U.S. Fireflies Flashing in Unison

A rare, dazzling spectacle may not be limited to far-flung places

A firefly in western Maryland.

By SUSAN MILIUS

A dark tree spangled with fireflies adorned the cover of the Aug. 31, 1991, issue of SCIENCE NEWS. Reader Lynn Faust of Knoxville, Tenn., still remembers it.

Hoping to read about the showy displays of the Great Smoky Mountains, Faust flipped to the cover article (SN: 8/3/91, p. 129). She learned that male Asian fireflies gather by the thousands in trees, flashing on and off in unison. The article disturbed her, however. "No matter how I read it, it seemed to mean that there were no real synchronous fireflies in the United States," she recalls.

What about the June ritual that she and her family regularly enjoyed at their cabin in the mountain resort of Elkmont, Tenn.? Around 10:30 at night, the family, sometimes 18 people representing three generations, would wrap themselves in blankets and sit silently on the unlit porch.

As eyes adjusted to the darkness, the yard appeared to twinkle with a natural light show. Dozens of fireflies flickered five to eight times, then all went dark for about 6 seconds only to burst into light again. And again. And again. In the background, fireflies high on a hillside started their sequence just a little ahead of the ones below, so light rippled down. "It looks like a waterfall of fireflies," Faust says.

"I didn't realize nobody knew they were there," she chuckles. She had always assumed that other vacationers in the mountains crowded onto their own porches on midsummer nights to watch the lights wink on and off.

After reading the SCIENCE NEWS article, however, Faust contacted firefly researcher Jonathan Copeland of Georgia Southern University in Statesboro. He's one of the current lightning bug devotees who study such questions as how the insects' internal pacemakers coordinate the show and how such fireworks evolved.

When Copeland and his colleagues visited the cabin, they found that the grassy hillsides with a handy creek support an unusual abundance of the firefly *Photinus carolinus*. Instead of relying on subjective thrills of watching the show, the researchers worked their way through videotapes, frame by frame, monitoring points of light appearing and disappearing in the blackness. Yes, the males definitely synchronize their flashes, Copeland says. "It makes you wonder how many more synchronic fireflies we'd find out there if we'd just leave our air-conditioned houses."

A few other reports of synchronous U.S. fireflies have flickered through the scientific literature. A Texas species, *Photinus concisus*, dazzled Dan Otte of the Academy of Natural Sciences in Philadelphia in the 1970s. The most common East Coast backyard flasher, *Photinus pyralis*, may not synchronize for more than a few cycles at a time in the wild, but when confined in a laboratory cage, males can pick up the beat and flash with each other.

An Asian firefly, Pteroptyx malaccae, *spends its nights roosting in trees, flashing in unison with thousands of nearby males.*

Since the description of the Tennessee flasher, other coordinated displays have turned up. Faust, an avid amateur naturalist who has been searching for leads to other examples, has herself found at least three more mountain spots where *P. carolinus* displays. The species seems to range along the Smokies at elevations around 2,000 feet and has been reported as far north as Pennsylvania. So, Faust was not surprised to get a late-night call from a woman with a cell phone standing bedazzled among synchronizing fireflies on the lawn of a North Carolina mountain fishing lodge.

One night in 1997, while walking the dog on Skidaway Island outside Savannah, Ga., Copeland's wife, Ursula Sterling, spotted a different coordinated display among yet another species of fireflies. Researchers have tentatively identified her find as *Photuris frontalis*, a species reported from Gulf states like Louisiana and Florida north to South Carolina.

A couple of months later, Copeland saw the same coordinated display twinkling in Congaree Swamp National Monument in South Carolina. He'd been tipped off by park naturalist Fran Rametta, who'd heard of the Elkmont display and began wondering about the light shows he had witnessed among the massive century-old swamp trees at night.

Questioning how fireflies synchronize "does not come easily to us as human beings because we accept our own ability to dance or to march in unison as being second nature," argued John Buck in his classic 1976 SCIENTIFIC AMERICAN article. Yet for the rest of nature, Buck considers this kind of synchrony—coordinating rhythmic actions in a group—very rare.

Other animals certainly can act in a coordinated way. They might respond to the same stimulus, such as when a flock of gulls startles and takes to the air in a single whoosh. Some creatures, like fish swimming in a school, can coordinate their spacing and zip off in the same direction as if connected by wires.

Yet, synchronized repeated motions are much rarer. The gulls that take off in a flock match wing beats only for a few measures. Buck points out that horses in harness don't match steps on their own. Beyond the foot-stomping, hand-clapping, Riverdancing throngs of humanity, he can think of only a few creatures that show tight, spontaneous synchrony: certain chorusing insects like crickets and katydids and, of course, some of the fireflies.

Michael Greenfield of the University of Kansas in Lawrence approaches synchrony from a slightly different viewpoint. He studies acoustic coordination in the great croakfests and chirpfests where male frogs and insects gather to advertise their studly charms, but he also ranks fireflies as special.

Although animals may not call in unison, they often adjust their timing in other ways, he says. Many species of frogs

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do perceive the beat in a neighbor's calls and respond by avoiding it. One frog who croaks, waits, and croaks again often finds a neighbor croaking during the pauses. This tendency to alternate holds across many species, Greenfield says. Only a very few frogs naturally adjust their timing to call simultaneously.

The evolutionary drive behind this, Greenfield suspects, comes from a neurological tendency to perceive only the first of two closely spaced stimuli. Basically, he who croaks first, even by a few milliseconds, gets the girl. The alternate croaking maximizes the time between the different frogs' signals.

Such simple rules for coordinating with a few buddies, however, can give rise to complicated sounds. For example, Greenfield has found that among the tungara frogs he studies in Panama, two males in an alternating duet will move over to make room, acoustically speaking, when a third joins in. The frogs space their calls so a back-and-forth duet becomes a 1-2-3, 1-2-3 trio. When an abundance of frogs converges, individuals seem to block out the crowd, still taking their timing cues from near neighbors. By overlapping, these local ensembles can create pond music of Wagnerian proportions.

Yet this degree of coordination does not match the feat of certain fireflies, Greenfield says. When frogs or many of the singing insects he's studied join a hootenanny, they do not really change their own basic rhythms, whether they're in or out of synch. Suppose a creature calls every 2 seconds. A neighbor's call may reset the clock, perhaps lengthening the pause between one set of chirps, so that both animals will start the next cycle at the same time. However, both continue to follow their basic 2-second rhythms.

A few firefly species, such as one in Thailand, seem able to do more. A twinkle of light resets the clock to a different starting point but can also change the basic pace. For instance, a firefly that naturally signals every 0.5 second could switch to a once-every-0.4-second pace.

Such adjustability does not occur often in nature, Greenfield says. One of the species of periodic cicadas, *Magicada cassini*, seems to do it, as can some katydids and perhaps a tree cricket. Even among synchronizing fireflies, this ability to change the natural pace is far from universal.

Fireflies are not flies, taxonomically speaking, but beetles. The whole family, some 2,000 species, covers much of the temperate and tropical world. Most North American species have earned the nickname rovers, because males patrol at night, flashing to advertise their services. Females, often on the ground or a stationary perch, respond with a characteristic answering flash that indicates an interest as well as an address.

Certain Indo-Pacific species play a different mating game. Males flock by the hundreds or thousands to trees, where they sit and wait, flashing in unison. Western explorers as early as the 16th century were moved by the spectacle. However, many were just as enthusiastic about mermaids, so Western scientists tended to remain skeptical until the dawning of the video era after World War II.

Even as Buck and his collaborator, Elisabeth Buck, set off to Thailand in 1969 to check out the stories, "we were more than half-convinced the phenomenon didn't occur," he recalls. But it did.

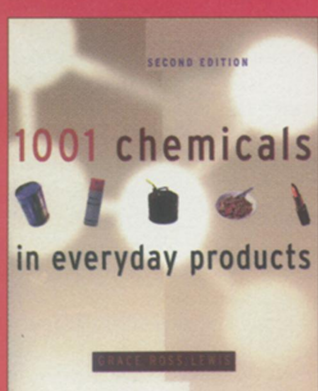
"It blows you away," Buck says, still relishing the memory of that first expedition. On a moonless night, canoeing on a jungle river, he watched trees along the banks coated with fireflies, seemingly at least one flasher per leaf, light up the night, then plunge into blackness and light up again. "The steady, silent pulsing of the firefly trees has an almost hypnotic effect," John and Elisabeth Buck recounted.

The Bucks reported that the most common of the synchronous Thai fireflies, *Pteroptyx malaccae*, keeps an unusually tight rhythm. It's more precise than other creatures often cited as examples of living clockwork: the whippoorwill repeatedly belting out its territorial call at night and the human heart beating during sleep.

Experiments showed that the Thai firefly could flick its blink in response to a neighbor's flare in 150 to 200 milliseconds. Yet the insects flash together in too tight a burst for a leader to be sending the signal for each surge. Even the slowpokes lag no more than 20 ms behind.

People can do the same thing, getting into phase without listening to a leader for each beat, Buck points out. In a classic test, experimenters asked people to close their eyes and tap the arm of a chair as soon after the leader's signal as possible. Even the fastest tappers need at least 150 ms from signal to tap. Yet when the leader asked the group members to tap in unison, even the slowest fell no more than 130 ms behind. The people weren't responding to the current taps but had picked up the rhythm from previous sounds. James F. Case, a long-time firefly researcher at the University of California, Santa Barbara, reports that an auditorium full of students can get into synch in just four or five taps.

Over the years, researchers have proposed many variations on this model for firefly synchrony, but the basics always involve some kind of internal pacemaker in the insect's tiny brain. During certain phases of its rhythm, the pacemaker becomes sensitive to a neighbor's flash, so a quick twinkle resets the clock. When the sensitivity occurs and what the resetting flash affects seem to vary by species. Researchers have coaxed fireflies into changing their natural rhythms by as much as 20 percent, Buck reports.

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In what he calls "an interesting footnote" to Westerners' nearly 400 years of fascination with synchronous fireflies, Buck notes that until recently, no one recorded speculations about the biological meaning of the displays. During the past couple of decades, however, scientists have made up for lost centuries.

Case, the only scientist so far to describe a synchronous Asian species actually mating, reports that males keep on flashing as a female lands in their midst. The male who triumphs in attracting her favors swivels his abdomen around so that his lantern blasts on and off right in front of his partner's eyes during the entire coupling. "It's to keep her mind off the other males," Case speculates.

Clearly, the flashing has something to do with mating. Males may be sending a neon message as direct as "Over here, girls!" But why broadcast it at nearly the same millisecond as thousands of other equally available guys?

"It's not mystical," grumbles James Lloyd of the University of Florida in Gainesville. He protests against a tendency to elevate synchrony to the status of unexplainable phenomenon.

In Buck's 1988 review of the field—a 50-year update of his first scientific review of the literature—he mentions nine hypotheses to explain synchrony. One suggests that flashing in unison aids the females in picking out the rhythm of the right species. Another proposes that females essentially get temporarily numbed by a flash and can't perceive or respond to a subsequent flash unless they get a brief resting period, so there's no point in one individual's lighting up before the others. Another idea was that a male would flash in unison with a neighbor already flirting with a female. That way he might get a chance to steal her fancy.

Copeland says that he wouldn't be surprised if the synchrony in Elkmont guarantees a nice, dark moment for roving males to get their bearings on the faint answering wink of a female, without the interference of some other hotshots showing off their flashers. "The male is enormously bright—it's just dazzling," he reports. He and Andrew Moiseff of the University of Connecticut in Storrs are just starting to work on the synchronicity of the coastal flashers.

Detecting males synchronizing for any reason can be tricky, he cautions. Insects can fall into phase just by chance, flashing together for cycle after cycle. Even traffic cones with flashing caution lights can seem to fall in step for six to eight cycles and then drift out of synch again. Copeland has demonstrated this illusion of synchronicity by visiting a road repair site at 3 a.m. and filming the traffic cones for a while.

"If you have to stretch and strain to see it, it's not there," he advises synchronicity hunters. Just by chance, fireflies often blink together for five, six, or more cycles before falling out of phase. However, fireflies that stay in synch for 3 or 4 minutes, and hundreds of flashes, merit serious attention.

He remembers his own experience seeing the Tennessee flashers for the first time. Thrilled with the discovery, he phoned Moiseff to tell him the males were synchronizing. "I said, 'Andy, it's absolutely obvious,' and he said, 'Prove it.'"

Copeland then spent the summer videotaping fireflies, recording flash activity of individuals in cages, and working through the data a few milliseconds at a time. With just a touch of crankiness, Copeland recalls that the next year, "when Andy finally came down and saw it, after about 30 seconds, he said, 'It's obvious.'" □

Behavior

Learning to make, keep adult neurons

Certain types of learning, and even regular exercise, appear to enhance the formation and survival of new brain cells in adult rodents, two teams of neuroscientists find.

Their investigations, both published in the March NATURE NEUROSCIENCE, focused on cell births in the mature hippocampus. A growing body of research indicates that this small neural structure, which contributes to learning and memory, produces fresh nerve cells throughout the lives of humans, monkeys, and other animals (SN: 10/31/98, p. 276).

A group led by Elizabeth Gould of Princeton University injected a group of rats with a chemical that labels newborn cells. A week later, some of these rats received training in one of four tasks.

The number of newly generated cells doubled in rats after training on one of the tasks that are known to require an intact hippocampus, the scientists report. One consisted of learning to expect delivery of an electric shock to the eyelids (as evidenced by eye blinks) just after hearing a distinctive blast of noise; the other required animals to find and remember the location of a submerged platform in a water-filled maze.

Two tasks that did not depend on the hippocampus—learning to associate noise blasts with concurrent electric shocks and to swim to a visible platform placed at random locations in a water maze—failed to generate increases in labeled neurons. Untrained mice also produced no extra neurons.

Hippocampus-dependent learning aids the survival of cells created before training, rather than sparking more cell production during training, Gould's team proposes. Labeled cells did not surge in number in rats that were injected immediately after starting any of the training sessions.

A second study, directed by Henriette van Praag of the Salk Institute for Biological Studies in La Jolla, Calif., finds marked increases in the surviving number of new hippocampal cells in adult mice that were put in cages with running wheels immediately after receiving injections of the chemical label for neural newcomers. Enriched housing, which featured opportunities for frequent social interaction and varied types of play, also yielded substantially greater numbers of surviving newborn cells.

Unlike the adult brain's outer layer, or cortex, the hippocampus may cultivate fresh neurons to deal with novel information as it discards others that have become obsolete, theorize William T. Greenough of the University of Illinois at Urbana-Champaign and his colleagues. —*B.B.*

Schizophrenia's places and seasons

Environmental factors may outweigh genes as contributors to population rates of schizophrenia, a Danish study finds.

Epidemiologists led by Preben Bo Mortensen of Aarhus University Hospital in Risskov, Denmark, used government data sources to identify 2,669 cases of schizophrenia among all 1.75 million people whose mothers were Danish women born between 1935 and 1978. Schizophrenia's fragmentation of thought and emotion usually emerges in young adulthood.

The likelihood of developing schizophrenia was sharply higher among people with a mother, father, or sibling who had schizophrenia, compared with people who had no schizophrenia in their families, the researchers report in the Feb. 25 NEW ENGLAND JOURNAL OF MEDICINE. Mortensen and his coworkers also found that urban birth exerted a powerful impact on the schizophrenia rate. After that came birth in February and March, followed by a family history of schizophrenia.

These findings may reflect the influence of prenatal brain disruptions in response to factors such as exposure to infections and poor maternal nutrition, in causing schizophrenia (SN: 2/3/96, p. 68), says psychiatrist Nancy C. Andreasen of the University of Iowa in Iowa City. —*B.B.*