Where Have All the Froggies Gone?

It has taken a decade, but herpetologists are hopping up and down about declining amphibian populations

IN THE PUBS OF CANTERBURY last September, there was some talk of a kind that isn't often heard in that English setting. Then again, the talkers weren't the usual denizens of Canterbury pubs. They were researchers attending the first World Congress of Herpetology, and their conversation was dominated by the fact that many of the frogs, toads, and other amphibians they study seemed to be vanishing before their eyes.

Indeed, the disappearing act dated back to the late 1970s and occurred almost simultaneously in points widely dispersed across the globe. Could a single cause be to blame? For most of the 1980s that idea simply didn't catch on. The reason, according to David Wake, director of the Museum of Vertebrate Zoology at the University of California at Berkeley, who was there in Canterbury, is that his fellow herpetologists are a "crusty bunch," who often work in isolation and are "very slow to push the panic button."

But at Canterbury, Wake had heard enough. When he got back to the United States he set about convincing the Biology Board of the National Research Council, of which he is a member, to hold a workshop on the amphibian declines—a meeting held last week in Irvine, California, which brought together experts in ecology, amphibian physiology, and global change to hear the disturbing reports from field biologists and decide what ought to be done by way of research and policy. The workshop focused on two key questions: Are the declines real? Do they have a single, global cause, such as the greenhouse effect or decreases in the ozone layer?

The answer to the first question seems to be yes. Even those who were previously skeptical appear to have been convinced by the tales told at the workshop. One self-admitted skeptic, Duke University ecologist Henry Wilbur, said: "The data are anecdotal, but it's so well repeated they certainly are believable."

And what were the anecdotes that persuaded the skeptics? Among them:

■ Wake himself told the story of returning to one of his favorite haunts for studying salamanders, a pine forest near Oaxaca, Mexico, in the early 1980s. A decade earlier the inch-long local salamanders had been abundant there: 80 or more often turned up under the bark of a single log. But when Wake and his colleagues returned, they got a shock. "We found . . . maybe one or two after searching all day."

Michael Fogden

Disappearing act. *The golden toad is in danger of vanishing from its tiny habitat in Costa Rica's Monteverde Cloud Forest Preserve.*

■ Until 1979, frogs were abundant and diverse at the University of Sao Paolo's field station at Boracea, Brazil, according to Stanley Rand of the Smithsonian Tropical Research Institute. But when Rand returned to Boracea in 1982, of 30 common frog species, 6 had disappeared completely and 7 had undergone dramatic decreases.

■ In 1974 Michael Tyler of the University of Adelaide, Australia, described a newly discovered frog species that broods its young in its stomach. The frog was once so common "an agile collector could have picked up 100 in a single night," Tyler says. By 1980 it had completely disappeared from its habitat (a 100-square-kilometer area in the Conondale Ranges, 100 miles north of Brisbane). It has not been seen since.

■ The spectacularly colored golden toad lives only in a 1/2-square-mile area of stunted forest near the continental divide in Costa Rica's pristine Monteverde Cloud Forest Preserve. In the early 1980s Marc Hayes of the University of Miami typically saw 500 to 700 males at one of the species' two or three known breeding sites. Since 1984 that site has never had more than a dozen males. At another site biologist Martha Crump observed 1000 males in 1987—but only one lone survivor in 1988 and another in 1989.

■ In the Rocky Mountains of Colorado and Wyoming, boreal toads used to be so abundant that "you had to kick them out of the way as you were walking down the trail," says Paul S. Corn of the U.S. Fish and Wildlife Service. Now they are difficult to find.

But if agreeing the declines are real was not difficult, achieving consensus on whether there is a single cause (and if so, what that cause might be) was problematic. One difficulty lies in sorting out a mass of local conditions that might have caused the declines. For example, Rand, who described the decline of frogs at Boracea, believes the crucial event there was a rare hard frost—of an intensity experienced only once a century—that took place in the winter of 1979.

In other cases the immediate cause may be acid rain. John Harte of UC Berkeley reported that tiger salamanders seem to be declining in some lakes in the Colorado Rockies because their eggs are sensitive to the influx of acidic water from melting snow that hits the lakes each spring just as the eggs are developing. Richard Wassersug of Dalhousie University in Halifax pointed out that while other species of frogs and toads decline in North America, the wood frog, known to be particularly tolerant of acid conditions, is doing well.

In some instances the precipitating event is not so clear. Tyler says he has ruled out over-collecting by herpetologists, pollution by logging or gold-panning, and drought as causes for the disappearance of the gastric-brooding frog. And Hayes is mystified by the demise of the golden toad. Illicit collection of the toads for sale as pets, which was a problem in the 1970s, was curbed before the decline began.

But whether the immediate cause is obvious or not, it is possible that all the observed declines are simply coincidental, resulting from the simultaneous appearance of adverse local conditions at the same time in the

1970s. And that is just what some people suspect. "I think there is a loss of amphibians," said ecologist James McMahon of Utah State University, who was invited to the workshop as a critic, "but whether there is one major, nefarious, worldwide, unknown factor is not so clear. It looks like a lot of individual factors."

McMahon, along with others, believes that the destruction of natural habitats, which affects many types of plants and animals other than amphibians, may be a significant factor in the amphibian declines. "Amphibian species are going extinct, but so is everything else," McMahon said.

"[Amphibians] were here when the dinosaurs were here, and [they] survived the age of mammals. They are tough survivors. If they're checking out now, I think it is significant."

—David Wake

Wilbur agreed that "habitat destruction is clearly the dominant thing going on." But he added that it's "not the whole story, because we have a lot of pristine areas where [amphibian] populations are going down the tubes as well."

Indeed, news that amphibians are disappearing from nature preserves where there is little human perturbation is what many herpetologists find most alarming. Such evidence suggests to some herpetologists, Wake included, that there is a single, unitary cause of the many observed declines. "I am personally dubious of any proximal explanation," he says. "[Amphibians] were here when the dinosaurs were here, and [they] survived the age of mammals. They are tough survivors. If they're checking out now, I think it is significant."

One thing that makes it plausible to see amphibians as global "canaries in a coal mine" is that they are likely, in a physiological sense, to be good early indicators of environmental decay. Their skin is permeable to airborne gases, they live on both land and water at different stages of their life, and they are high in the food chain. In addition, amphibians have been relatively well studied and all their life stages are amenable to experimentation.

But if amphibians are indicating the early stages of some significant global change, what might that change be? None of the possibilities raised at the workshop seems like a single satisfactory explanation. One possible culprit that was discussed is an increase in ultraviolet (UV) radiation. It has been suggested that a reduction in the ozone layer might lead to increases in UV radiation (to which amphibian embryos are known to be sensitive). But that hypothesis breaks down, Harte says, because although ozone levels have fallen in the past decade, the predicted increase in UV radiation has not been observed.

In the absence of a full consensus, both believers and skeptics at the workshop agreed on one thing: the need for more data. One of the most crippling problems in studying amphibian declines is a dearth of historical data on the size of amphibian populations. Without these baselines, normal fluctuations could easily be interpreted as population declines. To deal with the problem, the workshop recommended reviewing old studies and museum records and revisiting sites for which good population data have been collected.

They also stressed the need for long-term studies of amphibian populations that are declining or have characteristics that would make them good indicators (such as living in harsh habitats that push their tolerance to its limits). The participants drew up lists of the kind of data that should be collected to supplement population surveys, including environmental chemistry, bioassays on the animals present, and pathology and toxicology on dead animals.

But McMahon cautioned that while long-term studies are valuable, they may be a luxury science cannot afford. "We don't have much time to do this," he said. "By the time we can get enough data, the problem may be past us and unsolvable." For that reason he urged researchers to come up with short-term experiments. For example, if an amphibian species has recently disappeared from a habitat, he suggested reintroducing it and intensively studying its fate.

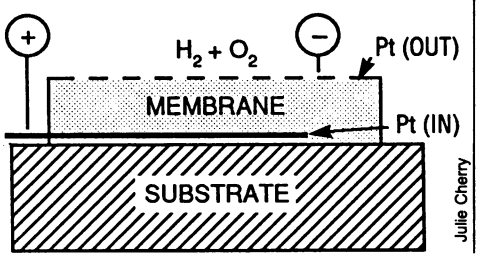
It is not yet clear whether the Irvine workshop will spur the National Research Council to investigate the significance of the amphibian data and produce a report. Even if it does, some other agency will have to pick up the ball and fund the necessary studies. Tired of the perennial struggle for funding, Michael Soule of UC Santa Cruz, expressed hope that such a report could set the wheels in motion for the creation of a new agency, public or private, to provide reliable funding for long-term biodiversity research.

■ MARCIA BARINAGA

Electricity by Serendipity

Christopher Dyer wasn't trying to invent a new type of fuel cell. "It was one of those things that just happen," he says. But the electrochemist at Bell Communications Research in Morristown, New Jersey, discovered a previously unknown way to coax electrical energy from oxygen and hydrogen while trying to build a miniature battery. The new fuel cell may make possible a number of applications, including such things as on-board power supplies for integrated circuits and small generators for portable phones.

Originally, Dyer says, he was experimenting with a battery that contained a palladium electrode and a platinum electrode separated by a thin film. To charge the battery he exposed it to hydrogen gas, which gradually seeps into palladium and stays there. One time, however, he got careless and used hydrogen that had been contaminated with oxygen. The battery went haywire. "I found I got the potentials the wrong way around, and it was a much higher voltage than I expected," Dyer says. Intrigued, he experimented with the device and found he had stumbled upon a method to make a fuel cell that worked in a fundamentally new way.



Julie Cherry

Fuel cells, which convert chemical energy directly into electrical energy, generally must keep their two fuels separate. The hydrogen/oxygen fuel cells used on spacecraft, for instance, have two electrodes which lie on opposite sides of a liquid electrolyte, and hydrogen is directed at one electrode while oxygen is piped to the other. A voltage is created between the two electrodes as hydrogen atoms at the first electrode give up their electrons, while oxygen atoms at the other electrode take up electrons. If the two gases are allowed to mix, the voltage disappears because the electrodes no longer sit in different atmospheres.

But Dyer discovered, serendipitously, how to make fuel cells that can function in a mixed hydrogen/oxygen atmosphere and thus avoid the complications associated with