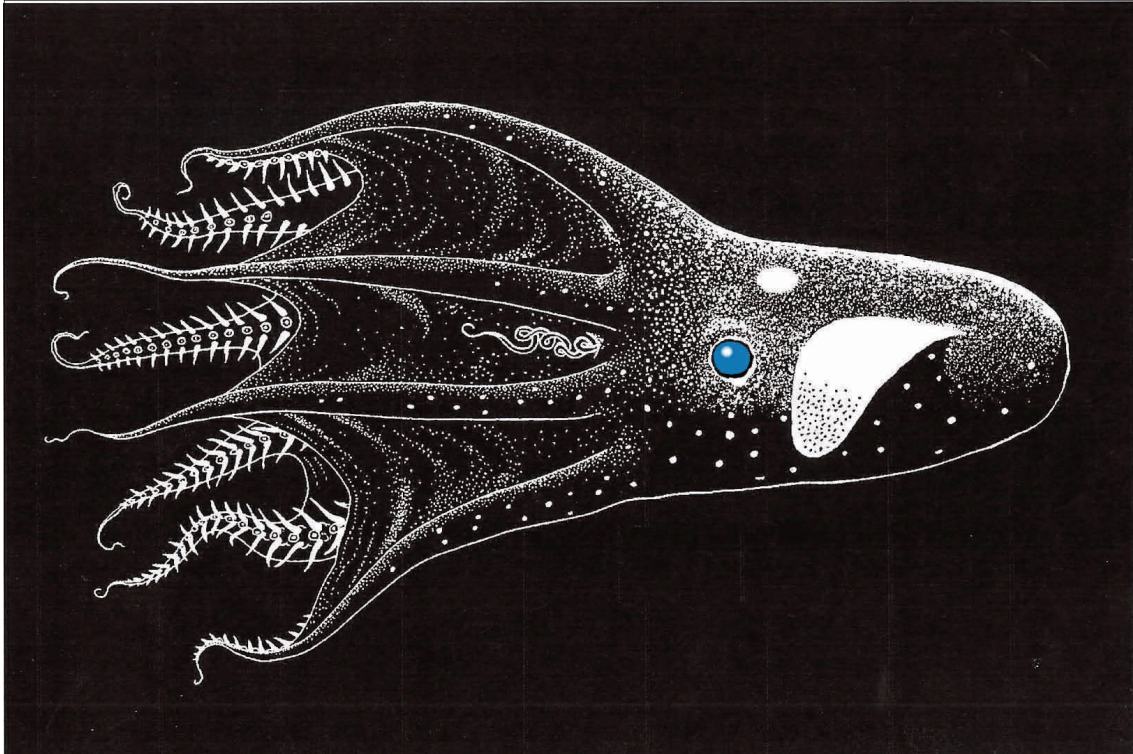


Figure 1: A drawing of the vampire squid by Richard Ellis and reproduced with permission, 2012.

they must be a part of the animals' *modus operandi*. They may be used to read ambient light levels, even at depths where there is very little light. Scientists have studied these photosensitive vesicles in *Vampyroteuthis*, and concluded that the photoreceptors are ideally located for reading ambient or downwelling light, and can also be used to read its own bioluminescence or that of the prey it is consuming, to insure that the vampire squid does not give off any light that would attract predators.

Little *Vampyroteuthis*, anomalous in so many aspects, has its own set of bioluminescent displays, not observed in any other species. The large, blue-glowing photophores near the base of the fins can be flashed, pulsed, flickered, or shut off altogether. If the animal is threatened by the presence of a potential predator, it raises its umbrella-like web prior to enclosing itself in the "pineapple posture," and turns on the two large light organs near the fins. To give the appearance of moving away, it slowly diminishes the size of these photophores until the web is closed over the body, essentially making the animal disappear. During an "escape," it can flash the arm-tip lights all at once or pulsate them, again

presenting a confusing image to a predator. These arm tips are also programmed to release bioluminescent mucous particles which can mask the escape of the vampire squid. *Vampyroteuthis* also has sphincter-like control of its eyes, where it can suck in the glowing blue globes so they cannot be seen (or be seen *with*) at all.

So little light penetrates the habitat of *Vampyroteuthis* that it must pick up the bioluminescent flashes of other creatures; it depends partially on its sense of sight to locate something to eat. Although there are exceptions (such as octopuses with no functional eyes at all), the eyesight of most cephalopods is excellent, and the oversized, dark-adapted orbs of *Vampyroteuthis* suggest exceptional efficiency. Because it lacks the two extensible feeding tentacles that characterize most other squid and cuttlefish species, it makes use of those attenuated filaments in a most unexpected manner. After deploying a single filament, the cephalopod drifts for several minutes, and if a filament contacts a prey animal, the vampire squid swims in a sweeping arc to where the contact was made. Upon locating the prey item, Vampy extends its arms, envelops the prey in its umbrella-like web, and draws it

toward the beak at the center of its arms.

But it is the prey items that further differentiate *Vampyroteuthis* from practically all other cephalopods. Instead of the little fishes, shrimps and jellyfish larva eaten by other cephalopods that occur in the same zone of the Monterey Canyon, the stomach contents of *Vampyroteuthis* included “agglomerated copepod parts, fecal pellets, radiolarians and fish scales, often embedded in a mucous matrix.” The source of this eclectic mix is marine snow, the constant fall of tiny particles that eventually constitute the sediment. “When I think of the floor of the deep sea,” wrote Rachel Carson in “The Long Snowfall” chapter of *The Sea Around Us*, “I always see the steady, unremitting, downward drift of materials from above, flake upon flake, layer upon layer – a drift that has continued for hundreds of millions of years, that will go on as long as there are seas and continents.” Life in the depths depends upon death in the shallows.

*Vampyroteuthis* is a *detritovore*, an eater of detritus. In 2012, Hendrik Hoving and Bruce Robison published the results of their analysis of more than 24 hours of video shot from ROVs in Monterey Bay between 1992 and 2012, and several specimens captured and brought up from the depths, observed in aquaria, and subsequently dissected. Microscopic examination of the filaments showed that one side contains a large axial nerve that runs the length of the filament and connects directly to the brain, while the other side has a band of muscle that is probably involved in retraction. Moreover, short, stiff hairs on the filaments suggest that these threadlike, sticky elements are not only used for food detection, but for food collection: the detritus is brought into the web and towards the mouth and scraped off the filaments by the cirri along the arms.

With its lucent blue eyes, soft brown body, multitude of light organs, trailing sensory filaments, bioluminescent ink cloud, and the ability to turn itself inside-out, *Vampyroteuthis* is an enigma wrapped in a black cloak of mystery. How does that business with reducing the size of its paired photophores work? Why pull its web over its head? Even now, it is unclear what color *Vampyroteuthis* really is. The first ones were described as black; then they were filmed showing that they were a light rust color, but then people argued that they were really dark brown or dark red, and that the rust

color was a function of the artificial light in which they were being filmed. (Ditto the big blue eyes.) The body of *Vampyroteuthis* is peppered with a regular array of what appear to be photophores, but in all the years that these animals have been photographed in the wild and in tanks, these spots have never been seen to light up. What good are lights if you never turn them on?

Whatever its bioluminescent capabilities, *Vampyroteuthis* is *sui generis*; it resides in its own highly specialized order, the Vampyromorphidae, oblivious to the early taxonomists’ uncertainty about its place on the tree of life; the number of appendages (and what to call them); what color it is; and how it earns a living in the darkness of its largely anaerobic habitat, thousands of feet below the surface. Little *Vampyroteuthis* satisfactorily answers these and all other questions with one overwhelmingly obvious response: it silently goes about its business in the darkness of the abyss, and has done so for eons.

Throughout its evolutionary history, *Vampyroteuthis* has somehow acquired the suite of characteristics and behaviors that define it, and because this lonely, lighted football of a creature has been around for tens of millions of years, it must be doing something that works. If it was not beneficial (in an evolutionary sense) to have a jellyfish body with trailing filaments, big baby-blue eyes, or arm tips that can emit a bioluminescent cloud, whatever forces could conspire to drive this enigmatic creature to extinction would have succeeded. As far as we know, that’s pretty much what happened to 99 percent of all the species that have ever lived on earth. We do not know why some species – indeed, almost all species – have become extinct. But we are able to make the a priori argument that species that are still living on earth have beat the odds, at least for the moment. Its peculiarities notwithstanding, *Vampyroteuthis infernalis* swims on, and will probably continue to do so for millions of years to come – assuming there are millions of years to come.

