ECOLOGY

Deformed Frogs Leap Into Spotlight at Health Workshop

RESEARCH TRIANGLE PARK, NORTH CAROLINA—When rumors of malformed frogs in America's northern Great Plains started circulating a few years ago, most wildlife scientists sang the same sad tune: The abnormalities, like the worldwide decline in amphibian numbers that gained attention in the mid-1980s, suggested an early warning of environmental deterioration. But soon after scientists began wading into lakes and wetlands to hunt for a cause of the malformations, the tune dissolved into dissonance. From similar field and lab data, three now hotly contested theories have emerged: Depending on who you listen to, the main culprit is either a parasite, ultraviolet radiation, or an environmental chemical.

To help determine whether what's hurting the frogs could hurt people too, and to perhaps defuse some of the tension, the National Institute of Environmental Health Sciences (NIEHS) held a workshop here last week to take a critical look at data that have been debated in the press long before they could reach the scientific journals. "I have never seen a scientific or biological phenomenon grow so fast with so few publications," says Stanley Sessions, an amphibian researcher at Hartwick College in Oneonta, New York. By the time the workshop ended, however, it was clear that far more questions than answers remain. Some frog researchers even argue that the alarm could be much ado about nothing: No one knows whether abnormalities are truly on the rise or if people have just become more assiduous at finding and reporting them. As Greg Hellyer of the Environmental Protection Agency's (EPA's) New England Regional Laboratory in Lexington, Massachusetts put it, "Is it a [real] phenomenon, or is it just because we're looking?"

Defects in Affected Vermont Northern Leopard Frogs July '97 Survey (n = 126)	
Missing/partial hind	65.4 %
Missing/short digits	21.1 %
Missing/partial front	8.4 %
Other	4.2 %
Missing/abnormal eye	0.07 %

SOURCE: VERMONT AGENCY OF NATURAL RESOURCES

The hullabaloo began in August 1995, when some Minnesota schoolchildren found dozens of multilegged and misshapen leopard frogs in a farm wetland. A couple of years earlier, state officials had looked into a report of malformed frogs, but after news broke nationwide of the children's cache, reports of misshapen frogs began pouring in from all over. Scientists reported that in some ponds and lakes, the rate of malformations ran as high as 67% of frogs surveyed; overall, in Minnesota, Quebec, and Vermont, about 8% of frogs sampled (mainly northern leopard frogs, but also other species) appear to be afflicted with abnormalities—most often missing or malformed hind limbs (see chart).

Among the first to weigh in with an explanation was Sessions, who had studied some salamanders and Pacific tree frogs with extra legs found in northern California in 1986. He and a colleague noticed that the amphibians' hind limbs were packed with encysted trematodes, parasitic flatworms that burrow into amphibians. The researchers found that when they embedded plastic beads—meant to resemble cysts—in the limbs of developing frogs and salamanders, the limbs would sometimes split and form two. Sessions thinks natural, sporadic peaks in populations of pond snails, the trematodes' primary host, may explain the apparent rise in deformed frogs.

"I'm quite satisfied that the parasite hypothesis does a lot of the work for us" in explaining the extra limbs being reported, says herpetologist David Wake, director of the University of California, Berkeley's Museum of Vertebrate Zoology. But many experts are unconvinced, noting that abnormal frogs in Minnesota and Vermont are no more likely to have cysts than normal ones. Sessions suggests, however, that cysts may disappear as a young frog's immune system develops and eventually destroys the parasite.

Other researchers have fingered a different culprit, the increase in ultraviolet B (UVB) light reaching Earth's surface because of the thinning ozone layer. UVB light, the theory goes, could be damaging amphibian embryo DNA, resulting in abnormalities during metamorphosis; it could also be transforming pesticides into teratogens, chemicals that can interfere with development and cause birth defects. Scientists at EPA's Mid-Continent Ecology Division in Duluth have reported at recent meetings that northern leopard frog embryos develop abnormalities—including deformed and missing limbs—after being exposed to about 30% of natural UVB levels for at least 24 days, according to EPA's Gary Ankley. "We wouldn't say it explains what happens in the field, but it's similar enough that we think it deserves further study," he says.

JUDY HELGEN/MINNESOTA POLLUTION CONTROL AGENCY

Whodunnit. Victim of new environmental scourge or of a mere predator?

This theory was strengthened earlier this month when new findings suggested that UVB rays can indeed penetrate the murk of the average North American pond and cause developmental changes. A team led by ecologist Andrew Blaustein of Oregon State University in Corvallis reported in the *Proceedings of the National Academy of Sciences* that long-toed salamander eggs in pond water exposed to the sun are more likely than those shielded from UVB to develop abnormalities such as edema—fluid-filled areas under the skin—and bent tails.

A third possibility is that certain watersheds may harbor an unidentified teratogen, presumably an environmental contaminant. Some scientists suspect retinoids, a class of chemicals including vitamin A that tell embryo cells to grow. Experiments have shown that retinoids can cause limb malformations in frogs. One candidate might be an insecticide such as Methoprene, a retinoid mimic widely used to kill mosquitoes.

A potential waterborne threat has grabbed the most headlines so far. Last September, NIEHS and the Minnesota Pollution Control Agency issued a press release detailing unpublished findings that water from two Minnesota ponds with abnormal frogs caused embryos of the African clawed frog to develop abnormally in the test tube. The findings were particularly alarming, as some Minnesota families draw their drinking water from the ponds. Although standard tests found the water safe to drink, the state offered bottled water to these families.

Other scientists assailed these provocative claims. Some questioned the relevance of abnormalities in African frogs to those in their far-removed Minnesota kin. And EPA-Duluth scientists argued that the NIEHS team had overlooked a technical point: African frog embryos won't grow in ordinary water unless certain salts are added. The

NIEHS group, they charged, had failed to correct natural ion imbalances in the Minnesota well water. When EPA scientists repeated the experiment after adding the ions to one site's water, they say, embryos developed normally.

But at the meeting, the NIEHS's Jim Burkhart said his team also performed the assay after adding back the ions, and the embryos still developed abnormally. He and his colleagues also presented data at the workshop showing that when organic compounds and metals were filtered out of the Minnesota water, it caused fewer deformities. NIEHS toxicologist George Lucier says his group has now independently tested water from 10 affected sites and from 10 reference sites, all but one in Minnesota, and found that the deformities appear only in water from the affected sites. "It's something in the water," concludes Lucier, adding that it's too early to say whether that something is natural—such as a plant steroid—or synthetic, such as a pesticide.

Some observers wonder whether the scale of the problem has been overblown. Experts note that naturalists have been reporting five-legged frogs and salamanders for at least 250 years. Yet it is difficult to know how common these abnormalities were in the past because museum collections tend to keep only scientifically interesting or pretty specimens. Without long-term monitoring, "there's virtually no way to figure out what the background levels are," says Smithsonian Institution ecologist Jamie Reaser.

Indeed, some ecologists suspect that normal predation attempts could spawn high background levels of deformity. Reaser says that in her fieldwork, she often notices tadpoles damaged by aquatic predators: "chunks taken out of tails, eyes damaged, legs damaged." Sessions adds that he has found that bullfrog tadpoles bred in cramped quarters will nibble off each other's limbs. As for the 1600-and-counting confirmed abnormalities since August 1995 compiled so far by the North American Reporting Center for Amphibian Malformations (www.npwrc.org/narcam), "I will not be surprised at all if it turns out this has been an enormous Chicken Little thing," says Sessions.

However, David Gardiner, a developmental biologist at the University of California, Irvine, disagrees. He recalls a family whose Minnesota farm he visited to collect water. As he was leaving, Gardiner says, a teenager remarked that his family is still waiting for an explanation. They are justifiably worried, he says, and "they'd like to figure this out." But that answer may be a long time in coming. Solving this puzzle, predicts Wake—who thinks multiple causes are at work—will be "a scientific nightmare."

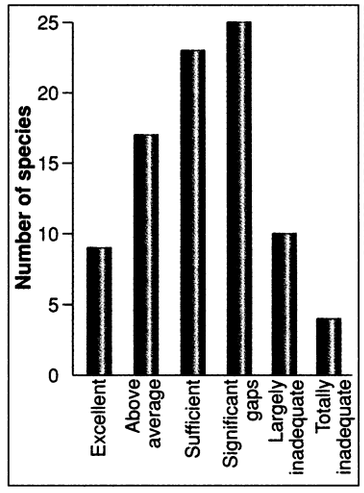
–Jocelyn Kaiser

ECOLOGY

Qualified Thumbs Up for Habitat Plan Science

SANTA BARBARA, CALIFORNIA—For 2 months earlier this fall, University of Washington, Seattle, grad student Amanda Stanley sifted through reams of documents—from dense scientific articles to denser federal reports—bearing on the fate of northern spotted owls, marbled murrelets, and other imperiled icons of the Pacific Northwest. Her task was to assess the quality of the science underpinning the state of Washington's 1996 plan to protect these species while allowing some logging on the state's land. Sound like a nightmarish grad school assignment? "I had no idea what I was getting into," Stanley admits.

The slogging was no mere academic exercise: Stanley was one of 106 grad students from eight universities who played a role in one of the most unusual ecological studies ever undertaken. Led by Peter Kareiva of the University of Washington and 12 other ecologists, the students last week completed an initial assessment of the science behind a divisive environmental policy tool: habitat-conservation plans (HCPs), agreements that allow developers to harm endangered species in return for specified efforts to protect habitat.



Critics rebuffed? HCPs did better than some assert at addressing habitat loss and other threats to species.

A growing chorus of environmentalists and scientists has argued that many HCPs—usually drafted by scientific consultants hired by landowners—are flawed and effectively promote extinction (*Science*, 13 June, p. 1636). But at a meeting here last week at the National Center for Ecological Analysis and Synthesis (NCEAS), Kareiva's group offered a different view: HCPs are far from the junk-science giveaways to developers depicted by their harshest critics. Although the group also reported that the plans are frequently plagued by inadequate monitoring and a lack of key data, the analysis puts HCPs in a better light. "What did surprise me," says meeting attendee Ron Pulliam of the University of Georgia in Athens, "was how well the science was used when it was available."

Created by a 1982 amendment to the Endangered Species Act (ESA), HCPs are meant to resolve conflicts between conservation and commercial interests. Because the ESA generally forbids harming listed species, it has led to frequent clashes between property owners and the U.S. Fish and Wildlife Service (FWS), which administers the act. The amendment gives landowners some leeway by allowing FWS to issue a permit for activities that harm a listed species. To receive a permit, developers must devise an HCP that will, "to the maximum extent practicable, minimize and mitigate the effects" on endangered species. The amendment was rarely used during the Reagan and Bush years; by 1992, only 11 HCPs had been signed.

That has changed. Since taking office in 1993, U.S. Interior Secretary Bruce Babbitt has championed HCPs, arguing that the amendment was the key to avoiding "environmental train wrecks" over endangered species. To make HCPs more attractive to landowners, Babbitt unveiled a "no surprises" policy 3 years ago, promising that "unforeseen circumstances"—for example, species being added to the endangered list that might trigger new protective steps—would generally not force modifications to existing HCPs. When a draft Senate ESA reauthorization bill with this change appeared last February, scientists and environmentalists were galvanized into scrutinizing the burgeoning HCP program, which now numbers more than 200 plans.

Most observers didn't like what they saw. The opening salvo came last April from nine well-known conservation biologists, led by Dennis Murphy of the University of Nevada, Reno, who charged that "many recent HCPs have been developed without adequate scientific guidance." A National Audubon Society task force drew similar conclusions soon after, claiming that a "disturbing number of HCPs are based upon questionable or risky scientific assumptions." The Administration, meanwhile, had few data supporting its rosier view. At a meeting on HCPs last April sponsored by the Environmental Defense Fund (EDF), Babbitt asked scientists to offer improvements to these controversial compromises.