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Cacapon

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Hollows, Peepers, & Highlanders: An Appalachian Mountain Ecology

"We have the power to see wonder in the commonplace, but only with a little practice." So writes George Constantz, the Lab's founder, in the introduction to his new book: Hollows, Peepers, and Highlanders: An Appalachian Mountain Ecology. *After a decade of work, the 257-page collection of essays was recently published by Mountain Press of Missoula, Montana.*

The book's 30 essays explore the natural conflicts that underlie the beauty and mystery of Appalachian life. Each chapter highlights a fascinating aspect of North America's oldest ecosystem, from the sex life of the Jack-in-the-Pulpit plant to the remarkable anti-freeze system developed by some insects. Other chapters reflect on the region's extraordinary history or uncertain future. Much of the book is set along Pine Cabin Run, the small stream that flows next to the Lab and George's home.

"I wrote this book for three reasons," George says. "First, I wanted to share my excitement for viewing Appalachian plants and animals from an evolutionary perspective. Second, I wanted to see people do more 'backyard biology.' My third motive was to stimulate preservation through appreciation — I'm a firm believer in the idea that if somebody appreciates something, they are going to be more motivated to help preserve it." He noted that all book proceeds are being donated to the Lab.

Below, we reprint one essay from the book.

INSIDE

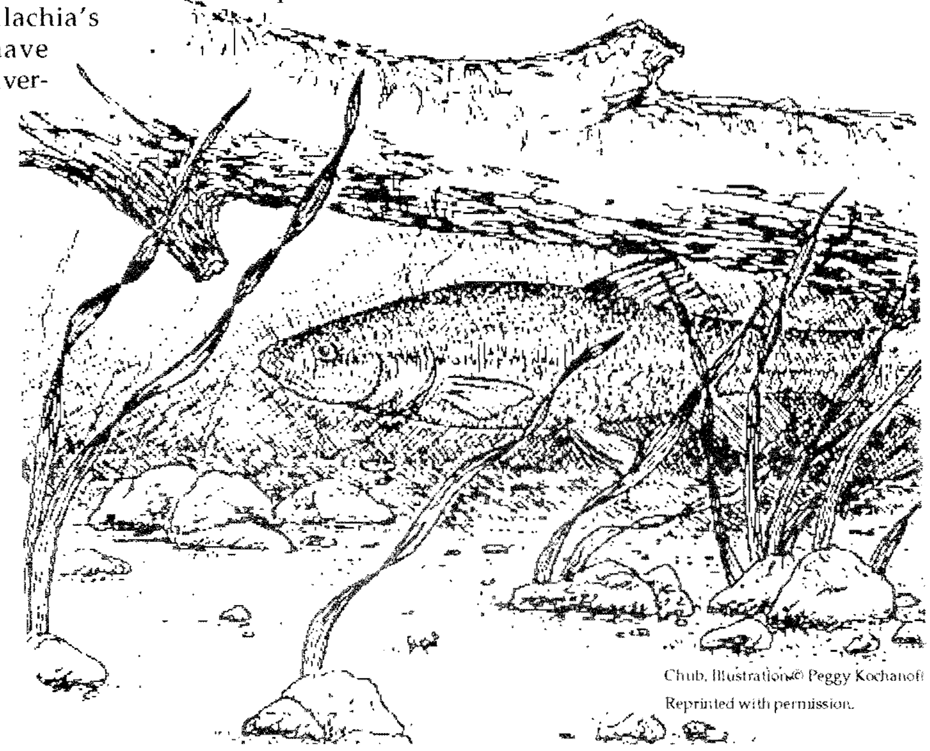
Small Fish in Shallow Headwaters

By George Constantz

As drivers of Appalachian dirt roads, we are at least subliminally aware of the schools of fish that dash madly about as we splash through a ford. The most common fishes flushed by our tires are members of the minnow, sucker, sunfish, and perch families. Within these comparatively few families, Appalachia's numerous small, steep streams have catalyzed the evolution of a great fish diversity.

Many fishes native to Appalachia live in the alternating pools and riffles of headwater streams. These habitats are shallow, subject to torrential spates and bone-dry droughts; the fish dwellers are exposed to predation by raccoons, snakes, and herons. How do small fish persist in shallow headwaters?

During spring and autumn, when streams flow abundantly, fish can move freely among pools before settling down for the season. Once established, fish seldom wander, even when moderate water levels allow them to explore other pools. One study found that after summer flash floods, 75 percent of the fish remained in their original, pre-flood



Chub, Illustration© Peggy Kochanoff
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locations. Darters and sunfishes in particular exhibit this kind of site loyalty.

If winters are so cold that fish risk being frozen in shallow water, they migrate from their springtime spawning grounds in shallow headwaters to deeper overwintering reaches farther downstream. Presumably, natural selection has favored young adults returning to breed in their own home pool — one of the best indicators of future reproductive success is that one's parents successfully reproduced there. Each creek, even each pool in a single reach, probably holds a unique chemical odor that becomes indelibly imprinted in the memory of the juvenile fish during its first summer. We know that coho salmon imprint on naturally occurring chemical cues for homing. The salmon's homing response is highly specific: molecules with atomic structures that differ slightly from the stimulating molecule do no elicit the homing response.

If we assume that small fish in Appalachian streams use chemical cues to return to their home pool, an important part of the story remains a mystery — what molecules provide pool-specific cues? Root exudates, the organic molecules released by the roots of trees, are a possibility. The number of combinations of different organic molecules comprising the exudate constellation in soil and water must be enormous, and their tree sources remain stable over the long term.

In Pine Cabin Run and thousands of other Appalachian headwaters, adult creek chubs prey on blacknose dace and cannibalize juvenile creek chubs. Adult creek chubs themselves fall prey to belted kingfishers and green herons. How do small fish in shallow headwater pools escape predation?

Where shelter is limited, adult creek chubs aggregate under cover during the day. At night, when the birds are gone, they disperse to find their prey. Where shelter is plentiful, adult chubs do not aggregate. Young chubs employ a combination of camouflage and stillness, finding cover beneath leaves and other small objects. As you might expect, in pools that host predators, prey density increases with complexity of cover provided by rocks, limbs, and overhangs. Both predator and prey choose pools that minimize their odds of falling prey.

Countershading, body coloration that combines a dark back and light belly, also reduces the odds of being eaten. Viewed from below, a fish with a pale belly presents less of a contrast against the sky than one with a dark underside. The dark back camouflages a fish from aerial fish-eating birds. A fish with a light back and dark belly would be obvious to predatory fishes from all directions.

Yet another way to avoid being eaten is to hide behind another individual. The random movements and indistinguishability of individuals within a school preclude the predator from fixing on one individual.

A fascinating adaptation for reducing the odds of being eaten is the alarm system, a method of communication in which a fish emits an alarm substance that elicits fright in pool mates. Two major groups of bony fishes — one including chubs, dace and catfishes; the other contains perch and darters — rely on alarm systems. Large, specialized cells, called club cells, produce the alarm substance, rupturing and releasing their contents when the skin is injured. Nearby fish of the same species smell the alarm substance and display a fright reaction. Each species, even each developmental stage, exhibits a fright reaction suited to its own specific predators. A species that normally schools may tighten, flee, and avoid the site of the stimulus. Other species swim against the bottom and stir up a cloud of silt. Some freeze on the bottom and rely on camouflage for protection. Adult creek chubs sink to the bottom individually, but juveniles flee as a school. Although individuals respond most strongly to the alarm substance released by other members of their species, fright reaction is not completely species-specific. The alarm substance of some fishes may elicit fright reaction in members of other, closely related species.

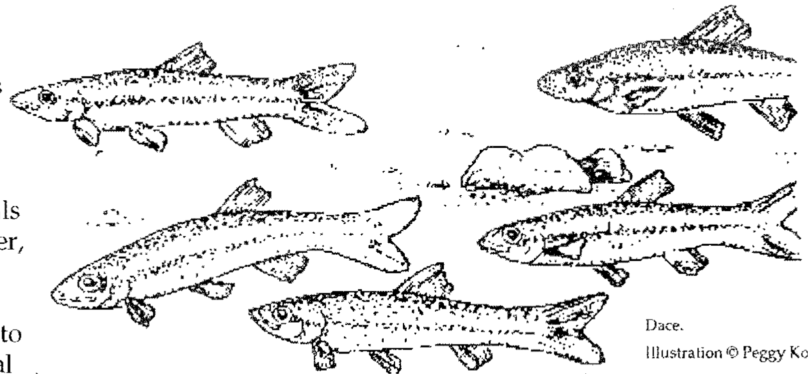
The fright reaction may even visually signal other members of the same species. For example, when two aquaria are placed together, an alarm-substance-induced fright reaction in one tank will trigger a fright reaction in fish of the adjacent tank, even through there is no exchange of water between the two tanks. This strategy allows rapid chemical and visual communication of danger among the fish in a pool.

The individuals of some species lose their alarm substance cells, but not necessarily the fright reaction, during the breeding season. Seasonal loss of the ability to alarm has evolved to complement abrasive spawning habits. At the onset of the spring breeding season, male fathead minnows lose the cells that contain alarm substance. This allows males to clean a site and spawn by rubbing against pebbles without releasing alarm substance that would frighten away interested females. In the fall, males regain the ability to produce alarm substance.

The alarm signal system of fishes resembles warning signals of other animals — alarm calls of birds, tail flagging by deer, and alarm pheromones of tadpoles — in that they appear altruistic. Over the past twenty years, biologists have been trying to understand how such seemingly sacrificial signaling systems could have evolved. If there is an evolutionary cost to the sender, such as producing and maintaining alarm substance cells or putting the sender at risk of predation, the trait is called an adaptation. However, if the substance eliciting fright is merely a normal bodily fluid that leaks passively, it may not be eligible for the status. Because the club cells in the skin seem to have no function other than to synthesize and store alarm substance, warning others has a cost.

The most likely evolutionary explanation for this adaptation seems to be kin selection. Recall that young fish return to their natal pool. Although fish in a school may not be full siblings, their site loyalty suggest that they are related. Kin selection could operate in a straight-forward manner: individuals releasing alarm substance may increase the odds that a nearby genetic relative will be aware of a predator. The alarm pheromone might even reduce cannibalism by inducing fright in a large fish of that species, thereby saving siblings.

Kin selection is easier to invoke if genetic relatives are spatially near each other. Even if kin disperse widely and nonrelatives school together, kin still might be able to favor each other. Recent evidence suggests that fish can identify relatives through chemical cues. In fact, in a wide variety of animals, an individual's odor is in part determined by its genes. Small fish in Appalachian headwater pools may be able to identify kin solely through olfaction, and then favor them with alarm signals. It is awesome to consider the possibility that scattered throughout Appalachia's hollows are brothers, sisters, and first cousins clustered in pools reciprocating favors while slighting unrelated individuals in the same pool.



Dace.
Illustration © Peggy Kochanoff.
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The other day as I drove my old truck through the ford of Pine Cabin Run, I tried to follow the streaking dace, my mind checking off the components of this intricate scene. It was daytime, so the dace were safe from predatory creek chubs who lurked under the rock ledge. Their countershading made them doubly hard to follow as they zig-zagged randomly within the school. I wondered whether any of them might have burst a few club cells and released a little alarm substance. It's getting harder all the time to simply splash through the ford and step on the gas.

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