Photo Courtesy of Bob Fulcher

Lovely and Dangerous Lights

By Bob Fulcher

Have you visited Pickett State Park during the early summer weeks and heard of the intriguing blue lights that glow all night in front of Hazard Cave? It is true that scientists cannot fully explain them. They are working on it.

There is nothing paranormal here, just another example of how much remains to be learned from familiar places and overlooked fauna. The blue lights are emitted by the larvae of fungus gnats. An adult fungus gnat looks about as unpleasant as it sounds: kin to the flies, mosquito sized and shaped, but appearing nervous to the point of acting manic. There are many species around the world, some considered pests of nursery stock, many with weird symbiotic relationships to fungus, most favoring dank, dark environments. The young of one species, *Orfelia fultoni*, are so strange, however, they could be featured in a sideshow of natural curiosities if only they were a hundred times larger. Or, their beauty is so sublime and seductive that you are tempted to fall in love at first sight.

At Pickett State Park the most obvious congregation of the larvae is along a streambed formed by an unnamed rivulet that first falls over a bluff face, pouring down in front of the opening of the sandstone rockhouse known as Hazard Cave. Much of time there is no flow of water at all, just wet, algae-stained sand beneath an untidy tangle of rosebay rhododendron. The intensity of their glow is dim enough to be obliterated by a flashlight, so their discovery had to wait for that rare individual who would travel through the woods at night in rank darkness. As far as I know, an eccentric state park naturalist named Richard Hilten was the first to pay attention to the animals that we came to call the "Hazard cave glow worms" in the early 1970s.

A group exodus to view the light show became a weekly feature of the June program for park visitors. More than a thousand of the tiny animals could be spread along the stream bank, giving the impression of a ferny, lamp-lit Lilliputian village. A most striking aspect of the light was its color, blue-jean blue, rather than the yellow-green of fireflies and their larvae (which are the better known "glow worms.") None of us, though, knew what these placid blue spots were.

A couple of years passed before we learned they were probably the larvae of fungus gnats, similar to the ones that decorate the ceiling of famous Waitomo Cave in New Zealand, and several more passed before the work of B.B. Fulton, for whom our American species was named, was shared with us.

In 1941, entomologist Fulton wrote, "If the water pail had not gone dry that night I probably would

never have discovered the luminous worms," describing his chance sighting of the glow worms at a spring behind his summer home in the mountains of North Carolina. Because the animals were so small, about one half inch long, he could not tell much about them, and thought they might be related to earthworms, but his observations soon revealed a fascinating fly maggot. Both their head and tail had centers of luminescence, easily seen through their mostly transparent and slimy looking bodies. They lodged in a den excavated in the soil beneath a small web of their own making, and glided along it courses as they laid new strands or attacked insects that were caught in the sticky silk. The worms appeared to produce the threads from their mouth, the attached fibers had unusual thickenings where they were anchored to the soil.

Their web strands were versatile tools. They could obviously catch prey and function as a physical barrier to the attack of predators. They were also effective lifelines, allowing a glow worm straying to the edge of its web to make a lightning fast retreat along a strand back to its burrow if disturbed.

Fulton noted that the strands were hung with small droplets. "The web reminds one of a spider's web in the early morning when it is sparkling with dew..." he wrote. "The worm rests on the central strand and is held to it by a film of liquid which surrounds the body. It is like an aquatic insect that carries its own pond..."

The first notice of their presence in Tennessee was published in 1949 by 18-year-old Thomas C. Barr Jr., who also thought they were segmented worms and supposed they were feeding on fungal threads in a Middle Tennessee cave. Barr soon learned of their general classification as fungus gnat larvae and continued his cave observations until he distinguished himself as one of the country's leading cave biologists (see *The Tennessee Conservationist,* Vol. LXIV, No. 1, 1998.) Nothing further has been published about them in Tennessee, though, and only three additional articles have appeared in the scientific literature since Fulton, one by a French biochemist, and two by John Sivinski.

Sivinski, a graduate student from the University of Florida, was looking for firefly larvae one night in 1978 at the Highlands Biological Station, not so far from the site of Fulton's discovery, when he walked past a streambank liberally speckled with blue lights. "That color attracted me, " Sivinski said. "It was like a starry night against the road bank. They were just so beautiful and once I learned that hardly anything was known about them, I got very interested."

Sivinski fashioned an experiment to research their survival strategies. Placing dark and clear traps around the webs and randomly, he found strong proof that the soft, innocent-looking, deep blue light of *O. fultoni* attracted certain flying insects to their death, especially gall midges and scuttle flies. Earlier researchers had shown that some insects orient and navigate by night lights - stars and the moon - the downside of that gift being a tendency to take a spiraling flight into a candle flame or a hot light bulb. Perhaps, gall midges look to the stars for direction, too, and wind up in silken traps? Other crawling invertebrates, like springtails and small beetles, showed no particular attraction to the *O. fultoni* lights, but were trapped in webs nonetheless, one of the hazards of wandering around in the dark.

Sivinski learned of a light-emitting, web-spinning fungus gnat that is vegetarian, a Japanese larva that apparently eats only fungal spores. "This attracts another hypothesis," says Sivinski -- the possibility that the light might also be a signal warning predators that *O. fultoni* larvae are distasteful, or be a repellent to predators that have an aversion to light. Earlier work with similar species had indicated that web-building fly larvae laced their webs with toxic drops of oxalic acid, a poison compound used by mechanics for cleaning radiators. It had been supposed that the acid assisted in predigesting of captured prey. Does *O. fultoni* have such a defense, and could the lights advertise this danger? As Sivinski puts it, "this is just an alternative explanation." No one has studied them enough to know.

Many basic details of their lives have not been discovered. How long do the adults live? Do they

retain any luminosity into adulthood to help in attracting mates, like firefly beetles? Do they eat, do they fly far away, or just mate, lay eggs, and die?

I have observed larvae lingering, seemingly probing beyond the end of their web strands, as though they were grazing on organic matter. Could they be more than carnivores, and have a taste for spores, or decaying organic matter like others in their family? No one has looked in their gut to find out. That pastoral behavior is in sharp contrast to their otherwise energetic feeding habits. I once threw a tiny bee into a web and watched what appeared to be a snake-like attack upon the bee, the glow worm striking and retreating to his burrow, then striking again, repeating the actions for several minutes. B.B. Fulton had noticed this, too, suspecting the worm was throwing liquid onto prey, "which impedes the activity of the victim." A sliming technique as seen in Ghostbusters?

Another less-than-cute trait that may belong to "*O. blue eyes*" is cannibalism. New Zealand glow worms fight each other over their territories, and the loser is lunch. Does the mostly generous spacing between webs of *O. fultoni* have anything to do with similar contests and appetites?

Fulton was fascinated by the evidence of a strong internal clock regulating their lamp lighting times. The Blue Ridge and the Pickett worms glow only at night, though they will take food during any hour of the day. Even if kept in complete darkness, their turning-on timing is impeccable. The glow worms in limestone caves, though, shine during the day, and no one yet has checked on their nocturnal activity.

How widespread is the range of this creature? We don't have good idea, because they are easy to miss. After three seasons of trying, I managed to photograph the dim lights of an *O. fultoni* community, which provided a census figure that was almost three times greater than the number estimated by a naked eye count. I have seen them at several seeping sandstone bluffs on the Cumberland Plateau and limestone caves on the Eastern Highland Rim of Tennessee. A privately-owned nature reserve in northwestern Alabama called Dismals Canyon offers tours that feature their blue "dismal lights," produced by "dismalites," which they claim to be New Zealand glow worms. If these populations are isolated enough, there is a possibility that more than one species has developed across these somewhat different habitats. They certainly seem to be another candidate for the theory developed by Dr. Thomas C. Barr Jr., that the ancestry of many cave animals is from cold-weather fauna of Pleistocene times, when glaciers covered the northern states. As the climate changed, some Pleistocene animals found refuge in cool cave climates, as others migrated to the tops of the Blue Ridge mountains.

In recent decades, bioluminescence has become an important tool in scientific and medical research. Light-generating genes have been spliced into other organisms and cells to act as indicators of chemical activity and visible gene markers. Bioluminescence is created by the oxidation of a molecule called luciferin, catalyzed by an enzyme, luciferase. But each species creates it own unique form of these molecules, and so each one has a different potential for research. A group of Harvard researchers have recently taken interest in *O. fultoni* and demonstrated that this fly has a previously unknown bioluminescent system, not activated by ATP like fireflies or the New Zealand glow worm.

If *O. fultoni*'s biochemical tricks can be understood and mastered, they might be quite beneficial to humankind. We've neglected them for a long time, but I suspect this disregard cannot last much longer. They know too many wonderful tricks. And when I asked Dr. Sivinski why he had studied them, he replied, "Because they were beautiful, mysterious lights in the night. It was mostly aesthetic."

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