News Feature: Animals that self-medicate

Many animal species have created their own pharmacies from ingredients that commonly occur in nature.

Joel Shurkin
Science Writer

Birds, bees, lizards, elephants, and chimpanzees all share a survival trait: They self-medicate. These animals eat things that make them feel better, or prevent disease, or kill parasites like flatworms, bacteria, and viruses, or just to aid in digestion. Even creatures with brains the size of pinheads somehow know to ingest certain plants or use them in unusual ways when they need them.

Anyone who has seen a dog eat grass during a walk has witnessed self-medication. The dog probably has an upset stomach or a parasite. The grass helps them vomit up the problem or eliminate it with the feces.

The science of animal self-medication is called zoopharmacognosy, derived from the roots zoo ("animal"), pharma ("drug"), and gnosy ("knowing"). It's not clear how much knowing or learning is involved, but many animals seem to have evolved an innate ability to detect the therapeutic constituents in plants. Although the evidence is entirely circumstantial, the examples are plentiful. The practice is spreading across the animal kingdom in sometimes surprising ways (see Box 1).

Most studies of animal self-medication, however, are in the great apes. In the 1960s, the Japanese anthropologist Toshisada Nishida observed chimpanzees in Tanzania eating *aspella* leaves, which had no nutritional value. Harvard primatologist Richard Wrangham saw the same behavior at Jane Goodall's Gombe reserve, where chimps were swallowing leaves whole. Other scientists noted the same in other chimp colonies. Without chewing, the animals weren't getting much nutritional benefit. So why do it?

In 1996, biologist Michael Huffman suggested the chimps were self-medicating. Huffman, an American who has worked for years in Japan at the Primate Research Institute at Kyoto University, first saw a parasite-ridden, constipated chimpanzee in Tanzania chew on the leaves of a noxious plant it would normally avoid. By the next day, the chimpanzee was completely recovered (1).

The plants had bristly leaves, rough to the touch. Huffman theorized the chimps were swallowing the plants to take advantage of that roughness, using the leaves and stems to scour their intestines and rid themselves of parasites. Other researchers observed the same practice among other apes across Africa.

Huffman established widely used criteria for judging when an animal is self-medicating. First, the plant eaten cannot be a regular part of the animal's diet; it is used as medicine not food. Second, the plant must provide little or no nutritional value to the animal. Third, the plant must be consumed during those times of year—for example, the rainy season—when parasites are most likely to cause infections. Fourth, other animals in the group don't participate (2, 3). If the activity meets these standards, it is safe to assume the animal is self-medicating, Huffman says. Researchers have observed the practice in 25 regions involving 40 different plants.

In an effort to self-medicate, a bonobo female selects stem of a *M. fulvum* plant for stripping. Image courtesy of LuiKotale Bonobo Project, copyright Max Koelbl.

Coping with Parasites

The latest example of self-medication among the great apes comes from the deepest part of the Congo Basin and involves bonobos, sometimes called pygmy chimps. Barbara Fruth and her team from the Max Plank Institute for Evolutionary Anthropology in Leipzig, including her husband Gottfried Hohman, have been studying bonobos since 1990. Researchers sit quietly in the forest watching a particular colony of the animals and searching the ground below their living quarters for feces—science at its least glamorous. The feces hunt, however, has revealed how the bonobos cope with parasites.

Fruth's fieldwork took place over several weeks between October 2007 and June 2009. Her team studies a bonobo community on the fringes of Salonga National Park, about 25 kilometers from the nearest village. The researchers follow the bonobos on foot, sometimes crawling under vines or

Box 1. Neighborhood Pharmacy

A wide range of animals self-prescribe the plants around them when they need a remedy.

- Bears, deer, elk, and various carnivores, as well as great apes, are known to consume medicinal plants apparently to self-medicate.
- Some lizards are believed to respond to a bite by a venomous snake by eating a certain root to counter the venom.
- Baboons in Ethiopia eat the leaves of a plant to combat the flatworms that cause schistosomiasis.
- Fruit flies lay eggs in plants containing high ethanol levels when they detect parasitoid wasps, a way of protecting their offspring.
- Red and green macaws, along with many animals, eat clay to aid digestion and kill bacteria.
- Female woolly spider monkeys in Brazil add plants to their diet to increase or decrease their fertility.
- Pregnant lemurs in Madagascar nibble on tamarind and fig leaves and bark to aid in milk production, kill parasites, and increase the chances of a successful birth.
- Pregnant elephants in Kenya eat the leaves of some trees to induce delivery.

wading through a swamp to follow. They generally stay at least seven meters from the animals, wearing masks to prevent human infections from spreading to the apes. Fruth watches with a good pair of Leica binoculars.

One of the plants Fruth saw the bonobos eat was *Manniophyton fulvum*, a shrub used by local humans to make animal traps. Sitting in the forest, watching and recording, even counting bites per minute, Fruth and her colleagues saw the bonobos take a leaf or stem from the *M. fulvum* and rest it flat on their tongues. The animals would layer the leaves on their tongues, produce saliva, and fold the leaves back, forming a ball while avoiding their lips [contact with the skin causes itching and sores (4)]. The bonobos eventually swallowed without chewing. The researchers saw it happen 56 times, according to their 2013 report in the online *American Journal of Primatology* (2).

The plant is not, Fruth points out, part of the bonobos' regular diet. They ingested the leaves mostly when the weather was prime for parasites. The practice fits four of Huffman's criteria.

The bonobos sleep in the trees and defecate in the early morning from their high perches. The morning after they observed the leaf swallowing, the researchers collected 694 piles of feces that had dropped to the ground.

Huffman's theory is that apes use the leaves as sandpaper to scour the parasites and speed elimination. The hairs on the outside of the leaves are made of rigid silica, and the apes eliminate it in six hours. Fruth thinks there's more to it, at least for the bonobos. Her team didn't see elimination speed up. Twenty-four hours later, the apes were still excreting leaves. She thinks of the packet of leaves as a time-release capsule with a medicinal, as well as scouring, effect.

"If you have something in your intestine for 24 hours and it does not accelerate your intestinal passage time, then you have to ask, what is it needed for and why is it swallowed entirely?" Fruth says. She hypothesizes that the bonobos make a package out of the plant to preserve it so it works farther down in the intestines.

Fruth thinks the leaves may also heal wounds caused by parasites and possibly have anti-inflammatory benefits. She hasn't yet determined the possible parasite culprit.

Across Africa, humans use the plant as suppositories, enemas, and as a treatment for hemorrhoids. Huffman suggests that if humans and great apes use the same medicinal plants, maybe early hominids did as well.

A Learned Behavior?

The obvious question is how do the animals—some of them not noted for intelligence—learn to do this? How did sparrows and finches learn to collect nicotine-heavy cigarette butts to reduce mite infections in their nests? How do honey bees and wood ants know to line their nests with resin to combat bacteria (5, 6)?

Some of the adaptations to self-medication are recent. The widespread collecting of cigarette butts must be less than 100 years old because cigarettes aren't much older. Other adaptations, however, are part of a long evolutionary process.

A simplistic explanation goes this way: one day a couple of million years ago, an animal, say a gorilla, had a stomach ache. For reasons unknown, he or she grabbed a leaf, chewed on it or swallowed it, and felt better. The animal remembered the action, and went to the same plant whenever the stomach ache returned.

It's a reasonable scenario, says Mark Hunter, a professor of ecology and environmental biology at the University of Michigan. Learning these practices can be either innate or behavioral, or both. Apes, being intelligent creatures, certainly pass their knowledge on to their progeny. They are always watching each other and can communicate both vocally and through gestures, so their children watch as they treat themselves: active learning. However, there is innate learning as well.

"You should never underestimate the power of natural selection," Hunter says. "It does not take a smart organism to develop an instinctive behavior." There could be a genetic variation that leads the gorilla to taste a plant it does not normally eat, and eating the plant makes it healthier. The gorillas with that genetic background live longer and have more progeny and no real thought goes into it. "That level of learning might operate with other kinds of organisms too," he says.

Take the monarch butterfly that lays its eggs on milkweed, which has antiparasite effects. "All we have to do is look at a healthy monarch butterfly and a sick monarch butterfly," says Jacobus de Roode, assistant professor of biology at Emory University, who specializes in the beautiful creatures. "Now, a sick monarch butterfly is really affected by these parasites. The parasites bore little holes in the abdomen, and she will lose some of her bodily fluids and doesn't feel good." The changes in her physiology can change the way she responds to smells of the vegetation around her and she may have a genetic preference for these that would do her good.

"She doesn't have to be aware of that," de Roode says. That genetic proclivity to healing plants means her offspring are likely to have it as well and will have a higher survival rate, so it will pass onto the next generation, de Roode explains. The behavior is in the genes (6).

The scientists researching zoopharmacognosy are convinced that humans can learn from the animals, particularly in finding new medications. Much of folk medicine, particularly in the undeveloped world, likely came from medicine men watching animals self-medicate, and in the case of the plant used by the bonobos, what they saw works. Huffman knows cases of medicine men deliberately studying animals for clues for treating their patients.

The monarch's milkweed, for example, appears to have antiparasite powers, and may be worth further study. Researchers have shown that the butterflies use milkweed chemicals called cardenolides to fend off a parasite called *Ophryocystis elektroscirrha* (7). Cardenolides are already used to relieve pain and as an aid to treating asthma (8).

Animals use other plants that can combat schistosomiasis, plasmodium, and leishmania, all terrible human afflictions, and some medicines have been derived from them (9). "If we can learn from animals that have used medicinal plants for millions of years, and then look at what they use it for, then we could learn interesting things," de Roode says.

1 Huffman M (1997) Current evidence for self-medication in primates: A multidisciplinary perspective. *Yearb Phys Anthropol* 104(suppl 25):171–200.
2 Fruth B, et al. (2014) New evidence for self-medication in bonobos: *Manniophyton fulvum* leaf- and stemstrip-swallowing from LuiKotale, Salonga National Park, DR Congo. *Am J Primatol* 76(2): 146–158.
3 Tedx Osaka (2012) Michael Huffman—Animal self-medication. Available at www.youtube.com/watch?v=WNn7b5VHowM. Accessed November 4, 2014.
4 Manniophyton fulvum Müll.Arg. Prota4u (Plant Resources of Tropical Africa). Available at www.prota4u.info/protav8.asp?h=M4&t=Manniophyton&p=Manniophyton+fulvum. Accessed November 4, 2014.
5 Simone-Finstrom MD, Spivak M (2012) Increased resin collection after parasite challenge: A case of self-medication in honey bees? *PLoS ONE* 7(3):e34601.
6 de Roode JC, Lefèvre T, Hunter MD (2013) Ecology. Self-medication in animals. *Science* 340(6129):150–151.
7 Lefèvre T, et al. (2010) Evidence for trans-generational medication in nature. *Ecology Letters* 13(12):1485–1493.
8 Nicholson D (2010) Monarch butterflies and humans both utilize milkweed's medical properties. Available at www.examiner.com/article/monarch-butterflies-and-humans-both-utilize-milkweed-s-medical-properties. Accessed November 4, 2014.
9 Allegretti SM, et al. (2012) The use of Brazilian medicinal plants to combat *Schistosoma mansoni*. *Schistosomiasis*, ed Bagher Rokni M. Available at www.intechopen.com/download/get/type/pdfs/id/25967. Accessed November 4, 2014.