The Search for Animal Inventors

How innovative are other species?

By SUSAN MILIUS

Just how human is that prized human capacity for innovation? Does a creative genius really need the rumpled sweatshirt and the caffeine? Or for that matter, does he, she, or it need an opposable thumb to wrap around the coffee cup?

And what about the everyday innovator, the blessed individual in the carpool who can always come up with a perfect shortcut? If that counts as innovation, are there innovators, even Edisons, among monkeys? Birds? Fish?

Kevin N. Laland might phrase his research problem a little differently, but he takes such questions seriously—so seriously that he and his students at the University of Cambridge in England are looking for innovative capacities among guppies.

Laland is one of the few researchers who explicitly examines innovation in animals. However, other behavioral and ecological research, such as studies of improvisation in bird songs or in chimps' tool use, also touch upon that "Aha!" of creativity. The implications of all this work ripple into the study of the origins of human culture.

"It's fundamental," Laland says.

Although innovation may be basic, it's not easy to define, and researchers' characterizations of it vary. Laland describes it as "new or modified behavior patterns." He quotes the textbook examples: Local groups of blue tits in England began to peck open the milk bottles on doorsteps and snitch the cream. A Japanese macaque collected potatoes left on the beach and dipped them in water to remove the sand. A chimp put extra whump in his threat display by banging empty kerosene cans together.

"We need to know that the animal is not just doing something bizarre and wacky—it's not just having a funny day," Laland says. "The animal has to learn something [useful]."

Therefore, Laland is not impressed when one of his guppies leaves its buddies and darts off in a new direction. It may be swimming boldly where no guppy has swum before, but Laland wants more payoff. He does, however, count as innovation a guppy's pioneering trip through a maze to unfamiliar food, a task Laland uses in his experiments.

Even that feat doesn't satisfy Bennett G. Galef Jr. of McMaster University in Hamilton, Ontario. "It's not clear he's captured what we mean by innovation," says Galef, a long-time researcher of how new behaviors spread.

He demands that an animal act in a manner more novel than just bumbling through a maze. One of his experiments, for example, focused on black-capped chickadees wrestling open and feasting on the little plastic cups of cream that restaurants supply for coffee.

Stan Shubel

The Blue Delta guppy may look like just another pretty tail, but some individual guppies are more creative in finding food than others are. Researchers at Oxford University uncovered this distinction during experiments on the drabber pet-store guppies.

Laland counters, "At this stage, we need a broad definition."

One of the basic questions that Laland and his student Simon M. Reader have explored is what factors inspire innovation, as they define it.

The researchers tested fish in groups, releasing them in one compartment of a divided tank. The guppies who found their way through a simple maze that they'd never seen before encountered a feeder stocked with freeze-dried bloodworms. The test fish had never before seen that traditional guppy delight.

The researchers noted characteristics of the guppy in each group that solved the puzzle first. "The most intuitive finding," Laland says, is that food-deprived fish tend to reach the food more often than their well-fed counterparts.

Less predictable was their finding of a gender difference. In 27 of 36 groups, the first guppy to strike the bloodworm feast was female. Age, size, and tendency to dash about cannot explain the difference, Laland says.

The finding made sense to Laland when he considered fish sex differences. One of the basic principles of modern behavioral ecology has been to follow the parental investment. A female guppy bears live young, a venture demanding considerably more from her than from the dad. Thus, the amount of food that she finds limits reproductive capacity. Availability of males, however, is not usually an issue because the female stores sperm from each mating.

A male faces the opposite situation. His primary challenge is to attract a female's attention with displays of his gaudy tail. Food doesn't limit his reproductive capacity. "He simply needs enough to give him the energy to keep chasing females," Laland says.

Thus, the male doesn't have the incentive to forage boldly and inventively, Laland concludes. The female, however, faces significant reproductive pressure to become a creative genius at finding freeze-dried bloodworms.

A gender difference appeared again when Laland and Reader tested guppies that had been sorted by their ability to compete with other fish when scrambling for food, according to results to be published soon in BEHAVIORAL ECOLOGY. Remembering the performance of hungry fish in the earlier experiments, the researchers predicted that the poor competitors—the perennial losers in scramble competitions—would turn out to be more innovative.

Scramble prowess did not predict the females' success. Laland interprets this result: For females, "it always pays to try to gather more food."

The loser males, however, proved more innovative than the tough competitors. For males, foraging innovation pays "only when you've done really, really badly" as a competitor, Laland concludes.

Guppies may not be the only species with particularly innovative females. The pattern shows up in descriptions of chimp behavior from Jane Goodall and other scientists. For example, females use tools to snag desirable nuts or bugs more often than males do.

A theme of the guppy findings, necessity as the mother of invention, also fits with some earlier studies of influences on innovation. Watching crowlike jackdaws, Gadi Katzir reported in the 1980s

Relative advantage: The bird family including this Florida scrub-jay and its crow and magpie kin consistently outranks ducks in a scientist's tally of innovative feeding behavior.

that mid- to low-ranking birds venture into novel spaces more often and try new foods sooner than their social superiors do. Goodall and Hans Kummer also reported that nonhuman primates on the fringes of social groups frequently prove to be the most innovative members.

Setting aside such issues as desperation and sex, Laland and Reader also assert that there are Edison-class guppies. The researchers selected the fish that proved fastest in two consecutive rounds of solving mazes. In a third round, with a third kind of maze, the researchers pitted two-time winners (presumed innovators) against two-time losers (presumed noninnovators).

The quick group again outperformed the others, reaching the food in an average of 15 minutes versus 23. Laland sees the test as evidence for identifiable innovators among guppies.

He admits enjoying the irony that his guppies, "not renowned for their intelligence," show evidence of individual innovative zest that some allegedly more highly evolved animals don't seem to have. For example, a test of capuchin monkeys, reported by Dorothy M. Fragaszy and Elisabette Visalberghi in 1990, provided no evidence of individuals with special innovative powers.

The frustration of trying to compare species based on the lab tests drove Louis Lefebvre of McGill University in Montreal to see what he could glean from reports of activities in the wild. He decided that he could count on the fervor of birdwatchers.

"Ornithologists report absolutely every new thing they see," he says. Journals routinely carry short descriptions of novelties, such as species sighted outside their ranges and birds eating something unusual or foraging in a peculiar way.

Computer searches couldn't sort accurately enough, so Lefebvre mobilized students to read through ornithology journals, noting reports of novel feeding. By now, they've evaluated 1,030 anecdotes in 25 journals.

The first installment of results, published in the March 1997 ANIMAL BEHAVIOUR, noted 322 reports of innovations among birds from North America and the British Isles. This list includes an osprey opening conch shells by dropping them on concrete-filled drums, a turnstone stealing food from sea anemones, and a house sparrow hovering in front of the sensor that triggers the automatic door at a bus station and then flying inside for food.

When Lefebvre ranked the bird groups on the creativity scale, crows and their relatives scored high. Ducks, chickens, and pheasants were low.

The innovation scores intrigue Lefebvre because they match work on brain anatomy. Birds at the top of the innovation tally have relatively bigger forebrains, he says. His newest work, not yet published, supports the correlation and narrows in on the forebrain area that seems important.

Lefebvre acknowledges risks of a method based on anecdotes, but he adds, "I'm saying, for the moment, it works."

Bird songs yield plenty of evidence for musical innovation, according to researchers at the Borror Laboratory of Bioacoustics at Ohio State University in Columbus. Dialects, which are geographic novelties thought to have started with some innovative songster, are of special interest to the laboratory's director, Douglas Nelson. "You can tell where you are in California, Oregon, or Washington if you know the white-crowned sparrow song," he notes.

By mapping the song variety of this sparrow in detail, ornithologists have demonstrated sharp borders between dialect areas. In some places in California, Nelson has discerned a shift in local sparrow dialects just by crossing a stream. Only a few other species have shown such clear demarcations.

Sandra L. Gaunt, from the same lab, is working on dialects in Costa Rica's green violet-ear hummingbird. When males want romance, they usually gather in clusters of two to six birds to sing and show off. All the birds within a cluster produce the same courtship song. Each cluster, or lek, however, has a different dialect, although to human ears the songs all are "very monotonous and staccato," according to Gaunt.

So many leks and so much new music may have arisen because no lek can get very large, Gaunt speculates. A male does not just sing over the notes of his competitors. He slips the phrases of his song into the slight pauses in theirs. As the males sing together, they speed up, making it especially tricky to coordinate notes. More than six birds interweaving their songs would crash into each other acoustically.

Improvising new songs instead of repeating old favorites may reflect a mobile life, suggests Donald E. Kroodsma of the University of Massachusetts at Amherst. A sedentary bird that always has the same neighbors can use shared songs as what Kroodsma calls "a common, learned code." The migratory life, instead, seems to favor improvising a large number of species-typical tunes for communicating with changing, wide-ranging neighbors.

In North America, for example, sedge wrens migrate, and each male improvises most of his several hundred songs. In Costa Rica, the same species tends to stay put, and neighbors' repertoires overlap, Kroodsma and colleagues reported in the April ANIMAL BEHAVIOUR. In Brazil, they observed an extreme version of a shared repertoire. In an hour-long musical duel called countersinging, two males matched more than a third of each other's songs.

Other renowned singing animals, the humpback whales, revise their songs constantly, notes Joseph R. Mobley Jr. of the University of Hawaii at West Oahu. Males in a region all sing the same highly structured number, with phrases combined according to syntax rules. As the breeding season progresses, the song is modified and all the males adopt the changes.

Many other animals have unchanging melodies that seem biologically preprogrammed, Mobley says. "It'd be pretty easy to hardwire the [whale] song." Since that isn't the case, he bets that the innovation will turn out to play some important role.

Humpback whales keep composing new tunes, changing the male choral song more often than some other mammals change hemlines.

Chimps clearly invent things, reports Sarah T. Boysen, who runs the primate lab at Ohio State. "I see something just about every day." She's not entirely happy about it, either.

One of her challenges has been to keep two chimps, now 28 and 32 months old, from scampering to the ceiling of their room and pulling apart the light fixtures. For 6 months, she kept them down by greasing the most attractive route, a

run of piping, with cooking spray so it was too slippery to climb. However, the chimps then started shredding materials in their cage and rubbing off the grease. Boysen gave up and installed a mesh ceiling to protect the chimps and the lights from each other.

She also relates what happened when, to create a new toy, she dangled a length of stretchy surgical tubing from the mesh. "They loved it—bungee, bungee, bungee!" she remembers. Then, the young female wove the loose end of the tubing back up into the mesh and made her own swing.

Innovation goes beyond the antics of captive animals, Boysen says. Studies of tool use among wild chimps show powerful evidence of lightening-bolt creativity. Animals in one part of Africa carry around stones that they use as hammers and anvils to crack open nuts. The same nuts grow among chimps elsewhere, but those animals don't pick up stones to crack the nutshells.

Such localized tool traditions keep popping up as investigators watch the animals in the field, Boysen notes. One group of chimps drags a plant through ponds and then eats the algae collected on the leaves and stems. Another group clambers to the top of oil palms, rips out the central fronds, and then pounds a pestle into the trunk to crush and release the soft innards.

These examples show how innovation allows animals to exploit a new niche,

Juvenile chimps come up with all kinds of antics, supporting the idea that, regardless of species, the creative spark flares especially bright among the young, the low-ranking, and the hungry.

Boysen observes. Classic evolutionary theory emphasized population processes, but to appreciate innovation, "the individual becomes very important," she says.

Primate studies in particular suggest that most individuals' innovations die with them. Laland notes, "Only a tiny, tiny fraction spread to the rest of the population."

Part of the reason may lie in the usually low status of innovators: the poor competitors, the small, and the hungry. "They're not being watched," he notes.

Actually, there may be Edisons all over the place, throughout the animal kingdom. The tricky part is getting anyone to notice. □

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more effective at low levels.

In your example, incandescent automobile headlights are rich in red and deficient in blue. Metal halide headlights, which are very strong in the blue region, are just now becoming available. Not only are these much more energy efficient, but they are also about three times as effective visually at these low levels. This should help compensate for the slower rod reaction.

Bill F. Jones
Orange, Calif.

For an entertaining demonstration of the difference in latency between rod and cone vision, just wiggle any small object that features a glowing part in front of your eyes under low lighting. The glowing part (perceived by the fast cones) appears to move out of synch with the rest of the world (perceived by the slower rods). A most dramatic form of this illusion is experienced when throwing an LED-equipped Frisbee under a full moon: In flight, the ring of light created by the spinning LED can appear to precede the disk it's mounted on by a yard. In order to catch the disk, one must learn to grab the ethereal ring of light.

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