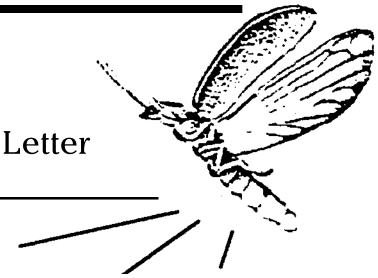
The firefly gives light to its pursuer. Oemaru

Fireflyer Companion & Letter

Vol. 1, Number 2 Spring 1996



Fireflies At Risk — UPDATE

Fireflyer. firefly + er. *n.* short for *firefly chaser.* A person who thinks about lightningbugs.

FIREFLIES USA — 26/4/96: For many years, without success I have tried to get entomologists who are knowledgeable of pesticides, their modes of action, application and side-effects, interested in determining the impact of various chemicals on fireflies and firefly populations. — As you may recall from the first issue of the *Companion* the question was raised as to whether such chemicals are adversely affecting fireflies and may be contributing to the obvious decline in their numbers that has been noted b so many firefly watchers. It is easy to imagine that they could, directly and/or indirectly through the food chain. — Recently an entomologist in west Florida who is involved in a mosquito control program contacted me about research he wished to conduct on the effects of mosquito adulticides on fireflies. Though the investigation is being slowed by the unusually cold spring, we may eventually have our first hard data on the matter. *(fdl)*

Introducing Fireflies

Dear Fireflyers, Fireflies are not flies, they are beetles and most Americans call them lightningbugs. Not only do different people call them by different names, but they have used them for different ideas, concepts and spirits — ghosts of ancestors, bits of truth in a dark world, foreboding of evil, triviality. They comprise one of several families of so-called Leatherwing Beetles, and are found on every continent except Antarctica. Their formal family name is Lampyridae. Worldwide there are over 1900 species that have been formally named, but I am certain that this is but half or fewer of those that are out there to be named. Over 170 species occur in North America, more than 50 on the tiny island of Jamaica, at least 30 are found in New York state and over 50 occur in Florida. The firefly-richest region of North America probably occurs along a 30-mile-wide swath on the Florida-Georgia border from the Big Bend Coast to the Okefenokee Swamp. In spring and summer in the eastern United States thousands of flying flashing males of many different species can be seen as they fly over meadows, fields, and marshes, emitting their amber, yellow, or green-yellow light, but west of Kansas flashers are a novelty in spite of past failed attempts by enthusiasts to introduce them.

The firefly's living light, which is a form of chemiluminescence known as bioluminescence, is neither electrical spark nor brief glimpse into a flaming furnace within. It is a chemical reaction in which visible light energy is released. The reaction involves the oxidation (a chemical burning) of luciferin, the light-emitting molecule; adenosine triphosphate (ATP), the energy-rich molecule that is the immediate source of energy for the numerous functions involved in movement and growth in all organisms; luciferase, the enzyme that catalyzes the reaction; and a co-factor, magnesium or manganese, which works with luciferase to "facilitate" the reaction. The emission of a flashing firefly is triggered by nerve impulses to the lantern. When removed from the tail of the firefly by various chemical treatments, or when firefly genes are put into other organisms, the photochemicals and photochemistry can be used for several applications in research and medicine, but it destroys the magic that inspired poets such as Tagore and Shelley. Some might argue that it is a new poetry for a new century that has been produced, but would they miss the point, about reaching for finer things? While there may well be a poetry in technology, for many of us technology is never poetry, and is perhaps one of the many reasons we seek out poetry.

If you spent your childhood with the flashing species of eastern North America, then fireflies are more than mere insects. They are glowing stripes smeared on shirts and foreheads, a Mason jar of flashes gathered from the front lawn at dusk and carried quickly-off-to-bed-to-be-watched-under-the-pillow-where-it-was-really-dark. Flashing fireflies met the colonists in Jamestown, and danced on the prairie with a fiddle and Sweet Betsy from Pike. Once there were plans for them to go with an even bigger fire in the tail - though in a form retaining little of their romantic selves — to outer space to hunt for extra-terrestrial life, but they were bumped.

A firefly's luminescence first appears in the embryo stage when the beetle is still within the egg "shell," though the shell (chorion) of the egg may also have been smeared with a short-lived glow as it passed down its mother's egg canal. After hatching and for the next weeks, months, or years — depending on the lifecycle and local ecology of the species — the larva glows from its two tiny posterior lanterns. The known larvae of all fireflies are luminous, even the larvae of species in which the adults have lost (over a very long time), their ability to shine. Why do larvae glow, for they are too young for sex, we presume? There have been numerous guesses over the past 100 years, yet no one knows for certain. You might look into this, and it should sustain your faith in nature and appreciation of pure biology. Is it not true that a subject too complex for us to ever fully comprehend is thus especially appealing, reassuring, and beautiful for the right-minded and thoughtful?

The function of larval light could be related to the predatory behavior of the larvae. They hunt snails, earthworms, larvae of other insects, and probably other soft-bodied animals on and in the soil, depending on what kind of firefly they are. Once it was suggested that the glowworms (a term sometimes applied to firefly larvae) attract prey with their light. This idea is a natural, and may have been stimulated by accounts of the predatory habits of luminous fungus gnats in New Zealand caves, or by watching flying insects attracted to porch lights. One guess is that the larvae of some species may use the glow as a call to arms. Because they sometimes hunt large snails or other prey, and each larva has a limited poison reserve with which to stun prey and could not possibly eat a big snail all by itself, maybe larvae call others to join a chase and gang up to subdue a giant. There is little evidence, circumstantial or otherwise, to support this *notion.* Commonly several larvae are found feeding upon the same kill, and after larvae of one species rediscovered the trail of a snail that they had been following, but momentarily lost, they again began to luminesce. Probably the light is used in several ways for several functions. Another promising but difficult to prove *notion* would be that larvae sometimes use their glows to coordinate life history events, such as pupating. In Japan when aquatic larvae leave the water to pupate on shore they all glow brightly as they walk up the bank to find a spot.

When the larval form of the beetle has completed its function (i.e., role, purpose) — that of growing larger and storing energy — the insect begins the dramatic, almost magical transformation during which it will rebuild itself completely and produce the body-form that is adapted for sex and reproduction. The period (=growth — stage) of rebuilding, generally termed the pupa, has sometimes been referred to as the resting stage, and it takes place in many insects including butterflies, flies, and fleas. Far from resting, the firefly builds wings, flight muscles, wing-covers, big and complex eyes with innumerable facets, long antennae, new neural circuits, and a new set of behavioral and physiological programs, patterns, and responses.

For this change of life, which may take a week or a month, the firefly hides itself. Larvae of *Pyractomena limbicollis* Green (a firefly of southeastern United States) climb up on tree trunks, bushes, and vines, and sometimes in a crack or crevice they glue their tails down. They "undress" by wriggling and squirming, while hanging upside down by what might be called their tail-end toes. Then they hang like a butterfly chrysalid for nearly two weeks. The pupa is cryptically (concealingly) colored and on some tree bark can be difficult to find. The larvae of *Pyractomena* fireflies are occasionally seen glowing, and on damp nights in damp woods they are sometimes found lit up as they walk up the trunks and along the branches of shrubs and trees. In general, *Pyractomena* species are rarer than those of our other flashing genera, *Photinus* and *Photuris*, and the habitats of many species are easily made unsuitable for them — low woods cut (as useless wasteland), and swamps and marshes drained.

In contrast to the aerial/arboreal transformation of *Pyractomena* fireflies, species of *Photinus* and *Photuris* are subterranean pupaters. Larvae of the genus *Photuris* are the most commonly seen glowworms in North America, for not only are they very common, as larvae they spend much time walking on the ground, presumably hunting, and often glow while doing it. Larvae of *Photinus* fireflies spend most of their time underground and rarely are seen glowing; though there are exceptions.

But back to *Photuris'* metamorphosis habits: the larvae dig a pit in the soil, climb in it, and continue to dig. They make soil crumbs into little pellets, and from the inside of their digs they form it into an igloo-shaped hut. After a few days in seclusion they shed their larval skins, and, in a reclining position on their back, reorganize their form and function and become born-again lighting-up bugs. The verb *eclose* is used to refer to both the hatching of the egg — when the embryo emerges from the shell to become a first instar larva — and the emergence of the untanned and ghostly pale (teneral) adult, fresh from the pupa.

Two features of *Photuris* firefly pupation are really different from those of *Pyractomena* fireflies, and are related to the site that it uses for its metamorphosis — that is, its transformation. The *Photuris* pupa is not pigmented, but is ghost white, and it readily turns on its light when it is touched. The lack of pigment may be adaptive in two respects. First, when the light is turned on the entire animal glows because its translucent tissues conduct the light. The light in this case may deter potential predators or subterranean wanderers that break into the chamber and might damage the transformer. This idea was generated ("notioned") by one of my students long ago, Larry Buschman, from his work on soil-inhabiting species, and me, from studies of species that spend their juvenile stages in rotten pine logs. We have not tested it, but it is thusly stated: since animals that live in the humid confines of the soil, rotten wood, or other dense media may have evolved negative responses to light — because light would be an indicator of the lethal outside world of low humidity and sharp-eyed predators — the light of the juvenile firefly may mimic daylight (above ground) and sometimes cause a soil- or log-inhabiting predator to quickly, at first sight, turn and move in another direction. Secondly, to build pigments may be expensive in ATP coinage of stored energy. A saving in pigment cost could be used to build more eggs, or make available more stored energy for mate-seeking activities later. Cost-benefit ratios and energy budgets are of some importance in the lives of many organisms, though perhaps sometimes their presumptive penny-wisdom is greatly overrated. I am not fond of either of these ideas, but they are there to think about, test, and improve on or put at the bottom of the plausibility list.

After the new *Pyractomena limbicollis* adult is formed, the firefly bursts through the front end of the pupal skin and crawls, squirms, and wriggles, and slides slowly out of it. The cuticle of the new adult is mostly white at this moment, but it gradually becomes charcoal- and rose-colored, and then black and red. Color changes are accompanied by hardening of the cuticle and a firming of the muscle attachments within, and in a few hours the adult beetle, fresh and sparking like a new automobile, is able to move about with vigor, and to fly the first time it tries, virtually without practice. Amazing magic on the wing and all lit up.

With the setting of the sun on the first day of adulthood the events that are most apt to catch the human eye and fancy can begin. Because there is an incredible amount of variation among the fireflies, a single description could not serve them all. Here is a brief sketch to give a basic pattern that is found in North American flashing fireflies. The adult mating behavior of

J.E. Lloyd (Ed.), with Mara Addison, and Joshua Trotter.
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the Big Dipper Firefly, *Photinus pyralis* (L.) was first described by Baron von Osten Sachen 130 years ago. It was studied in more detail in the early 1900s by the father of American fireflyology, Frank McDermott. A little before dusk females climb up on blades of grass or herbs. Males take flight and emit a half-second flash every 5 to 6 seconds. As they flash they make a swoop, a swooping U or J in flight, then pause and hover for 2 seconds or so, then they fly several feet in one big flying hump, drop down low and aim, and swoop-flash again.

When a female sees the male's flash she waits for 2-3 seconds and emits her half-second flash. Her flash is presented during the period when the male is hovering, immediately following his flash — that is why he has remained there hovering for more than two seconds before flying on to deliver his next advertisement. He then turns and flies a few feet towards where he saw her flash, and flashes again. The pair continues a dialogue that lasts for a minute and sometimes much longer. Eventually he lands near and walks to her, still talking but sometimes whispering to her. Then, with possibly, maybe, perhaps a chemical "by-your-leave," the male mounts and transfers sperm to her. This takes her full cooperation, because if she turns her tail down he will never find the right place to put the sperm in.

The mating behavior just described generally applies for flashing fireflies, the lightningbug fireflies. There are two other major communication systems found in fireflies in North America. In glowworm fireflies usually only the females have lights. They live in underground burrows but come to their doorway above ground to show their glowing light and attract a mate. Then they retire underground to lay their eggs and they eventually die there. Because there are only a few species of glowworm fireflies, and because males of most of them do not have lights, they are seldom seen. Adults of some firefly species have no lights, and they use chemical signals (pheromones) for sexual signaling. These dark fireflies apparently fly exclusively in the daytime.

Quiet and mysterious trails, *(fd)*

Henry David Thoreau and the "Fireflies"

Henry David Thoreau — author of the American liter-ary classic, Walden, or Life in the Woods (1853) —was a competent naturalist, especially a very good botanist. But, for various reasons, when he tried his hand at coleoptera, despite all his efforts, he had little or no success at identifying the two batches of luminescent worms that his friend Marston Watson, a very successful Plymouth, Massachusetts, horticulturist, had twice deposited to his care.

The first batch from Watson awaited Thoreau when he returned to Concord and Walden Pond on 8 August 1857 from a twenty-day sojourn in the Maine woods. On the very day Thoreau set out from Concord for Maine, Watson had shipped him six "fireflies" that he had found in the hills above Plymouth. They had been found in the grass under the wild cherry trees, where it is very dry, Watson told Thoreau in a note that accompanied the worms. But when Thoreau got back to Concord on 8 August, only two of the worms still had all their luciferin firepower. The other four were definitely worse for the wait.

In his note, Watson had declared these fireflies to be very scarce. Nonetheless, he wanted to know the species. He wanted Thoreau to find out what they were, and Thoreau sought to do so. He gave the two hardy worms careful goings-over by night and by day and carefully entered his observations in his journal (10:3-5). By night, one of them had two bright dots near together on the head and two more bright dots at the other extremity, wider apart than the first. The firefly was composed of twelve segments or overlapping scales divided by nine transverse lines of light, with a bright dot on each side opposite the transverse lines. The bright dots glowed with a greenish light.

By light of day, the smaller worm measured seven-eighths of an inch long, one-sixth of an inch wide, and about one-twelfth of an inch thick, with a head nearly one-twentieth of an inch wide, and with a tail wider than the head. They have six light-brown legs, Thoreau noted, within a quarter inch of the forward extremity. The smaller worm had six short antennae-like projections from the head, the two outer on each side the longest, the two inner very short. The worms were a pale brownish-yellow or buff. The head was dark brown; the antennae were chestnut and white or whitish on the sides and beneath.

What kind are these? Thoreau asked in his journal. But Thoreau would never know that the fireflies he had so carefully described were doubtless or at least most likely *Phengodes plumosa* larvae or larviform females, a species of the Phengodinae sub-family of the beetle family Phengodidae. As early as 1790, Guillaume Antoine Oliver described and pictured the *Phengodes plumosa* adult female; but Thoreau's may be the first description, so far as we know, *in English* and the first recorded instance of the *Phengodes plumosa* larviform female having been found in Massachusetts. In fact, Walter Wittmer in his discussion of the "Genus Phengodes in the United States (Coleoptera: Phengodidae)" in a 1975 number of The Coleopterist Bulletin does not indicate that any *Phengodes plumosa* Oliver worms, so far as he could discover, were found in Massachusetts before 1894. Thoreau described the worms forty-seven years earlier.

Nonetheless, despite Thoreau's meticulous examination of his worms, in the fall of 1857 he was not able to determine what he had. He went to his own library but without success. He complained in a letter to Watson that Kirby and Spence's *An Introduction to Entomology* (London, 1856), John Knapp's *TheJournal of a Naturalist* (London, 1829), and James Rennie's three companion volumes — *Insect Architecture, Insect Miscellanies, and Insect Transformation* — all three published in London in 1830-31 — contained no minute, scientific descriptions. But if Kirby and Spence, Knapp, and Rennie had contained detailed scientific descriptions, Thoreau should have been aware that they would have been of little or no help. All of these works have an Old World (English) orientation and were not likely to be a means of providing the identification and classification that Thoreau sought to determine.

However, while Thoreau was pondering his firefly problem, the Boston Daily Evening Traveller on 12 August 1857 carried an untitled front page account of two fireflies exhibited on 2 July by Dr. Silas Durkee, a Boston physician, at a meeting of the Boston Society of Natural History. Thoreau was struck with the similarity between his worms and what Durkee said of his. Could Durkee's batch and Thoreau's be the same species? Possibly, Thoreau thought. But two things bothered Thoreau. One was Durkee's claim that his worms often glowed with a light equally diffused throughout the entire length of the worm. The other was Durkee's claim that his worms were the so-called common English glowworm firefly, *Lampyris noctiluca* — the firefly the English literary writers most often wrote about. Thoreau was convinced that Durkee's worms were not *Lampyris noctiluca.* Durkee quoted from Kirby and Spence to back up his claim that his were *L. noctiluca.* But Thoreau no doubt read Kirby and Spence more carefully than Durkee had; and Thoreau no doubt noticed that Kirby and Spence had noted specifically that authors who have noticed the luminous parts of the common female glowworms have usually contented themselves with stating that the light issues from the last ventral segment of the abdomen (p. 539). Durkee claimed that his worms diffusely glowed equally throughout. Kirby and Spence indicated that *L. noctiluca* did not glow in such a fashion. Thoreau went along with Kirby and Spence, and Thoreau was right. *Lampyris noctiluca* was an Old World beetle; and to this day, there is no documented record of even an accidental arrival of *L. noctiluca* in the United States in ballast or otherwise. Thoreau was convinced that his worms were of a species distinct from *L. noctiluca,* though he would never know just what species he had.

Unsuccessful as Thoreau was in identifying the first batch, Marston Watson nevertheless sent a second batch of worms that he found in Lincoln, Massachusetts, on 15 September 18 5 7. They were, Thoreau noted in his journal (10:33-34), deep brown creatures. They averaged about five-eighths of an inch long, with six brown legs within about one-fourth of an inch of the forward extremity. The worms, he observed, were composed of twelve scale-like segments, including the head, which, at will, is drawn under the foremost scale. When he touched one of the worms, it stretched and showed its light for a moment, *only* under the last segment. The worm's first segment was broadly conical, much the largest. The other segments were very narrow in proportion to their breadth, and successively narrower, slightly recurved at tip and bristle pointed.

These little worms, Thoreau especially noticed, had light organs only on the apical. sternites of the abdomen. Had not Kirby and Spence said that this was a characteristic of the *Lampyris noctiluca?* So Thoreau jumped to the conclusion that the worms indeed were *L. noctiluca* this time.

Of course they were not — could not have been. In fact, Thoreau's journal description was a very accurate portrait of a larva of a species of a *Photuris* firefly (subfamily Photurinae of the family Lampyridae). The larva Thoreau described in detail was one of several species, which, in Thoreau's day and well into this century, were lumped under the name *Photuris pennsylvanica.* Although there were several taxonomic studies dealing with *Photuris* in Thoreau's time, there is no evidence that he was acquainted with them or had access to them. Yet he needed more light and different light from what was available to him in Kirby and Spence, Knapp, and Rennie with their lack of minute, scientific description and their Old World orientation. It is too bad that Thoreau, in his day, did not have something similar to Ross H. Arnett's *The Beetles of the United States (A Manual for Identification)* [Ann Arbor: The American Entomological Institute, 1968] to enable him to corrrectly identify the *Photuris* females and the *Phengodes plumosa* worms that Marston Watson sent him.

F. B. Dedmond (Boone, NC
— The Firefly Capital of America)

Reference: *The Journal of Henry D. Thoreau,* ed. Bradford Torrey and Francis H. Allen (14 vols; Boston: Houghton Mifflin Co., 1906).

Notes From A Firefly Sadist

J.E. Lloyd, in response to my request for some material on fireflies, sent me a couple of pounds of it. I'd barely digested the opening ounces when I remembered something gruesome from my childhood. I used to squish the rear ends of fireflies in hope of harvesting for my own use a stash of their luminescent paste.

With that memory returned a flood of images dating from between the ages of three and ten. Only one was patently untrue: I couldn't have outfitted a cicada with a harness, and walked it along the lawn as on a leash. More smacking of the truth was the memory of poking sticks into cow patties to expose the grubs. I recalled inserting any item that resembled a cocoon into a wooden match box, and waiting to see what would emerge. Some were moths. Others were spiders. One was a wasp. Certainly I fed crickets on bread and milk; when they died, they turned belly up in their makeshift tin-can cages. Green katydids faded when killed by chloroform; caterpillars rotted. Grasshopper "tobacco juice" did not make a good ink. The ones with red legs kicked so hard they kicked them off. Ants make a hissing or popping sound when burnt with a match. Decapitated horse flies walked headless.

These were cruel and revolting memories to adult sensibilities, but they were suffused with glee. I discerned in them not the slightest tinge of moral difference between the image of rescuing a silverfish from drowning in the bathtub (by drying it on a bed of folded toilet paper) and that of tearing heads off flies in attempt to acquire their emerald eyes. Eyes, juice, chirp, kick, glow, and even the recovering twitch of antennae on a near-drowned silverfish are phenomena of great interest to children, and if moral judgement is pertinent at all, it is to be found in the intimacy with other creatures to which such experiments are prelude.

I didn't become the scientist that an intensity of such interests presaged in several of my children, but neither did I become someone who idly sprays to kill. I became an interested participant in the systems by which my former victims are supported, and which they in turn support. I think I learned something.

Firefly luminescence, I can tell you, doesn't even last 'til bedtime. But the realization that it fades because it dies, that only the living body of the firefly itself can keep it glowing, lights the adult mind as vividly as those viscous smears so transiently lit my fingernails fifty years ago. Of all creatures, insects are the most abundant and the most available to children, the most various and enchanting, and the most correctly scaled in that they fit into small hands and boxes, and the most desirably alien in that they do not scream or bleed.

Of all insects, fireflies are the best. They are the best because parents must let their children stay up past sunset to indulge their joy; because the beetles speak a common language of flashes in the night; because they make mayonnaise jars into bedtime lanterns; because they are easy to catch.

And because — boluxing as they may be to Dr. Lloyd and fellow systematists whose childhood chasings now can be weighed by the academic pound — fireflies all look pretty much alike. It's hard to answer butterfly questions: Is it nymph or satyr, comma or question mark? It's easy to answer sparkles in the night:

Yes, my dear, they are fireflies.

S. Stein, July 14, 1994

Sara Stein is the author of gardening books but recently turned her attention, writing skill, and botanical knowledge to conservation/restoration in her book *Noah's Garden.*

Answers to *Trivial Flashlets*

1. What State in the U.S. has more firefly species than any other? Ans.: Georgia, with about 56, though recently Florida has apparently matched **this** number. But, what is a species?

2. What city has a firefly festival every year, and has been designated the firefly capitol of the U.S.? Ans.: Boone, North Carolina, with a queen, art, and good food, so I am told.

3. What continent has no fireflies at all? Ans.: Antarctica.

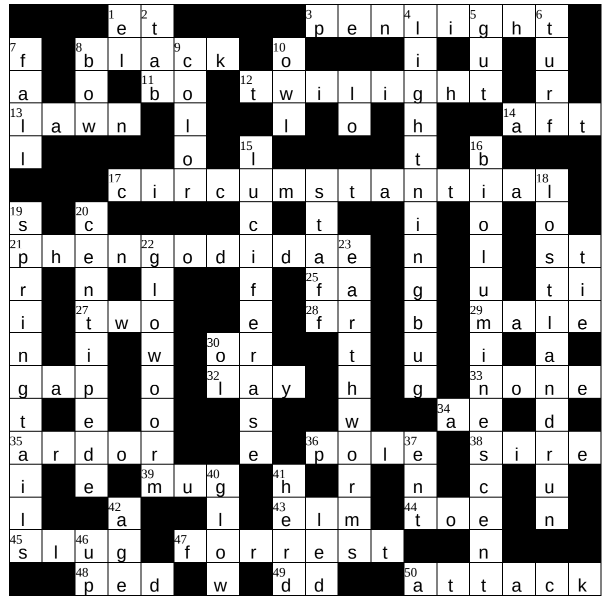
4. What city built a monument to honor the boll weevil? Ans.: Enterprise, Alabama.

5. What town has a 3-ft high statue of a mosquito in the square by the flagpole, and a mosquito festival and queen? Ans.: Effie, Minnesota, away up north.

6. What is the largest firefly in the world and where does it occur? Ans.: To the best of my knowledge it is probably one of the tropical species in the genus *Cratomorphus*, that lives (lived?) in the forests of Brazil. Length?, 1.5 inches or more. *Cratomorphus is* in the tribe Cratomorphini, with our *Pyractomena* species.

7. Are any firefly species cave-dwellers? Ans.: Herbert S. Barber, the Great-Uncle of firefly biosystematics noted the possibility of cave-living species in Jamaica. In New Zealand there is a cave-dwelling fungus gnat (Diptera, Mycetophilidae) that is luminous, and snares prey in sticky webs hanging from the cave ceiling.

Answers to last Crossword



Firefly Lifehistory

Across

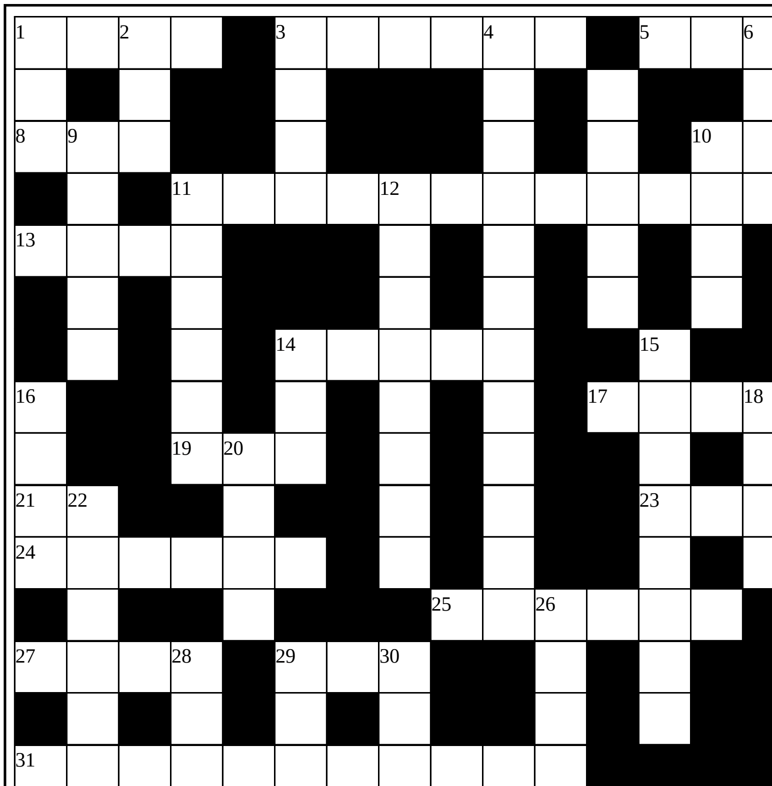
1. midthoracic prefix
3. prey for *Pyractomena*
5. notum *of* a segment
8. tarsal sole
10. Australia slang (abbr.)
11. firefly
13. transition stage
14. mouthpart fingers
17. firefly flightwing segment
19. first lifestage
21. single species (abbr.)
23. three (prefix)
24. feature of larval firefly mandibles
25. srotective bleeding
27. amaica
29. English nickname for mating
31. location of *Photinus* larvae

Down

1. plot of firefly locations
2. *Photuris* egg receptacle
3. *Pyractomena* prey
4. light
6. cap on cop
7. vertebrate nerve sensitive to firefly poison
9. mating life stage
10. sexlife onset
11. predaceous juveniles
12. yellow-light time
14. prefix meaning tail
15. elytral texture of fireflies and kin
16. marsh herb for some *Pyractomena* pupation

(Down cont'd)

18. not a firefly climate
20. steady emission of light
22. snail supressor used by fireflies
26. earthworms, snails, and dead insects
28. flash-signal detector
29. in an ecosystem, fireflies are a tiny one
30. first thoracic segment (prefix)



PHENGODIDS: Giant Glowworm Beetles

(A Taxonomic Survey of Lanterns and their Use)

(continued from Companion 1)

We will look into explanations for the phengodid peculiarity of subterranean light after introducing our North American giant glowworm fauna. The most commonly collected species belong to the widespread genus *Phengodes* and the western/southwestern genus *Zarhipis. Euryopa* is a less known member of the same tribe, the phengodini. The obscure ranks of the tribe Mastinocerini consist of seldom seen and little known genera such as *Cenophengus, Paraptorthodius, Distremocephalus* and *Mastinocerus.* Due to the variety of forms within populations, the number of North American species is open to debate. In *Zarhipis,* there are at least three species. *Z. integripennis* is the most widely distributed species, being found in western Washington and Oregon, throughout California to the southern half of Arizona and Baja Mexico. In Arizona it is restricted to mountains and appears to favor somewhat moister regions than *Z. truncaticeps,* which is a desert dweller, found in Arizona, California and New Mexico, and possibly southwestern Texas. *Z. tiemanni* is most abundant in the China Lake district of California, but has been collected in Nevada and Arizona as well.

Among *Phengodes, P. mexicana* is known from Arizona, New Mexico and Durango. *P. arizonensis, inflata* and *fenestrata* are likewise western and southwestern species. *P. fucipes* inhabits both sides of the Mississippi River. *R. plumosa* lives in the east and Midwest, from Ontario to Georgia and New York to Nebraska. *P. nigromaculata* is a southern native. Larvae are a pale cream and brown color like those of *R. plumosa.* The geographic range of *R. laticollis* overlaps those of nigromaculata and plumosa, but laticollis is a much larger insect. The larva is black with orange blotches.

As far as anyone knows all glowworms are specialized hunters of millipedes. There is a 19th century record of a Texan *Distremocephalus* (= Mastinocerus) larva subsisting on small snails, but since mollusks are a typical prey of firefly larvae, this may have been a mistaken identification. The detailed observations of the late Darwin Tiernann on *Z. integrepennis* are similar to what I have seen of millipede stalking and killing by *Phengodes laticollis* and *nigromaculata* and suggest a long and close evolutionary relationship. A larva "races" alongside a millipede much larger than itself, mounts its back, and then coils around it. It stretches full length, and reaching the vulnerable neck articulation, severs the main nerve. Both *Zarhipis* and *Phengodes* will drag their bulky trophy underground, where they remove the head. A larva then pushes its own head into the wound and eats its way into the body cavity, sometimes entirely disappearing into the hollowed-out "shell." It can take days for a glowworm to complete its meal.

All stages of the phengodid life cycle bear lights. Embryos can be seen glowing inside the egg and the larvae and larviform females sport multiple light organs, the pattern varying somewhat among species. In *Zarhipis* and *Phengodes* there are points of light on the sides of the second through twelfth body segments and stripes of light shine between the segments. One species of *Phengodes,* whose identity is not yet confirmed, has a double row of lights down its belly. *Mastinocerus opaculas* has two very large lights on the head with much smaller and dimmer organs glowing along the abdomen. Pupae are also luminous and while the light pattern is larva-like, its intensity is greater. North American males are generally not well lit. I have seen *P. laticollis* suffused with a greenish glow that gradually dims and expires over the insect's brief life. *Zarhipis* males have a feeble luminescence that requires allowing the eyes to become dark-adapted before it can be seen. *Cenophengus ciceroi,* from Arizona saguaro country, has faint green spots on the tip of the abdomen that glow continuously. However, an early description of a male *Distremocephalus texanus* with conspicuous lights in the head and tail sounds more prepossessing.

The value of luminescence to a beetle larva is a mystery. It is particularly puzzling when the larva lives and glows underground. A number of reasons for carrying lights have been proposed, but the first one to consider is aposematism" or "warning coloration." The great 19th century naturalists, particularly H. W. Bates, pointed out that some insects were distasteful to birds and other predators and that poisonous species often "advertise" their unpalatability with bright warning colors. The familiar Monarch butterfly contains cardiac glycodide heart poisons and its bright orange and black wings stick in the memory as well as in the craw of a bird that eats one — and later vomits it up. A few such trials will cause a bird to avoid Monarchs and butterflies that look like Monarchs. In addition to orange, red (as in lady bird beetles) and yellow (as in wasps) are used to advertise nauseous secretions and venoms, the same colors found in eye-catching traffic signals. The brighter and more obvious an animal is the earlier a predator will take note and the less likely it is to complete an attack that would have a bad effect on both participants, In some cases, then, it pays to be noticed.

A light in the dark is very noticeable. If this obviousness could be coupled to evidence of a potent defense, then warning coloration could be a plausible explanation for luminescence in phengodids. Unfortunately, the rarity of phengodids makes it difficult to experimentally test the idea. However, there is indirect evidence of defensive chemicals. When handled, *P. laticollis* secretes copious amounts of yellow fluid that quickly spreads over the entire insect. Once I put one in a cage with a large centipede that it attacked but did not eat, though the predator immediately afterwards ate a large mealworm. When roughly handled, *Z. integripennis* secretes a clear amber fluid from U-shaped pores on abdominal segments 2-9. *Phrixothrix,* a Latin American genus, discharges an irritating reddish oily substance from the anus when disturbed. It will turn the end of its body towards its attacker and swing it from side to side while ejecting its anal fluid. A collector bitten on the hand by a *Phrixothrix* larva noticed a brown substance on the wound and the surrounding skin remained inflamed for several days. The Old World tropic genus *Rhagophthalmus* has a caustic odor. All of this at least suggests a chemical defense that might be advertised by phengodid glows. A bit of circumstantial evidence is that the lights of many glowworms brighten or light up when the insect is disturbed. They may be intensifying their warning as danger approaches — just as a rattlesnake may increase the frequency of its buzzes.

Even if phengodids pack a potent chemical punch, could a warning signal that can't be sent through the surrounding soil be of any use? Well, yes it could, if it were the first thing a burrowing predator saw as it broke in upon its prey. To insure being noticed an underground light display should be spread over the surface of the insect. Phengodids tend to have numerous light organs dispersed over their bodies. *Phengodes* and *Zarhipis* species have already been described. Among tropical genera there are some spectacular variations. Besides 11 pairs of thoracic and abdominal lights, *Rhagophthalmus* has large firefly-like taillights, as does *Dioptoma adamsi. Diplocladon hasselti* bears a line of lights down the middle of its back as well as blue-green lights on the sides of every body segment except the head and tip of the tail. *Phrixothrix* has rose-red headlights and yellow-green lights from the middle of the thorax to the ninth abdominal segment. The light arrangement is similar in *Stenophrixothrix,* headlights plus lateral spots on the last 8 abdominal segments, though their lights are yellow-green in color throughout. *Ceratophengus* is much like *Stenophrixothrix,* but some *Mastinocerus* possess headlights and a row of 9 lights down the middle of their back. In an undescribed and colorful Brazilian species, the headlights are orange and the body lights yellow. *Ceratophengus* males are reported to have a pair of lights on their head and another pair near the tip of their tail, while *Dictenum* males bear greenish-yellow light organs on each body segment. In sum, Phengodids are well lit, all over.

Besides being spread out, a subterranean signaling system should be on a lot of the time. There may be little warning of an unseen predator's attack. It would be better to signal continuously so as not to be literally in the jaws of death before giving your luminous warning. Many Phengodids spend most or all of their lives illuminated.

Of course, all of this argument about warning lights and chemical warfare is educated guesswork. The naturalists who will invest the energy and time to watch phengodids and design experiments to discover why glowworms glow may not as yet have turned over their first log or lifted their first spade of soil. There is much work that could be done by the patient amateur. But, before leaving the always-agreeable land of "maybe," there is one more luminous landmark to visit the *Phrixothrix* species. Latin America's wonderful "railroad worms" have two colors of light, some of which are set in unusual locations. Lights on the heads of beetle larvae are rare, occurring only in a handful of phengodid genera. Red-colored lights are very rare. Only *Phrixothrix,* the mysterious "Astraptor," found once on a Guatemalan streambank, and a few as yet undescribed Brazilian species have red glows. However, in all the cases where there are both headlights and red lights, the headlights are red! When two peculiar things occur together it is tempting to suspect that they are related. In the world revealed by the invertebrate eye the color red has one unusual feature; it isn't there. Most arthropods cannot see red light. But what if a predatory species could both emit and see by a light that its prey could not sense? Then it would stalk victims illuminated by invisible beams and ignorant of their danger. Astraptor's light shines in a direction consistent with this view. Its collector noted that its ruby light was not easily seen from above and was best observed reflecting from objects in front of it. If red lights are killing lights in the Phengodidae, then they might have a parallel in the red photophores carried by the deep-sea fish *Pachystomias* behind its eyes. Since nothing is simple, least of all bioluminescent animals, it should be noted that Dr. Chabora of the University of Sao Paulo has recently discovered a new glowworm in the and savannas of Brazil. Unlike *Phrixothrix,* which has a red light in the head and yellowish-green lights along its body, this new species has red lights all over! It does not seem likely that abdominal lights are used for self-illumination, but then the Phengodidae are an unlikely bunch.

Light and love entwine in some luminous organisms. Fireflies are very well known examples of this; however, the role of luminescence in phengodid mating is not always clear. Some males, like those of *Diptoma adamsi* with their scattering of 26 emerald green lights, become brilliantly lit when sexually excited. Both male and female *Phrixothrix tiemanni* luminance while coupling in burrows. A luminous organ on the abdomen of the *Stenophengus* male is backed by a white reflector like that found in some fireflies. Such a specialization would seem to be an adaptation to increase the efficiency (range/cost) of a broadcast signal. As discussed earlier, our North American males are less photo-endowed. They usually glow weakly and only for a short time. It seems they are less likely than their tropical relatives to be broadcasting sexual messages. But it is important to remember that only a few of our native species have been seen mating and those only rarely, so no one really knows what sort of fireworks may take place under the right conditions.

Female phengodids have the same compliment of light organs as the larvae, but females are often more brightly luminous. Lights could supplement chemical sexual signals females emit to guide potential mates. Female glows might be particularly important in genera such as *Dioptoma,* in which males have large eyes and much-reduced antennae. In others, such as our native *Zarhipis* adult females, lights probably continue to function for the same reason that they shine in the larvae… whatever that may be! Males have small eyes and mating occurs in daylight.

The following are papers someone with an interest in phengodids can refer to for More detailed information. Notice as you read how little is known and how nearly every careful observation will be of interest to your fellow naturalists. Just this year I have found new light organs on one of our most common species and finally discovered the millipede prey of another. (John Siviniski, USDA Gainesville)

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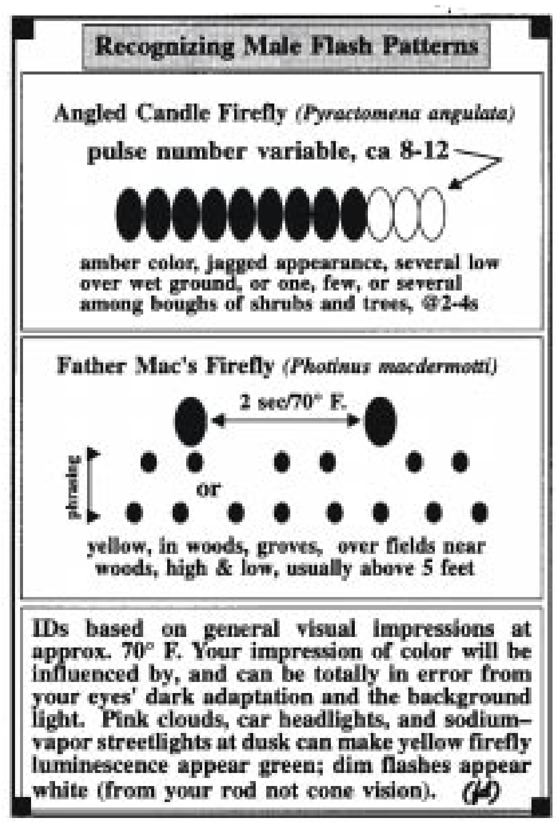


Letters to the Firefly Doc

"Where can I find information on raising fireflies"

Karen
Endorphan Park FL

Dear Karen,

I have been asked this question many times and I can only answer that there is little information available and there have been no real successes reported for North American fireflies. In the few cases known to me where fireflies were reared from egg to adult, the successful graduate students tended their charges almost daily and had a very low success rate. Larvae die sooner or later though their cages are kept clean, unused food (snails and cut-up earthworms) and dead individuals removed. The causes of death seem to be many, including infections, starvation in the presence of apparently suitable food, and even strangulation - when bitten and numbed snails "wake up" and flex, greatly extending the necks of feeding fireflies. In Japan a highly successful rearing program was developed and apparently brought their two major species back from near extinction. Their fireflies are aquatic, and apparently in a "hydroponic" system it is easier to provide the essential requirements. This is not a project that any wise graduate student would take on for a degree. Whatever financial motivation there once might have been is now gone, with the development of gene transfer technology and alternative production methods for the light-emission chemicals (see Oleksa essay). *(fd)*

"There is a population of fireflies at a nearby hot spring, at an elevation of 8000'. Could you send any ID info to me..."

Caren
Villa Grove, CO

Dear Caren,

There are not many flashing species to be found as far west as Villa Grove, but there are some daytime (use pheromones) and glowworm (females burrow, males unlit) species. As a guess I would suggest *Pyractomena dispersa* Green. This is a marsh and wet pasture species, whose larvae specialize on snails. Adults are generally dark brown to black except the pronoturn, which has a black midline (with keel) and a rosy color on each side. Males flash 5-6 rapid pulses (rate about 3-5 per second in each flash pattern, with 2-4 sec between patterns, temperature dependent. See if you can get a specimen. Put it in 70 percent isopropyl alcohol (rubbing alcohol) and send it to me.

• • •

Dear Caren,

Thanks for sending the specimen. The genus is Photuris, and it belongs to the *pennsylvanica* complex, but whether it is the same as the ones I have seen in Nebraska or the Dakotas I can't say until I have seen it flashing in the field. It certainly must represent one of the most western populations reported. *(fd)*

"Our fireflies are back! I wrote to you last year about their disappearance - I missed them. They returned about two weeks ago (i.e. 15 June).

There are hundreds of them - as many as ever. I can't put a reason to their return any more than I could to their absence. Nothing is different - no building or lack of it, no spraying or lack. All that was different was that we had a very severe winter (in Mayville where the fireflies are). The snow didn't melt from Dec. to April - my blueberry bushes were badly damaged. It's the first winter in 30 years that we couldn't drive in.

This was followed by a wet May, a very hot dry (95') early June and now a very rainy spell ......

Lucille
Tonawanda NY

"Some time ago a friend and I were commenting on the fact that there are fewer lightningbugs now than when we were children. Being originally from Jamaica, he told me their word for lightningbug is peeney-walley. Since then I have written a children's story and a poem using that term.... I though perhaps you would like to read it."

GOODBYE, MR. PEENEY-WALLEY

Goodbye, Mr. Peeney-Walley.
Where did you go
with your incandescence
and luminous glow?
Did we capture too many
and put them in jars?
Or did you find it too hard
to compete with the stars?
You bring back the memories
of sweet childhood days;
of swinging and tea parties
and playing croquet.
Of chasing the chickens
and riding bareback,
of milking the cows
and sliding down haystacks.
But childhood is gone, alas and alack.
So please, Mr. Peeney-Walley, won't you come back?

W. J. W.
Austin TX

Dear W.J.W.,

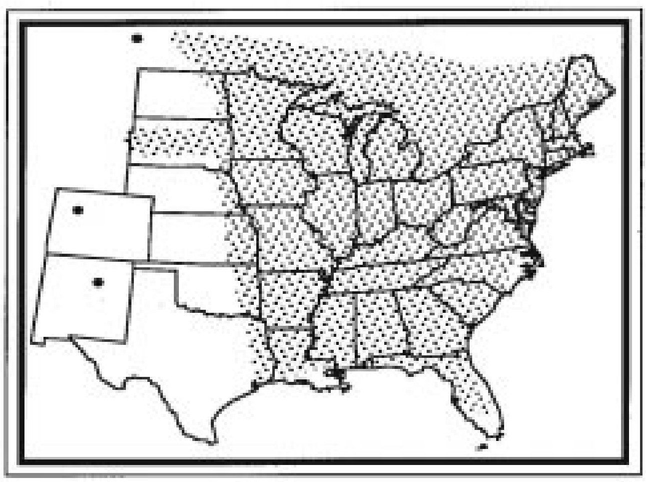
Thanks for your note and the poem. I heard th term peeney-walley used for luminescent clicl beetles (Elateridae, Pyrophorus) when I was in Ja maica in 1967, and fireflies (Lampyridae) were called **blinkies.** As I recall this was in the vicinity of Wor. thy Park, not far from Spanishtown, I believe. Per. haps there are regional differences(?). *(fd)*

Firefly Profiles #2

the Angled Candle Firefly

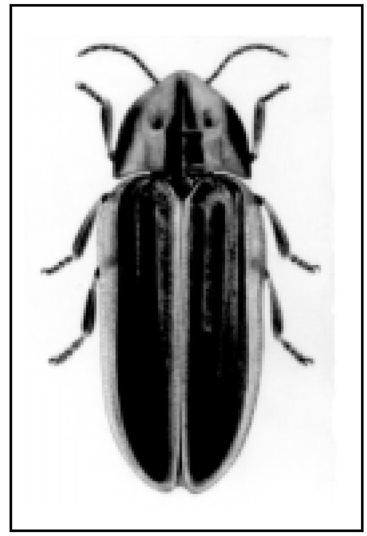
The only North American firefly whose geographic distribution can rival that of the Big Dipper Firefly, *Photinus pyralis* (L.) (see Companion #1:9), is the Angled Candle Firefly, *Pyractomena angulata* (Say). Its known range extends from the eastern edges of the high plains, except for a couple of questionable outliers and a western extension along the Missouri River and its tributaries in South Dakota, south to the Gulf, east to the Atlantic Ocean, and north into Canada some undetermined distance (see map below).

Thomas Say, the father of American zoology, — we will profile him in a future number — probably chose the epithet *angulata* because of the angular outline of the pronotum (see habitus drawing). Although Say's specimen was lost, eaten by dennestid beetles along with most of his collection 150 years ago, a contemporary, F.E. or J.F. Melsheimer had probably compared it with a specimen in the Melsheimer collection which is still in existence. Thus, we can have some degree of confidence, though not complete certainty, what the firefly was that Say actually named. Note that Say's name is placed in parentheses in the formal name; this is because Say classified this species in the genus *Lampyris* and it was subsequently placed in a different genus (now *Pyractomena).*

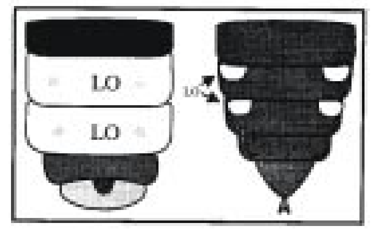


A working distribution of the Angled Candle Firefly, *Pyractomena angulata* (Say).

The habitus illustration (a carbon dust drawing by Laura Line) shows the diagnostic angled form, wide pale margins on the elytra. (wing covers), lateral dark vittae (stripes) on the pronotum, and a median triangular vitta on the pronotum. Note the costae (slight ridges) on the elytra and the median carinula (little keel) on the pronotum. This is a beautiful firefly, perhaps our most beautiful, with black, yellow, and red coloration. After all of this, its luminescence is equally remarkable.



I call *Py. angulata* a "candle" firefly because its flash pattern is of an amber color, and composed of 8-12 rapid and connected pulses (see p. 7), thus appearing like a flickering candle. In another descriptive phrase, I could say that its signal is a ragged, yellow-orange flicker. This pattern is repeated each 2 to 4 seconds depending upon the temperature. The Angled Candle Firefly appears early in the spring over low wet ground, up into shrubs, and even around boughs at the tops of trees. Though you may sometimes see dozens at once over grassland by a marsh, usually you will see only one or two males at a time, and even into mid-summer, as they meander silently around high foliage but they never set it afire.



Lanterns (LO) of male (left) and female *Pyractomena* fireflies.

If you answer males with a half-second flash from below, they will often disappear for a few minutes and then flicker from foliage below where you saw them flying. They sometimes fall (land) in your hair or on your shoulder if you are standing under them when you answer. Apparently they drop and remain dark to avoid attack by *Photuris* fireflies following a responding flash. The lanterns of female *Pyractomena* fireflies are distinctive, being divided into four parts, and positioned at the corners of two plates ("sternites") under the abdomen. *(fd)*

The Caribbean (W.I.). A colleague recently passed a printout along to me from the (ugh) Internet, which noted the story (legend?) of luminescent click beetles in Cuba being mistaken for Spaniards with torches, that sent the British under Cavendish packing to Jamaica, where they worked their colonial wonders instead. The message asked whether the account, which he saw in H. Evan's *Life On A Little Known Planet* was "more than just a tale." Seems to me that this is a good literature project for a future issue of the *Fireflyer Companion.* Have we a volunteer to look into the matter?

Gainesville FL. On the 25th of April '96 the third "annual" firefly lecture and field expedition was held as one of the Outdoor Adventures sponsored in the Community Education Program. Participants first heard a slide lecture on firefly natural history and identification, then set off in a caravan to choice sites near the airport for field observation and experimentation. This year the flash patterns of 7 firefly species were seen, a count that was down from last year's total of 9 species, according to those with working memories. The class, entitled *A Historical Ecology of Fireflies,* was organized by Dr. Bruce Fergusen, the veterinarian of Micanopy, Florida, and conducted by fd.

Occurrence of Aggressive Mimicry In A Brazilian *Bicellonycha* Firefly

(Lampyridae; Photurinae)

by Vadim Viviani, Sao Paulo, Brazil

The occurrence of aggressive minticry in North American *Photuris* fireflies is well documented (Lloyd 1984). With the exception of its probable occurrence in a Colombian photurine of an undescribed genus (Lloyd unpublished obs.), it has not been observed elsewhere in the family. I pbserved it in *Bicellonycha ornaticollis* (Blanchard), a common firefly of marshy areas in the vicinity of Campinas, in southeastern Brazil (Viviani 1988). This is the first record of occurrence of aggressive mimicry in the genus *Bicellonycha*, and it may be expected to occur in other South American Photurinae.

Fireflies of *B. ornaticollis* commonly occur in open marshy areas with *Bicellonycha lividipennis* (Motschulski), which typically outnumbers the former. Occasionally individuals can be found in adjacent forests. Adults are active from October to February. Males emit single yellowgreen flashes. Females are found on vegetation and occasionally are seen flying and flickering. Females were observed to flash-respond to the flash patterns of flying *lividipennis* males (n=2). The males flew toward and landed near the females. The females remained on their leaves with anterior legs raised. Subsequently one of these females ate the attracted male. I do not know how similar the response flashes used by these females were to the mating signal of *lividipermis* females, since the latter response is unknown.

I made other observations relative to the occurrence of this predatory tactic in *ornaticollis* (see Lloyd 1984 for a hierarchy of evidence levels): females ate adults of *lividipennis, Pyrogaster sp., Photinus sp., Aspisoma sp.,* when confined in a cage with them; and females were found eating males of *lividipennis* in the field (n=2).

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A Field of Phengodids

by Steve Wing, Gainesville, Florida

You don’t have to be a professional entomologist to make important discoveries, and this is especially true in the study of bioluminescent insects. Take, for example, a recent “find” for the family Phengodidae. Larvae and the larviform females of this family are spectacularly bioluminescent (e.g., see Tiemann 1970). Males with their elaborate antennae fly at night in search of females (Tiemarm 1967, Lloyd 1979), and males occasionally turn up in light traps. Females and larvae apparently spend most of their lives underground (Atkinson 1887), and are only rarely encountered by nocturnal entomologists (Smith 1900). Members of the genus *Phengodes* are so rare that E.N. Harvey (1952) saw “only four living luminous specimens in 25 years.” Even though these insects are easy to spot in the dark and generations of naturalists have sought them, new discoveries may wait to be found literally in your own back yard.

On the night of 16 August 1995, Brian and Jason Russell were scouting potential deer hunting sites near the southern outskirts of Waldo, Florida. Walking through a grassy field about 11:00 PM they were amazed to see numerous glowing worm-like creatures, perhaps two centimeters long, maybe a little shorter, on the grass. They collected about thirty five and kept them in a mason jar. (This, sadly, was probably a major fraction of the population and would never be able to reproduce.) The next day their father/uncle, Doug Russell, wanted to find out more about these creatures and he called the University of Florida, where he was eventually connected with the editor of the *Companion.* Lloyd listened to the story and, lacking the time to give to the project, called me. I telephoned Doug and arranged to go out to see the creatures that evening.

Jason, Brian, and Wesley, the boy whose house/yard the field borders, took my wife Susan and me through Wesley’s yard to the field. At 8:48, about 20 minutes after sunset, the first glowing insect appeared. We walked around the field and found them in several locations. The boys seemed to think they were particularly attracted to a small herbaceous plant with round leaves, so I collected some specimens. I also took two of the insects the boys had collected and collected one more myself. It was evident that these were phengodid larvae or females.

Phengodids in such numbers had been reported only once previously. I had found 90 of them in one hour at a site that I visited nightly near the regional airport near Gainesville. In my years of visits to the sight, I previously had found only one. But on this occasion of note, the field was flooded after heavy rains, and I speculated that the flooding had forced the phengodids above ground (Wing 1984a**).** After the field dried out, once again there were no phengodids to be seen. But there was no flooding in Wesley’s field, and no other reason was evident that might have driven the insects from the soil. The field was not used for agriculture, was not sprayed, and had no livestock.

I began visiting the field nightly at first, and then weekly. I marked the locations of the insects as they emerged from the soil glowing, which occurred around 9:00 pm each evening. They would remain out and glowing for hours, perhaps all night, though I didn’t remain that long. Closer observation showed that they were not feeding. By marking locations, it became clear that the insects emerged at the same locations nightly, evening after evening, but eventually failed to return.

These observations are consistent with the behavior of flightless female fireflies (e.g., Wing 1984b). However, it was not clear whether these were females or larvae. A dissection was inconclusive, as was examination of the specimens with a microscope. I observed individuals carefully, expecting that if they were females males would eventually arrive. In addition, John Sivinski lent me some traps, which basically were screen domes over the insects so that the glow remained visible, but they had a ring of sticky gel to capture any male that might land. The traps caught crickets and other insects, but no male phengodids. I followed the appearances for over a month, tracking a total of 35 or so insects. The numbers of new insects appearing tapered off to zero as winter approached. This year, I will be visiting the field again to see if the phengodids reappear and continue observations, and perhaps I can determine whether they are adult females.

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Essays by Little-Known American Authors

Fireflies: Beauty and Beyond

by James Oleksa

Nearly everyone has seen, at one time or another in their lifetime, the brilliant flashing of fireflies dancing through the night air. This captivating phenomenon can be very beautiful. At the same time, it can also be quite intriguing. After taking in the magnificent light display put on by fireflies, one often wonders, "how do these insects generate light?" This question has also been pondered by scientists for many years. Through years of study and experimentation, the process of bioluminescence, by which fireflies and other organisms produce chemical light, has been uncovered. Along with gaining an understanding of bioluminescence, scientists are also learning how to harness its power for a vast number of practical uses.

The process of bioluminescence is not as complex as one would think. It only involves three substances, which react in the presence of oxygen to produce chemical light. These three substances are: a molecule called luciferin, an enzyme called luciferase, and the energy molecule common to all living organisms known as adenosine triphosphate (ATP). Fireflies glow when the enzyme luciferase reacts with the molecule luciferin to create a very short-lived high energy compound. This reaction takes place only in the presence of oxygen and ATP. The high-energy compound created immediately returns to its lower energy state, causing the emission of a photon of light. This whole process takes place in the specialized light organ of the firefly, all within a fraction of a second (Weiss). In other bioluminescent organisms, such as plankton and certain bacteria, the process is very similar except for the luminescent substances involved. While the molecules are still called luciferases and luciferins, they have slight differences depending on the organism involved, and are not interchangeable between bioluminescent species. For example, luciferase from *Photobacterium fischeri* reacts only in the presence of the molecules FMNH2 and NADH, rather than ATP as in fireflies (Lewis 17).

The fact that firefly luciferin reacts only in the presence of ATP is the primary reason that so much research is being conducted on it. All living cells require ATP to survive, and, consequently, where life is present ATP must be present. Therefore, bioluminescence can and does serve as an accurate test for the presence of living organisms (Lewis 17). There are many practical uses for such testing. For instance, NASA is considering using it to detect life on other planets. Soil on Mars, for example, could be mixed with luciferin and luciferase and scanned for the presence of bioluminescence with sensitive light detection instruments, which would indicate the presence of life (Weiss). Coca Cola® presently uses bioluminescent technology to test beverages for bacterial contamination before they are bottled (Lewis 18). Similar techniques are being put in place to detect contamination in milk, meat, juices, etc. (Internet 1). Using bioluminescence is far more efficient than the traditional tests for food safety. Instead of waiting days for the growth of bacteria in culture dishes, bioluminescence gives results within minutes. Furthermore, the number of bacteria present in any one food sample can easily be determined because the amount of light emitted in testing is equal to the number of bacteria present (Weiss).

Biolurninescence also has many practical uses in the medical field. Firefly luciferase is used to assess whether tumor cells respond to specific drugs before testing the drugs on cancer patients. Tumor cells are cultured, exposed to different combinations of drugs, and then the number of cells present is estimated through the use of bioluminescence. Declining luminescence in the culture indicates that the cells are being killed. This relatively fast procedure enables doctors to quickly evaluate appropriate chemotherapies for rare and/or drug resistant cancers (Lewis 18). Along those same lines, bioluminescence is being used in fighting drug-resistant strains of bacteria, such as tuberculosis. Because TB; bacteria grow extremely slowly, it can often take weeks to determine whether a drug being administered to a patient is working to kill the bacteria. Using bioluminescence, researchers can determine within a couple of days whether the bacteria are surviving by looking for faint glows of light in the culture (Weiss). Additionally, bioluminescent tests are being developed to quickly test for bacterial infections in wounds and tissues (Ugarova).

The technology of firefly bioluminescence is also being applied in the field of ecology. Tests for the bacterial contamination of drinking water are currently being put to use (Ugarova). Also, bioluminescent marine organisms are currently being studied as indicators of water pollution levels in the oceans. Quite simply, a decline in light output by such organisms in samples of marine water may be a simple screen for the presence of toxic substances in the water (Weiss).

Bioluminescent technology is not just limited to the detection of bacteria and pollution, but is quite prominent in the field of molecular biology as well. Bioluminescence first entered the realm of molecular biology when the gene for firefly luciferase was inserted into a bacterial plasmid which then infected tobacco leaf cell cultures, thus transmitting the gene to the plant cells. From this cell culture, a tobacco plant which glowed when exposed to luciferin was grown (Bames 353). A variety of researchers now use the firefly luciferase gene by linking it to various genes of interest in other organisms. They are then able to follow gene expression by detecting bioluminescence in different cells and tissues at different stages of development in these organisms (Lewis 1 8). Biologists are using this technology to study biological rhythms in plants, for instance. The gene for luciferase is inserted into plant DNA to track plant genes as they get turned on and off during the day. Water containing luciferin is fed to the plants, then they are monitored closely in a dark room. When the leaves begin to glow, the luciferase gene is known to be turned on and, thus, the plant is undergoing a certain phase in its biological rhythm. This research could be used to study the specific genes that alter a plant's biological clock to possibly speed up growth and increase crop yields (Weiss).

Although it seems like a perfect process for many applications, the use of bioluminescence is not without its problems. The most commercially viable source for the luciferase and luciferin used in biolurninescent technology are field-collected fireflies themselves. Many labs obtain their luciferin and luciferase from thousands of freeze-dried firefly abdomens shipped in from a company on the east coast of the United States (Lewis 18). With the interest in bioluminescent research continually increasing, it is putting a major strain on diminishing firefly populations. This pressure, in combination with the already shrinking population of fireflies due to the loss of natural areas, including suburban woods, and the increased used of insecticides, is concerning ecologists (Weiss). Fortunately, scientists are beginning to find alternate sources and ways of obtaining the chemicals they need. Using much of the same technology applied in the molecular applications of bioluminescence, luciferase and luciferin are obtained from DNA cloned and reproduced in *E. coli* bacteria. This is known as recombinant DNA technology (Lewis 18). Additionally, scientists are finding ways to chemically synthesize their own luminescent molecules using the information obtained from research with the real things (Weiss).

Fireflies provide much more than just a pretty display of nature's wonders. By studying how fireflies are able to generate their chemical light, scientists have unearthed a whole new area of technology and practical applications revolving around bioluminescence. By harnessing the power of bioluminescence, a wide variety of new techniques in the fields of medicine, molecular biology, ecology, and food safety have been developed. The list of new discoveries will continue to grow as research continues in this fresh and vast field of bioluminescence.

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These essays were originally written as term papers toward fulfillment of the "Gordon Rule" requirement for students in the Honors I program — 6000 words of essays for certain courses, including *AGG-2931, Biology and Natural History with Fireflies.*

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Creationism and Evolution

by Michelle Thresher

The debate between evolutionists and creationists has frequently been characterized as a "war." The image of a war between religion and science developed in the late 19th century, but has flourished recently in the current debate (Moore 12). "Through constant repetition in historical and philosophical exposition of every kind, from pulpit, platform, and printed page, the idea of science and religion at 'war' has become an integral part of Western intellectual culture" (Moore 20).

It is somewhat odd that things have gotten to this point. This state of "war" this debate sparks between religion and science is fairly strange, because religion and science generally do not attempt to answer the same questions. Science can explain, describe, discuss "how" things happen. Religion attempts to find meaning in life — to try to answer the big "why" questions: "Why is there something rather than nothing?" "Why do I exist?" Leo Tolstoy once said, "Science is meaningless because it gives no answer to the question, the only question important for us: "What shall we do and how shall we live?" (Taylor 288). Tolstoy's statement shows that science and religion are not by nature at war with one another because they attempt to answer different questions.

Regardless of this, religion and science are often seen as "opposites," and this is especially true in the creation vs. evolution debate in the United States. George M. Marsden, in his essay *A Case of the Excluded Middle: Creation Versus Evolution in America,* writes, "In a widely held view that seems to be gaining in popularity, biological evolution is regarded as an opposite of divine creation and hence incompatible with traditional Christian belief." Marsden points out that the creation-science movement only accepts one view of creation based on a literal reading of the creation accounts in *Genesis.* According to this view, "the six days of creation are literal twenty-four-hour days so that the Earth cannot be more than some thousands of years old. Evolution of any species, accordingly, is absolutely precluded" (Marsden 132).

Many insist on this dichotomy between creation and evolution, and neglect what Marsden calls the "excluded middle" — those who do not deny the theory of evolution, but who don't think that it necessarily rules out the existence of a divine creator. The "excluded middle" sees God as behind the process of creation, and sees evolution as the process by which God carries out the divine plan. An example of this argument follows:
"God controls all natural processes through his providential care. The questions raised by biological evolution are therefore not in principle different from those suggested by other natural phenomena, such as photosynthesis. A fully naturalistic account of the process does not preclude belief that God planned or controlled it." (Marsden 133).

Though evolution and religion are not by nature opposites, opposition to evolution has become for many a test of faith (Marsden 134). This stems from the fundamentalist view of the inerrancy of the Bible, and of the need to interpret it literally. They believe that "because the Bible is God's Word, it must be accurate in matters of science and history as well as in doctrine" (Marsden 136). From this view, taking *Genesis* as true and reading it literally and not symbolically, standing with the biblical account of creation means standing against the theory of evolution.

The anti-evolutionists were most successful at times when they could argue convincingly that believing in the biblical view of creation, rather than evolution, was "crucial to the future of civilization" (Marsdan 141). An example is just after World War I when anti-evolutionists claimed that Darwinism had caused the war "by substituting the law of the jungle for the teachings of Christ" *(Numbers).* Because of this, the evolution vs. creation has a strange marriage with moral issues. Jerry Falwell said of Ronald Reagan, "Reagan is for Adam and Eve and against the theory of evolution. He's for the family and against sex education. He's against homosexuality and abortion and feminism and all that welfare. Above all, he's for America being No. 1 again, having the strongest military since creation" (Czarnecki 58).

Creationism is especially prevalent in the South. Marsden traces the roots of this to the Civil War, when the South justified their separation from the Northern churches by claiming the Northern churches were "infected by a liberal spirit" (Marsden 143). The Northern churches, rather than interpreting the Bible literally, said the liberating message of the New Testament disallows slavery. The Southern churches interpreted the Bible literally and said that slavery was allowed. "The Bible condemned slavery only if one forsook the letter of the text for the alleged spirit" (Marsden 143). Thus, many Southerners come from a tradition that took the Bible literally.

While I have shown how religion contributes to the polarization on the issue of creation vs. evolution, the scientific community's attitude toward the controversy also leads to greater division. Evolution is talked about in the same terms as religion — as something one "believes in." As in many other churches, when one from the scientific community dissents from these views, it is sometimes called "heresy," and the community pushes for excommunication of the unbeliever (Eastland 34).

For instance, free-lance writer Forrest Mims claims that in 1991 he was refused a job writing an "Amateur Scientist" column for *Scientific American* because of his religious views (Eastland 32). During the interview process for the job, Mims mentioned that as well as writing articles for *Modern Photography, Physics Today, Popular Mechanics,* and *Popular Electronics,* he had also written articles for Christian publications on bicycling and photography. This prompted the editor to ask Mims' views on the theory of evolution, and he said that he did not accept it. He was not offered the job, though Mims maintains that the editors had told him he would get the job before they knew of his views on the theory of evolution (Eastland 32). It's war, then, from both sides of the debate. This is damaging to both, and serves to further divide the two camps. The inability to see the middle ground further polarizes the two groups, which leads to a lack of dialogue and a lack of understanding.

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What is it?

It Went Somewhere Else

On silver feet,
I bear it coming.
Miles away it pounds closer.
A whisper of wind,
promises of things to come.
Far away flashing footsteps illuminate
faint still lifes
fainter still,
as it walks away
without seeing me.

(Chris Tipping)

W.S. Blatchley: Tramp Naturalist

by Michelle Derrow

1. *"We salute thee, 0 America, new-born! Henceforth, within thy bounds, let there be no east, no west no north, no south, but only one grand country under one glorious flag.* — A Citizen's Creed, 1918
2. *" …and a new and more loyal love for the old Hoosier State will be engendered in your souls.* — A Recall, 1916
3. *"To her to whom I owe my three most priceless possessions: life, hope, ambition: these three, which have made me what I am, I owe to her — my mother."* — Boulder Reveries, 1906

Willis Stanley Blatchley was an American first, a Hoosier second, a mama's boy third, and a naturalist from conception. He was author, teacher, historian, taxonomist, father, and, throughout nearly all of his life, awestruck Indiana schoolboy. Variety was the prize in the Cracker Jack box for Blatchley. Nature was a sweet confection on its own, but *variety* in nature — that was where the euphoria of discovery was to be found.

Indeed, Blatchley knew that euphoria well. By the time he died, he had described more than 370 new species and varieties of Coleoptera, approximately 66 new species of Heteroptera, and 29 new species of Orthoptera.

Summertime romping was as much a part of Blatchley's study of the natural world as detailed taxonomy or published writings. A man who was equally comfortable catching catfish at his beloved Raccoon Creek *(Woodland Idyls,* 1912) as he was writing essays titled *What is Greatness?* (1922), W.S. Blatchley was "Happiest those days in which I have wandered far and wide through field and woodland, adding here and there some specimen before unseen, noting now and again some life habits, some food-plant, or place of retreat, before unobserved" *(The Coleoptera of Indiana).*

Willis Stanley Blatchley was born Oct. 6,1859, in North Madison, Conn., the son of Hiram and Sarah Blatchley. It was a time when *entomology* was something young children studied without being asked to — and probably without realizing it. The great tragedies and comedies of the natural world were played out by actors as tiny as rolledup pill bugs under a log or a colony of ants disrupted by a probing stick. Children such as Willis Stanley were both entertained and educated by the natural world around them, and for Blatchley, that world was the great Hoosier state, Indiana. The Blatchley family arrived in Indiana one year after Willis was born, settling first in the farmland of Hendricks County, and moving one year later to the town of Groveland in Putnam County. There, Willis Stanley attended a local country school, where his father was a teacher, for three years.

In 1869, the Blatchley family moved again, this time to a small farm 1 1/4 miles east of Bainbridge, Putnam County. 10-year-old Willis attended school in Bainbridge until the age of 17, assisting with his father's market gardening business during the summers of those years.

Blatchley himself noted that at the time of his last year in "high school," there were "no grades and no graduating exercises," an essentially informal method of schooling.

In 1879, the 20-year-old Blatchley received his first teaching job as a country school teacher in Cloverdale, Ind., at a salary of $1.50 per day. In the summer of 1880, young Blatchley traveled the country on foot, selling maps and taking orders for enlarging pictures. In 1882, he married Clara Fordice, and soon after acquired the position of principal of the Putnamville town school.

In September 1883, Blatchley moved his wife and newborn son, Raymond, to Bloomington, Ind., to begin studying at Indiana University. He then worked his way through four years of college by "janitoring, collecting delinquent taxes, gathering all the plants used by the botany classes," etc. *(Blatchleyana),* while continuing to sell book and maps in the summer. He majored in science and took only one term of entomology. He graduated in 1887 with the degree of "A.B." and a graduating thesis on *The Flora of Monroe County, Indiana (Blatchleyana).*

From 1887 to 1894 Blatchley served as head of the department of science in the Terre Haute Wiley School, teaching chemistry, botany, zoology, and physiology, as well as physical geography and physics. In the summer of 1891, he became one of five members of the J.T. Scovell Expedition to determine the height (18,314 feet) and natural history features of Volcano Orizaba, Old Mexico.

In 1891, Blatchley returned to Indiana University, this time to earn his A.M. degree on a thesis titled *The Butterflies of Indiana.* Then, in November 1894, Blatchley was elected to the post of state geologist, a position he would hold for the next 16 years. It was during these years that Blatchley published his most well-known work, *The Coleoptera of Indiana,* as well as two other widely read writings, *A Nature Wooing (1899)* and *Boulder Reveries (1906).*

The Coleoptera ofIndiana is just what its title indicates: a thorough, complete (at the time) guide to the identification and classification of Indiana beetles. What's surprising, perhaps, is the care Blatchley took to ensure the accessibility of the book to the general public. In the introduction to *The Coleoptera of Indiana,* Blatchley addresses an audience ranging from the mischievous young country boy to the aggravated Midwestern farmer, speaking to all with the encouraging voice of a patient teacher. Blatchley himself emphasizes this idea when he states, "I have prepared the present paper, not for specialists in Coleoptera, but for beginners, a few of whom, I trust may in time become enough interested to devote their lives to the everpleasing, health-giving and inspiring study of Nature" *(The Coleoptera of Indiana).*

In *1899,* on a doctor's recommendation, Blatchley made his first sojourn to Florida, where he headquartered in Ormond and compiled his *Gleanings from Nature* from previous writings. He also took a new set of notes in Florida, which would later become *A Nature Wooing.* Blatchley's infatuation with the state is evident; *A Nature Wooing* includes such declarations as "I still delight to chase the winged butterfly o'er field and pasture; draw the seine through ripple and shallow for silvery minnow and rainbow darter — climb hill and wade pond for partridge berry or water lily…" The language of *A Nature Wooing is* infectious. Blatchley's enthusiasm seeps through his words and transports the reader to a marshy play land of dragonflies and cattails, designed to evoke the naturalist in everyone.

Blatchley returned to Florida for the second time in 1911, spending most of the winter collecting insects in Ormond, Sanford, St. Petersburg, Sarasota, Ft. Myers, Key West and Little River. He also made his first trip to Lake Okeechobee, which "at that time [had] but three houses on the shores of the lake" *(Blatchleyana).* It was also during this time that Blatchley began work on *Woodland Idylls,* which would again reflect his puckish joy and constant reverie of the natural world around him.

In 1913, Blatchley took a trip to Dunedin, Fla., and became so enraptured with the area that he proceeded to purchase "300 feet of uncleared bay front" *(Blatchliana)* upon which he built a two-story winter house. Four years later, Blatchley paid his first visit to Gainesville, where on Feb. 5, 1917, he gave an address before the Florida Entomological Society on *Bug Hunting as a Pastime.* In fact, Blatchley's contributions to the study and knowledge of Floridian entomology range from essays on *Water Beetles* of Florida (1919) to *Some Apparently New Heteroptera firom* Florida (1924) to *The Scarabaeidae* of Florida (1927), as well as various other topics.

In his essay titled *What is Greatness?* (1922), Blatchley ,quotes the Bible's Golden Rule: "Do unto others as you would that they should do unto you." In fact, what W.S. Blatchley did for others was exactly what he sought for himself: the discovery of something new and different, but nonetheless as much a part of the universe as the sky under which it is viewed; the careful uncovering of the various interrelationships between all the elements of the universe in this "grand and perfect whole" (A *Nature Wooing,* 1899), and above all else, a savory delight in the chirping of a cricket on an early Sunday morning.

Willis Stanley Blatchley died on May 28, 1940 (*Current Biography,* 1940), at the age of 80, one man out of "ten thousand men [who] ... looks up into the sky and wonders why it is there — looks out into space and ponders o'er the porch lights of other sun-ruled systems — treads the earth and thinks of her as a moving sphere" *(Woodland Idylls,* 1912).

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On Luminosity in Fungi

by Joshua Even

Is there an evolutionary benefit of luminescence in fungi? Some argue there is none. But there must be some reason why, after millions of years of evolutionary change, nature selected some fungi to use their precious energy reserves for light emission. Does the production of light attract animals (insects) that would be beneficial to the survival and subsequent thriving of the fungus in question? Light in otherwise dark surrounding must be noticed by the inhabitants of the fungi's surroundings, and therefore must be instrumental in the attraction or repulsion of those inhabitants. One cannot write the phenomena of bioluminescence off as some haphazard mutation without any evolutionary benefit. What exactly is that evolutionary purpose?

What about the animals that, when attracted to the light, would do harm to the fungi? In an attempt to find reasonably sound answers to these puzzling questions, a colleague (esteemed entomologist-to-be Joshua Trotter) and I carried out a series of experimental scenarios. Using luminescent fungus models, we set out to find exactly which insects would be attracted to the light.

To simulate a luminescent fungus, we used a "glow-stick" (for lack of a better word) housed in an inverted test tube. A rubber stopper pierced by a dissecting needle plugged the end of the test tube to secure the "glow-stick" and form a support with which we could secure the "fungus" into the earth. To catch the insect visitors during the night, the test tubes were sheathed with a condom (for protection!) and slathered with a very, very sticky substance called "Tangle-trap." Obviously, this last step was saved for the field.

The first location we visited was the Med Garden at the University of Florida. We arrived at approximately 7:30 pm and set out three traps. We hoped to sample the different ecozones represented at the Med Garden (namely the "open field," "marsh vegetation," and "damp woods") in order to catch the representative species at each site. Given the nature of the fungus we were interested in (growing in damp, wooded areas with a great deal of dead and decaying vegetation) we naturally expected that the traps set out at some locations were going to be more productive than traps set out at others. We had little hope for the "open field" trap, but expected great discoveries from the "damp woods" pseudo-fungus.

The following afternoon the only insects on the "open field" trap were several ants (evidently from a colony nearby, if not directly underneath, the trap). Many of them were still alive and crawling up and down the dissecting needle and under the condom. I initially suspected that the ants found the trap recently, during the day, since there were very few individuals stuck to the outside of the condom while many still ventured up the trap from the ground. Reading in an entomology text, however, I found a bit of information that suggests the ants were not just exploring for the sake of exploration; they might have been searching for something. The diet of the ants (family Formicidae) is varied, including animal matter (both dead and alive), plants, sap, nectar, other animals' excretions, and *(ding, ding, ding!)* fungi. Why would a fungus, the apparent object of a colony of ants' desire for nourishment, advertise itself as free for the taking? Bah! Another question. But at least we found the first piece of evidence (not very convincing, I agree) that leads to an answer.

The evidence of over-night insect visitation in the "marsh vegetation" area was slightly better than the "open field" trap, but still not on par with the grand collection of insects I was imagining. Upon first inspection, we saw one largish lepidopteran and several minute insect specks drowned in the clear, thick goo. Back at the lab, when trying to gently pry the insects from the condom, I realized we spread the Tangle-trap a little too thick. Each specimen (with the exception of the moth, which was too big) was positively covered with the sticky Tangle-trap, and worse, the goo apparently had a softening effect on the exoskeletons of the insects. With each pull and pry, the frail bodies disintegrated to the point where positive identification under the microscope became almost impossible. The wings of the moth (by far the easiest way to identify a family) were obliterated, and the remaining insects were unrecognizable save for a few features, including the heads and modified rear wings (order Diptera, for sure). So what can be gleaned from this small insight? Moths, like all Lepidoptera, have very specialized mouth parts that are good for sucking and little else, so allraction to fungus for dietary purposes does not make sense. Could the moth be attracted to a potential place for her larvae to thrive? Again, the facts do not hold up; Lepidoptera. larvae usually feed on the leaves of plants or grasses. What's left? All I can think of is the fact that moth's are (inherently?) attracted to light. The fungus thus attracts the moth with the "hopes of inadvertently" picking up some of the fungus' spores for later dispersal. This situation would be the most advantageous adaptation of the fungus. It spends its energy glowing so as to attract those insects that would spread its spores and therefore facilitate the continuation of "the species."

Is it the same deal with the small Diptera as well? Possibly, but a more probable situation concerns the larvae. Diptera larvae spend their time feeding in decayed animal and plant matter, where, consequently, fungi also grow. Is the glowing fungus a sign to female flies that there is a nice rotten spot for their young to grow up? If so, it benefits the fungus, which absorb nourishment from the droppings of larvae. Additionally, when the female flies land on the fungus to lay eggs, they take fungal spores with them to their next stop. If this is a viable situation, leading to the propagation of its genes, the fungus has spent its ATP well.

The last trap was retrieved from the "damp woods" area of the Med Garden. Again, we were initially unimpressed. Back at the lab, after carefully attempting to remove the insects and cursing the oozing goop that got attached to our skin, hair, clothes, and tweezers, we evaluated our findings. The largest insect was recognizably a cockroach, and keyed out to be of family Blaberidae. The presence of a cockroach confused me; thinking back to all my prior observations of them scuttling out of the way at the slightest illumination I could not imagine why these creatures would be attracted to a glowing fungus. The only thing I could think of that explained their presence is their omnivorous feeding habits and their affinity for dark, damp places. Along with the roach, a tiny, yet strikingly beautiful leafliopper (family Cicadellidae) was present, as well as a small Diptera, family Cecidomyiidae. The presence of the leafhopper befuddled me as well; they are characteristically leaf eaters in both adult and larval form, so the only remaining option is that the glowing of the fungus attracts them so they can pick up a legfull of spores for rapid transportation. As opposed to the roach and leafhopper, who seemed somewhat out of place attached to a glowing condom out in the middle of the woods, the remaining Diptera, a gall gnat, seemed to have a good reason for being there. Gall gnats, also called gall midges, are mostly plant feeding, but a few species live in decaying organic matter or fungi and feed on aphids and other small insects. The glowing fungus, then, must have a good relationship with the gall gnat, and vice versa. Here is a possible situation: The glowing of a particular fungus attracts (for whatever reason) small insects and larvae. The nearby gall gnat is therefore attracted to the glow because "it suspects" a potential meal, as well a place to live, is available. The gall gnat moves in and preys upon the small insects, returning to the fungus its excrement. When the gall gnat decides to move on to bigger and better things, it takes with it a small sample of fungal spores to deposit elsewhere and start the cycle over. Everyone is happy (well, at least the fungus and gall gnat are). Again, the fungus is sustained and its lineage progresses, presumably because of its adaptive evolution of a nighttime glow.

So, as it stood, we had one half of our project completed, and already we had some (not rock-solid) evidence supporting our initial notion as to why these certain fungi glow. On to part two.

We decided early on that we needed to split our traps between at least two locations so as to get a wide variety of insect habitats. The Med Garden was an easy choice. It was close, it had diversified eco-niches, and at least one of those mini-ecosystems was of the "damp woods" type. In the interest of time and convenience, we decided that our other site would be the YMCA campgrounds where our class would be camping out over one weekend. As it turned out, the location was indeed convenient. Since we were going to stay overnight, we could put out the traps just as the sunset and retrieve them early the next morning. The land at the campground was not as diversified as the Med Garden, it being solely a dry wooded area with a few more leafy meadows near the horse's fenced-in field. I set out the traps (six of them) along the path that led into the woods and toward the lake. Admittedly, I was not as careful in laying these traps as I was at the Med Garden. At the Med Garden, where students typically stroll along the boardwalk, we had to make sure the traps were out of sight. This time, though, I was certain there wasn't going to be any unnecessary foot traffic through the YMCA woods at night (we were the only ones in that particular area), so the traps were not so inconspicuous. After a grand night of s'mores and Mad Libs, my partner and I proceeded to recover our traps.

At the next lab session, we again tackled the Tangle-trap (this time it wasn't as bad; our wise professor gave us a can of easy-to-apply-but-still-as-uncooperative aerosol goo) and struggled to identify the insects we had attracted. Again, the dissolving action of the Tangle-trap left many of our specimens liquefied, but the YMCA harvest had been quite bountiful. We had lured in two bright green long-horned grasshoppers (family Tettigoniidae) on two separate test tubes. These long-horns, like all grasshoppers, usually feed on leaves and blades, but a few species may feed on other insects. Why would he be attracted to the glowing fungus? The answer is clear if this particular species did indeed feed on other, smaller insects (perhaps like the minute Diptera we had observed from the Med Garden), that were, in turn, attracted to the glowing fungus (for reasons of nourishment or egg-laying). On the same test tubes, in fact, were many very small insects that, had our trap been a legitimate fungus, might have ended up as the long-horn's dinner.

A male black fly (or buffalo gnat), family Simuliidae, was recovered. These small pests are quite ferocious; there is an instance cited in the entomology text concerning a horde of black flies attacking and killing livestock! These devilish creatures suck blood, carry diseases (in Africa and Central America), and can cause blindness by flying into one's eye! So what was a male doing attached to my fungus-trap? An anomaly, for sure. He was not searching for food, nor could he have been scoping out for a place to lay eggs. My only explanation is that, like the moth, this black fly was attracted to the light, and the fungi took advantage of that instinct. Hopefully for the fungus it means that the black fly (or the moth, or the leafhopper) will stop by, possibly excrete some nourishment, and then fly away with a few spores attached.

Along with the black fly, a yellow-and-black leafhopper was found. Also, another small Homoptera, this time of family Derbidae was picked from the gooey trap. This individual, a part of the superfamily of planthoppers, the Fulgoroidea, is tropical, and almost exclusively feeds on woody fungi. Therefore it would be advantageous for these Derbidae to have developed an attraction to a faint glow in the woods that could signal a patch of fungi. The fungi, although sacrificing a bit of itself to the planthopper, benefits from the fact that the insect will lead to the dispersal of spores, and will leave a bit of feces to feed the fungus (this relationship carries over to the ants from the Med Garden, as well).

The last insect of note was recognizably a click beetle, rust colored and elongated, with two small spines extending off the back of the pronotum. The adults of this famlily (Elateridae) are strictly plant-eating [sic], so the little beetle was probably not looking for food. However, it may have been looking for a place to lay eggs. Larvae of the click beetles are omnivorous and many of them live within rotting logs. Perhaps the fungal glow has become a signal to click beetle mothers-to-be that there is a place to lay her eggs. While thumbing through the entomology text I came across a very interesting bit of information: some click beetles glow. These species (natives of the southern states) have two posterior light organs on the prothorax and one under the abdomen. If the click beetle we trapped is one of these, then it explains another possible use for the fungi's glow. Perhaps the airborne glowing click beetles mistake the glowing fungus for a member of its own species. Does it approach it? I don't know much at all about the behavior of these beetles, but I can assume (through knowledge of fireflies) that the night time glow might have something to do with mating. If that is the case, the glowing male would be attracted to the fungus, and through subsequent contact (the beetle landing on or brushing against the fungus), the ftingus would have some of its spores dispersed.

Through all these complex (and hypothetical) relationships between insects and glowing fungi (which actually are scarcely represented in Florida), I think there is enough circumstantial evidence to say that there is definitely a reason for the presence of bioluminescence in some fungi, in some places in the world. Granted, the experiment was not flawless: a control group of non-glowing sticky traps in the same area as the glowing traps could have been used to see which insects were actually attracted to the light and which haphazardly flew into the Tangle-trap. But all in all, it demonstrated that there could be several evolutionary "purposes" for this strange fungal trait. No matter what the exact relationship, the ends to the fungi's means are the same: continued survival of the genes for glowing.

REFERENCES: Field & Lab Handout 40, J.E. Lloyd, and refs.

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Existentialism… and Fireflies?

by Andrew Aronsohn

The term *existentialism* was coined by Gabriel Marcel to describe the philosophical ideas of Jean-Paul Sartre and Simone de Beauvoir, and the ideas came about as a consequence of the social, political, and cultural changes that were occurring in France in the 1940's. Jean-Paul Sartre classified himself as an existentialist and was one of it's most famous exponents, but this form of philosophy went far beyond the ideas of just one man. Authors such as Camus, Dostoevsky, and Kafka did not write as existentialists, but are now thought to have taken an existential point of view in their literature. Existential expression is not limited to books, for some of the most popular means by which existential thought are conveyed are movies, plays, paintings, and music. In addition to art, existentialism has permeated the realm of religion with philosophers such as Soren Kierkegaard, who demonstrated the Christian perspective to existentialism in contrast to Sartre's atheistic perspective. Existentialism, like almost all other forms of philosophy, includes divergent interpretations according to differing opinions of philosophers. This essay will begin with a focus on the existential ideas of Jean-Paul Sartre because his ideas represent some of the most widely held views concerning existentialism, and then will discuss some of the unifying themes and purposes of existentialism. Finally I will attempt to take existentialism out of the minds of philosophers and place it where it can be viewed (and criticized, and tuned?) a bit more easily — in the summer night sky.

The life of Sartre in a nutshell... Jean-Paul Sartre was born in 1905 and was educated at the Ecole Normale Superiecture in Paris. From 1934-1935, he spent a year teaching at the Institut Francais in Berlin. After this, he resigned to devote himself to writing exclusively. He was a member of the French army during World War II and was a German prisoner of war. Sartre took complex philosophical ideas and made them more understandable in the forms of short stories and novels. His most famous works concerning existentialism include *Being and Nothingness* (1943) and *Existentialism Is a Humanism* (1946).

Existence precedes essence . . .. Although Sartre did not actually invent existentialism, he was responsible for one of the most fundamental themes of existentialism "existence precedes essence." To understand this enigmatic phrase, one must first understand the *essence* of a manufactured object such as a paper knife. A paper knife is made by someone who has a conception of it in his mind. In order to produce a paper knife, the producer must know that he must use a certain type of material in order to form an object with a sharp edge that will be suitable for cutting, prior to his actually doing anything. It is impossible to make something if you do not know how to make it or what the object is to be used for. If the term *essence* means the procedure by which something is made and the purpose for which something is made, in the paper knife's case *essence* precedes its *existence.*

When someone looks at a paper knife, he can tell exactly what the useful purpose of the object is. The paper knife is only a representative of the entire set of manufactured things, and thus, by the same line of logic used with the paper knife, essence precedes existence with all manufactured things. The argument thickens a bit when man is brought into the question. When considering the nature of man, many would say that man is a product of a creator named God. With the concept of God comes the idea that when God creates man, He knows exactly what He is creating. As unflattering to mankind as it sounds, these statements about God throw humankind into the same category as the paper knife and other manufactured goods.

In this view, each individual, just as the paper knife, is a realization of the conception that God had before he created the individual. Non-existential theist philosophers prior to Sartre supported this idea by saying that mankind possesses the same essence conceived by God, and it is this essence common to all men that precedes concrete or historic existence. Sartre shook the philosophical world up a bit when said that there is no God. This poses a problem because now mankind has no "creator" — and, of course, (happily?), we are separated from the paper knives. The absence of a creator means that it is impossible for mankind to be created by something with a preconceived notion of how we were to be made and any purpose that we were supposed to fulfill. Human nature cannot be defined in the same manner that a paper knife can be defined because, unlike a knife, the purpose of a human being was not completely thought out in advance. Man, unlike everything else, exists first, then defines himself and his purpose. That is, his *"existence* precedes his *essence."* Sartre's major point here is that a paper knife exists for the purpose of cutting things; that is the reason knives are made. Human beings exist first, and our purpose is determined by what we make out of ourselves.

Comparing a man and a stone... In the previous argument, Sartre proved a major theme of existentialism — that man has the unique ability to be able to make anything he wishes out of himself. Sartre takes this argument further by stating that man also has a greater *dignity* than an object such as a stone. At first glance this does not seem like such a bold statement because stones are not often thought of as very dignified characters, but, to understand this statement one must be aware of Sartre's definition of *dignity.* Dignity, as Sartre puts it, is something that consciously moves itself towards a future. Man is conscious of moving towards the future whereas a stone does not really know much of anything. Stemming from the idea of dignity is the concept of the two different modes of being: "being-in-itself" and "being-for-itself." "Being-in-itself" means simply to exist and "being-for-itself" means being conscious of existing. Human beings possess both of these modes in that mankind is and he is conscious of it. A stone is only "being-in-itself'. What sets mankind apart and makes us possess both modes of being is that we are consciously interactive with the future, unlike the stone. Since man makes himself what he is and is consciously interacting with the future, man is fully responsible for himself. This leads us to the next major point of existentialism: for each and every action of a particular man, it is that man and that man only who is responsible for committing it.

Man is not only responsible for who's in the mirror... Existentialism, according to Sartre, goes beyond the idea that man is responsible for himself, for it also holds that man is responsible for all men. When man chooses to make himself a certain way, he is not only making himself, but he is also setting an example for others to follow in making themselves. The idea of a value is a subjective one, meaning that there is no absolute standard guide that tells us correct decisions and correct values, so each individual is forced to make value judgments of his own. If a value is truly good for an individual, than it is by definition a good value for all. By adhering to certain values, one is saying that it is good for himself and that is also good for all. Every value chosen is to be seen as an example for all others to see and consider. According to existentialism, in making a decision one must realize the consequences of other people acting in accordance to the same values that one picks for himself. Sartre says that simply saying "others won't act the way I do" is a form of self deception, and people that utilize this form of self-deception will never be fully at ease with their conscience. Men must make all decisions with a great deal of anguish, because with each decision men are not only responsible for themselves but for all of mankind.

The abandoned condition of humankind... Sartre along with many other existentialists, were strict atheists. He was a believer in Nietzsche's idea that "God is dead" and supported Heidegger's theory that man's condition is one of abandonment. Sartre did not mean abandonment in the physical sense of the word, but rather in a psychological sense. Since we, according to Sartre, live in a Godless world, there is absolutely no chance of humankind ever getting any moral or ethical help from "upstairs." Existentialism brings forth the idea that each individual is put on this earth with a lifetime of decisions to make which he is completely responsible for, yet there is no real authority to turn to when left to grapple with an especially challenging decision.

A few words on determinism... In order to continue this discussion of existentialism, another philosophical concept is needed — namely the idea of *determinism.* Determinism equates man's life to being on a track where it is impossible to swerve off, speed up, or slow down. According to determinism, there is no such thing as free *will. Free will* would mean one could get on and off the track, or just stop, if one so desired. Determinism means every action that an individual commits is caused by one thing or another, and nothing happens for absolutely no reason. The only reason that someone picks one choice over another is because that choice has a more compelling cause. A free action is only an illusion because even if someone thinks that his or her action was completely free of cause, there is in reality an underlying cause that provoked the action. But if all of our actions are caused, as determinism states, then how can we be responsible for any wrongdoing? All of our decisions are "beyond our control," so in determinism we are not to be held responsible for anything. Who should accept responsibility is a major point on which determinism is often attacked.

Prisoners of freedom... In Sartre's *Nausea,* we finally see the relevance of the word "exist" in existentialism. The present is the only thing that actually exists and what is not in the present does not exist. The here and now is the only thing to be sure of and, therefore, this is what really exists. Our world consists of things that are as they appear to be, and if it were not for these things there would be absolutely nothing. These few statements prove to be extremely powerful ones when supporting the doctrines of existentialism. If one is to take these statements as the truth then one would be forced to deny the existence of many abstract entities such as God, a moral standard, and determinism. The "causes" that the logic of determinism rely so heavily upon are not something that we can always see or even be sure that they exist, so by the existential logic they do not exist and neither does determinism. If there is no determinism then man is free. This seems like a relief from the helpless situation we find ourselves in when in the determinists' world, but, unfortunately, the existential picture may put us in an even worse predicament.

According to Sartre, man not only is free but he is condemned to be free. We are thrown into this world by no choice of our own, then once we are conscious of ourselves we are forced to take full responsibility for all of our actions. Free will may seem like a luxury when compared to the helplessness of determinism, but when we recognize the enormous burden of responsibility that lies within every free-willed decision, free will no longer seems like such an attractive idea. Kierkegaard spoke of a dizziness of freedom, and other existentialists have labeled freedom as "appalling." It is truly a scary thought when we think of ourselves as abandoned in this complex world, so free that there is nothing pushing us from behind, nothing leading our way, and no way to escape this situation. Prisoner of freedom, after existentialism explains it, no longer seems like an oxymoron.

Unifying themes of existentialism... Most of the ideas that have been presented thus far have been heavily influenced by Jean-Paul Sartre. His ideas do an excellent job in explaining the foundation of ideas concerning existentialism, but what has yet to be discussed are some unifying themes of existentialism and the purpose of existentialism itself. The following are three ideas upon which almost all existentialists agree.

1. Acceptance of anguish and suffering as a condition of experience. This seems a little harsh, but according to the existentialists this is a so-called "fact of life." It was previously mentioned that one must assume complete responsibility for himself and everyone else with every decision made. This burden of responsibility is not possible without anguish, so every decision means anguish. What about the experience of love? What could possibly be said about anguish concerning love? Existentialism defines love not as a state of happiness, but rather a concern for someone whose death would result in an irreparable personal loss. There is nothing that can exist without anguish and suffering.

2. Anguish is seen in different forms. When questioned about anguish, most would say that they in fact do not experience anguish and suffering with every decision. How do existentialists explain the fact that I just decided to get a drink of water, yet I do not recall any feelings of intense anguish or suffering while doing so? Their answer to this is that anguish takes the form of many other commonplace negative feelings such as tedium, anxiety, apathy, and fear. The source of these many times unexplained feelings, according to existentialism, is a misunderstanding of anguish which is necessary in life. One of the purposes of existentialism is to liberate mankind from these "unwholesome" manifestations of anguish and realize these feelings for what they really are.

3. Existential values serve a purpose of intensifying consciousness and give reason to engage total energy in life. Intensity is a key word for existentialists. We are not on a path which we are determined to stay on but one on which we are forced to make choices that we must take responsibility for. Intensity of conscience and energy is a requirement in order to deal with the anguish that accompanies this.

Existentialism is by no means a positive philosophy but it does have its points of attraction. This philosophy received such widespread popularity because of its almost shocking refusal of faith in the unknown and its glaring acceptance of concrete reality and free will. Many are troubled by existentialism's constant references to anguish and suffering, yet there are many who accept existentialism's harsh responsibility with open arms. Whether or not one agrees with the ideas of existentialism, it should be praised for its innovative ideas and historical importance. As a neophyte philosophy student, I find it refreshing to break out of the ancient thoughts of Greece and Rome, if only for a little while, to study an idea that was completely conceived in this century.

The firefly — the unsung existentialist? (ending #1)… It is only appropriate to include our friend, the firefly, in our discussion of existentialism. What better example of something taking full responsibility for their actions than the firefly? This may seem like an odd statement at first, but at closer inspection it becomes obvious that for the firefly, existence truly precedes essence. The firefly is not by any means like the paper knife. Our bioluminescent friends are not here to perform some mundane task like the knife, but rather to lead a life filled with freedom and choice. A firefly, just like a human being, exists first as a mere arthropod but he must make himself into the firefly that he is. Our physical actions and speech that reflect our choices can be equated with flight patterns, flash colors, and flash patterns. The male firefly will notjust reproduce just as the knife will cut, but rather he must take on the responsibility himself. On any given summer night ' one can see existentialism illuminate the night sky because the male firefly knows that he must take on the responsibility, wholeheartedly, to signal the female himself. The male realizes his burden of responsibility and accepts it with an intensity that would please any true existentialist. In addition, the male firefly exercises his free will every night when he decides to signal the females to find a mate. Finally, the firefly is a prisoner of freedom, just like us. They, like humans, are thrown into the world and are forced to lead a life of freedom. Fireflies accept this sentence of freedom with much more dignity, however, because while the human existentialist complains about intense anguish, the firefly just lights up the sky.

Some flashes of disapproval concerning existentialism. (ending #2)... Our luciferase-bearing friend, the firefly, can be used to accentuate some holes in the logic of existentialism. Fireflies are living creatures just like human beings, yet when one analyses their lives it does not seem as though they have the luxury (or curse, as the case may be) of free will. Fireflies, along with most other members of the animal kingdom serve as pillars that support the idea of determinism. The causes of actions that existentialists say do not always exist can be easily seen in the firefly. The male firefly flashes as a result of a specific cause — to find females. It is hard to imagine that a firefly equipped with such a paltry nervous system is flying around pondering the notion of whether to light up or not to light up. It is an even more difficult task to find anything that the firefly does that is not directly caused by its program to survive and reproduce. Fireflies do not make choices but rather act out what needs to be done — what they are programmed phylogentically to do. If fireflies still seem too "free," then what about a sponge? The sponge is a living creature, yet it does not seem to be making choices concerning reproduction and feeding. At what point along the hierarchy of complexity exhibited in the animal kingdom can one say that these animals lead determined lives and these animals live lives of free will? Once determinism is proved, the idea of free will and existentialism seem to fall apart. Sometimes, in order to find the answers to some of the "big" questions, one need not look through piles of old dusty books, but rather look out into the summer night sky.

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Women's Role in the Study of Nature

by Stacey Hannah

Dear Firefly Doc, I would like to begin by explaining to you why I am writing this letter. When you first told me I could write my paper about women's work in nature, I admittedly was quite relieved. Having already found a few books specifically on this topic, I figured it would be easy enough to choose a few individuals, maybe find a couple more sources, and compile information. However, as I began to get further into my research and to think about what exactly I would write, my own feelings about what I was learning dominated my thoughts. Being, of course, a woman, or girl (a title I am sometimes more secure with), who is interested in science and has very general aspirations of making some sort of a career out of it, what I read about these women naturally conjured up emotion. It would have been a terribly difficult task for me to write an objective, strictly fact-filled paper. I am almost entirely confident that you will appreciate this. Your willingness to let your students think for themselves and your interest in what we discover thereafter is evident to me in your unique way of teaching. I also figured, since you write us, your students, so many letters, I could write one back to you. Because so many times in our studies we are forced to "color inside the lines," I've taken this opportunity to go a little on the outside. My hope is that, through this, we both receive more enjoyment out of the task.

Never fear; it is my first intention to state a few facts on the subject of women's role in the study of nature. As you can imagine, it has always been greatly down-played, especially before the twentieth century. As I read through source after source about woman after woman, the seemingly off-handed remarks blatantly denying any feminine involvement in the study of nature jumped out at me from the pages. I thought I would share several of these statements with you. First, Paul Quinnett, in his spoof called "Of Bugs and Women," reflected on the fact that he had never met a female entomologist and concluded that "all women have an inbred dislike of insects" (Bonta 145). Obviously he never attended Honors *Biology of Fireflies* class. A second quote came from a leading Bureau of Entomology man upon his learning of the appointment of Edith Patch as teacher of entomology and agricultural English at the University of Maine. "A *woman* can't catch grasshoppers," he said (Bonta 175). In his article "The Invisible Woman," Stephen Gould spoke about women's involvement in botany. He stated that this was acceptable because it followed the conception of the "perfect lady," whereas other forms of natural study did not (Gould 14). His rationale was that botany coincided with gardening, which was an acceptable interest for women to have. A ruling of the Wisconsin Supreme Court in 1875 actually placed a definition on the role of women, stating that "the Law of Nature ... qualifies the female sex for the bearing and nurturing of the children ... and for the custody of the homes of the world..." (LaBastille 69). I guess this left no room for women to study the nature that provided that law.

In a different context, a famous painting entitled *Celia Thaxter in Her Garden* by Childe Hassam, through its portrayal of the typical view of a woman in a garden, further supported the (mis)conception of women in nature. While the painting did depict a woman in nature, the garden that Thaxter stood in was not the hard-core wilderness that so many women were involved in, but rather one more part of her domesticated life (Norwood 104). Therefore, by standing in her garden, Thaxter was not progressing as some radical female, but, rather contradictorily, she was following in her typical role as a housewife. In stating these facts, I am not trying to expose some great historical injustice done to women. I realize and respect the beauty of how history has shaped and changed women's roles in every aspect of society. And even in today's world I would hesitate to call myself an active feminist. I merely find this information incredibly striking. To think that women were considered so insignificant in a field where they offered so much fascinates me. It furthers my appreciation for the beauty of how time so dramatically changes the fundamental ways in which we think.

As is the case with most generalizations, the ones that no female is comfortable in the wilderness, that girls don't know how to camp, that women hate bugs, etc. are simply not true. Much factual evidence exists to support this. Countless women have made countless achievements ever since the pioneer days. Rachel Carson, with her unprecedentedly influential work on the effects of pesticides in nature, is immediately brought to mind upon the topic of women's accomplishments. She is still considered to be America's most famous female naturalist (Norwood 147). (I thought it important to mention Carson, even though her work was all done in the twentieth century.) To list a couple of other accomplishments, Kate Brandagee was offered the position of curator of botany at the California Academy of Science (Bonta 86), and Elizabeth G.K. Britton was considered one the three most prominent worldwide bryologists (Bonta 129). Anna Botsford Comstock, a famous entomologist, published the *Handbook of Nature Study* which soon became known as the "Nature Bible" (Bonta 154). Annie Trumbull Slosson, another entomologist, had a species of insect named after her. The species with the epithet *slossonae* could not represent all that she discovered (Bonta 169).

On top of these accomplishments, which I could go on listing for pages, these women not only defied the misconceptions mentioned by their involvement in nature, they consistently proved it wrong by throwing themselves into their work. Every woman of whom I read was characterized by hard work and long hours, sometimes despite failing health. Another commonplace was that these women worked till very old ages, most till their eighties. Anna Comstock, for example, retired a full five years after her husband did, even though the two worked together for their entire married life (Comstock 252). It so happened, also, that Anna was still teaching until just two weeks before her death (Bonta 166). The dedication to and excellence of these women's work in nature I found to be awesome.

So far, I have presented what I learned about the traditionally viewed role of women in nature as compared with that of men, and the seemingly contrasting significant accomplishments of women in nature. As I read more and more about the work of these women naturalists, despite the fact that they were so doubted by men who worked in the same field, it seemed significant to me to focus on their relationships with these men. Each woman was greatly influenced by the men in her life, and I began to notice a sort of pattern in these relationships. These relationships were consistent among most of these women, not because they each had identical relationships with the prominent men in their lives, but because these relationships all reflected the way in which they viewed and went about their work. Mostly, women who worked with men took on a supporting role. However, this does not negate the fact that the women viewed the natural world in a whole different manner than men, and, in fact, these relationships supported that fact (Norwood xv). This all resulted from the simple, yet often-denied fact that men and women inherently view this world in much different lights.

The major example I found of this behavioral/psychological difference was exemplified by the life of Anna Botsford Comstock. Four specific examples clearly displayed her acquisition of a supporting role to her husband, John "Harry" Comstock. The first two examples related expressly to the couple's research and experimentation. Even before their marriage, Harry gave Anna her first set of drawing tools, with which she began drawing insects for him (Bonta 157). During their life together, Anna continued to draw the insects Harry found, eventually enabling him to classify much of the Coccidae of America (Comstock 130). Though he greatly praised Anna's work, the bottom line was that Harry ended up with much of her credit. Secondly, upon the initial publication of her own book, *The Handbook of Nature Study,* Harry thought it would lose five thousand dollars (Bonta 154). Despite this obviously mistaken thinking, however, Anna viewed her husband as being supportive. Did she just overlook his obvious doubt of her work? The answer must be "yes," because this type of what seems nowadays as almost condescending approval, is said to have typified their marriage (Bonta 154).

Examples were also evident in the couple's life together outside of their profession. A story I found somewhat amusing, in somewhat of a sick way, told of a time when Anna made too much pie crust and the couple ended up with enough cranberry pie to feed an army. When Harry tired of this treat, he simply threw the pies away, despite "shocking and scandalizing (Anna's) frugal self" (Comstock 102). Although this may seem to some as an insignificant occurrence, it seems to accurately reflect the couple's relationship, even professionally. A final example was, simply enough, that Anna stated, upon Harry's stroke and acquiring of terminal illness, that "this calamity, for us, ended life. All that came after was merely existence" (Bonta 166). A final seemingly minor detail, yet one that struck me as significant, was simply that on the first page of her own autobiography (from which I have taken much of this information), is a large picture of her husband.

Admittedly, Anna and Harry's dedication to one another displayed an ideal marital relationship. However, it was glaringly clear to me, in reading Anna's own words, some as previously quoted, that her life revolved around him. And while she engaged in so much important entomological study and research, it was usually dictated by his work. I am not discounting this, or saying that it is wrong; I am merely reflecting that, because of the time in which they lived, Anna's way of thinking seemed to be so much resolved to the fact that her work revolved around her husband's that she did not even question it. She looked upon his dominance of their personal relationship with unquestioning laughter, as is evident in the humorous tone she used to tell the cranberry pie story. She viewed her work, and even her life, as her own for the simple fact that she lived in a world where something that was a woman's own work or possession was usually something given to her by a man. And I, as a woman approaching the twenty-first century, am forced to question any thinking of the sort.

Just about every other woman naturalist before the twentieth century worked with the mindset of Anna Comstock. Countless women drew for men, as Anna did for Harry. Jane Colden's early floral drawings specifically displayed the fact that illustration had become a female occupation in which women could adhere to their natural inclination to decorate (Norwood 60). It is interesting, and pertinent, I believe, to point out that most women naturalists had positive relationships with the men in their lives. Alice Eastwood, a botanist, spoke confidently of her positive male friendships (Bonta 96). Anna Comstock also had this to say on the subject: "Blessed is the girl who learns early in life that men are good" (Bonta 155). Most women worked under male mentors and felt positive support from these men, as well as the men in their families. These good relationships contributed to the inclination for these women to unquestioningly accept the inferior role they took to these men. They were grateful for the support they received from these men, which to women today would undoubtedly be seen as condescending. They viewed these relationships as positive, when today they would surely be seen as negative.

Ever since the pioneer days up until the twentieth century, and even beyond that, women's role in the study of nature has been downplayed. While this is a fairly logical fact, I became overwhelmed with its irony as I did my research. As I have said before, it did not necessarily infuriate me, but rather interested me, and made me more aware of the intensity with which these women studied nature. You see, I thought and thought about why women would so passively accept almost condescending support from fathers, brothers, husbands, and mentors. I realized, after speculation, that it all boils down to the unconditional commitment these women had to their work. They were so intensely dedicated that they were concerned with their work and nothing else. They thought little about why or how they received the opportunity to work in nature; they cared so little about recognition that they did not even think twice when a husband or a mentor received their deserved credit; and they obviously did not think twice about the perceived role of women in the study of nature. These women's sole thought was that they were learning about and helping to provide others with knowledge of the natural world. One female entomologist summed it all up when she said, "My work means more to me than living..." (Bonta 153).

Intrigued and questioning trails, Stacy Hannah

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"After reading about you and your extreme interest in fireflies in the St. Petersburg Times, I thought you would appreciate the following poem written by my mother to my daughter."

Rebecca Heard a Firefly

"Did you hear the firefly?"
Asked Rebecca who's only three.
"Did you hear the firefly?
I heard it calling me."

And so I listened carefully,
I know its quite absurd.
But I listened and I listened,
and never heard a word.

"Don't you hear it? Listen!
And when its light is lit
he tells me all about himself.
I mean every little bit."

"He tells me that's his job,
to light up in the dark.
And that's why you can find him
in almost every park."

So, once again I listened
and listened with all my might.
From the deepest of my memories,
I, too, had heard one night.

Oh, those many years ago.
Was I really only three?
But, yes, I heard the firefly.
He really talked to me.

Rebecca and I sat and listened.
We saw the little glow.
And we each received a message
as the light would come and go.

I love you, my Rebecca.
I love your sweet, sweet ways.
And Rebecca said she loves me
and will for all our days.

Come on little firefly,
keep talking to we two.
And we'll always remember
the night we talked to you.

Edna T. Thomas

I thought I should pass this along to you. I hope you enjoyed it.

Sincerely, Lynn.
St. Petersburg, FL

Thanks Lynn, and Grandma Thomas. I think this poem will become part of the American lightningbug tradition. *fd*