Glass-eating turtle fills unique niche

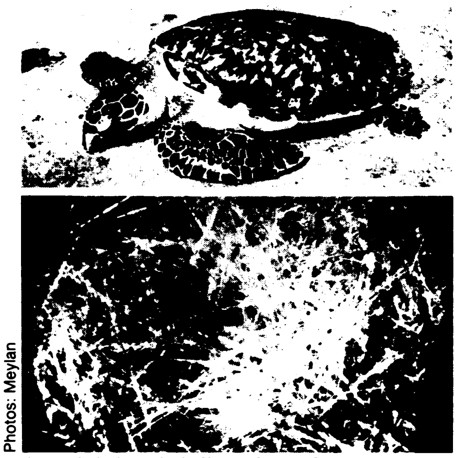
What weighs 250 pounds, lives on a diet of razor-sharp glass needles and is a sought-after entree at ceremonial dinners – even though those who eat it run the risk of dying the next day? The hawksbill turtle, *Eretmochelys imbricata*, is such a creature. But despite its willingness, in an evolutionary sense, to relegate itself to such an unenviable niche, the hawksbill is on the verge of extinction because its beautiful shell reaps a profit on the international market.

"It's really a spectacular animal in the flesh, it's a beautiful animal," says Anne Meylan, a researcher with the Department of Natural Resources in St. Petersburg, Fla., who has spent years looking into the turtle's unique natural history. In research appearing in the Jan. 22 SCIENCE, Meylan refutes earlier reports that the hawksbill is a relatively indiscriminate feeder. Rather, she finds the large marine turtle is a "dedicated spongivore," feeding almost exclusively on subtropical sponges that are unpalatable to other species because of their glass spines and poisonous secretions.

No comparable diet has been described in any other vertebrate, Meylan says. Examining the digestive-tract contents of 61 hawksbill carcasses caught by fishermen in the Caribbean, she found that sponges contributed more than 95 percent of the total dry mass of all digested food. Moreover, among the relatively few species that the turtle seems to prefer are some of the best-defended sponges known. These include the so-called demosponges that are made mostly of silica-rich needles, or spicules – many of them equipped with hooks and barbs. The spicules are made of a hydrated, amorphous form of silica that is similar to opal, a type of glass.

Nobody knows how the hawksbill digests such vitreous vittles. Its digestive tract is typically full of glass shards "that go right through your skin," making autopsies a potentially painful affair for researchers, Meylan told SCIENCE NEWS. She notes that some sponge-eating fish coat their food with mucus and certain marine invertebrates have specialized organs that compact spicules into innocuous bundles. No such features have been identified in the hawksbill, however, nor are its digestive tract walls thicker than those of other turtles. The turtle's feces, which are "concentrated into pretty solid glass," are "incredibly abrasive," she adds. "It's pretty frightening."

The hawksbill seems equally unperturbed by the poisons – neurotoxins, blood-destroying compounds and other metabolic blockers – that are found in some of its favorite sponges. "There are many types of poisons in these sponges,



Photos: Meylan

An adult hawksbill turtle and a photomicrograph of dried intestinal contents, primarily siliceous sponge spicules.

and we don't know how the turtle deals with them," Meylan says. "We don't know if they concentrate them or how they detoxify them." There's a possibility, however, that concentrations of sponge poisons in the turtle's flesh might explain a series of deaths that have been reported over the years among tropical islanders who have eaten the turtles during ceremonies.

"The turtle is used in a lot of these villages in the South Pacific for feasts, when a lot of people will eat from the same turtle. And then the next day so many people would be dead, so many people would be in the hospital," Meylan says. But hawksbills usually are not toxic, she adds, and it is not clear why they occasionally are. She says it's possible that some hawksbills have defective livers that are not properly detoxifying the poisons. Alternatively, it may be that some hawksbills have been contaminated with poisonous algae that often live in close association with subtropical sponges.

Because of their unique ability to harvest such well-defended foods, hawksbills may be important links in the delicate ecology of coral reefs, Meylan says. Other marine animals appear to benefit from the "leftovers" exposed by the hawksbill's activities. And the natural process of ecological succession, through which an ecological community "matures," may be significantly influenced by the turtle's activities.

Meylan notes that many of the world's reefs are deteriorating – in part because of human activities – thus adding to the pressures that already endanger the hawksbill. Of seven species of marine turtles in the world, five are ranked internationally as endangered, with the hawksbill considered the second most endangered. The hard, thin epidermal layer covering its bony shell is prized for its durability and beauty, and is used to make jewelry, trinkets and Japanese ceremonial wedding combs. *– R. Weiss*

The curious power of large numbers

Sometimes it takes more than 200 years and the help of a computer to solve a mathematics problem. In 1769, Leonhard Euler, while thinking about a problem now known as Fermat's last theorem (SN: 6/20/87, p.397), proposed that no set of positive integers, a, b, c and d, satisfies the equation $a^4 + b^4 + c^4 = d^4$ in the same way that numbers such as 3, 4 and 5 satisfy the more familiar equation $x^2 + y^2 = z^2$. Euler's guess seemed reasonable because Pierre de Fermat, a century earlier, had proved that the simpler equation $a^4 + b^4 = c^4$ had no positive integer solutions.

Last summer, mathematician Noam D. Elkies of Harvard University found the first counterexample that proved Euler's conjecture was wrong. In other words, he found that the equation is true if a = 2,682,440, b = 15,365,639, c = 18,796,760 and d = 20,615,673. More recently, computer programmer Roger Frye of Thinking Machines Corp. in Cambridge, Mass., succeeded in finding the smallest positive integers that fit the equation. His exhaustive computer search showed that a = 95,800, b = 217,519, c = 414,560 and d = 422,560.

"I found my counterexample by a method that combined theoretical reasoning and a relatively short computer search," says Elkies. He converted the problem into an equivalent mathematical form that enabled him to pick out candidates likely to satisfy Euler's equation. A few other mathematicians had tried a similar approach, says Elkies, but either they gave up too soon or they were thinking in terms of proving rather than disproving the conjecture.

Once Elkies found the first counterexample, he was able to prove that there are infinitely many, each consisting of enormously large numbers. What Elkies didn't know yet was whether his initial solution was the smallest one.

Frye saw news of Elkies's achievement on a computer network bulletin board. Using hints supplied by Elkies to shorten the search, he wrote a computer program to look for smaller solutions. Working at night in his spare time, Frye used 110 hours of computer time on various Connection Machine computers before he was satisfied with the result.

No one knows whether another set of numbers, somewhere between those found by Frye and those discovered by Elkies, fits Euler's equation. "I've gone up to a million and not found a second set," says Frye. At that stage, the search begins to gobble up an excessive amount of computer time. Possible answers, although there are an infinite number of them, seem to be sparsely distributed.

– I. Peterson