lymphatic tissue, with the CD4s in the blood representing only about 2% of the total population. Several researchers at the meeting theorized that because HIV progressively destroys the architecture of the lymph nodes, it might also somehow lead the nodes to sequester more and more CD4s than they otherwise would.

Stanford University immunologist Mario Roederer said he believes redistribution is "a very strong possibility." Roederer has been studying how HIV alters the balance between "naive" T cells—ones that have never seen an invader—and "memory" T cells, which have memorized what an invader looks like and committed themselves to attacking it if they see it again. He has found that levels of naive CD4 cells drop much more precipitously in HIV-infected people than do those of memory CD4s. And, curiously, he found that naive CD8 cells—another key immune-system actor—drop in lockstep with naive CD4s, even though memory CD8 cells actually rise during an HIV infection. Because CD8s are not susceptible to HIV infection, Roederer concludes that the synchronized decline in naive CD4s and CD8s cannot be due to direct killing. He favors redistribution, and he also speculates that the loss of naive T cells might be linked to the fact that HIV destroys the thymus, which is where naive T cells are minted.

The University of California, San Francisco's, Jay Levy, a virologist who did not attend the Berkeley meeting, is glad these researchers are encouraging colleagues to reevaluate the Ho and Shaw papers and the role of direct killing. "[The papers] have value, absolutely," says Levy, who wrote a 106-page tome on HIV pathogenesis in the March 1993 *Microbiological Reviews* and believes indirect killing is key. "But I think they've been over-touted."

Levy hopes the alternative views will lead AIDS clinicians to broaden their thinking beyond anti-HIV drugs. Indeed, the treatment implications stemming from alternative HIV pathogenic mechanisms are many. If false signaling is a critical pathogenic mechanism, for example, then treatments should be aimed primarily at blocking signals. If specific HIV proteins prevent the apoptosis of HIV-infected cells, then those proteins should be targeted. Or if Roederer's hunch is right, perhaps it makes sense to do thymic transplants coupled with therapies that protect the new thymus.

While some of these ideas might seem far-out to AIDS researchers who are banking on anti-HIV drugs, no treatment, to date, has had much success. And unless that bleak reality changes, alternative thinkers will likely keep needling their establishment colleagues and urging them to rethink their basic understanding of the disease.

–Jon Cohen

MEETING BRIEFS

Ecologists Flock to Snowbird For Varied Banquet of Findings

SNOWBIRD, UTAH—About 2500 ecologists converged here from 30 July through 3 August for the largest meeting ever of the Ecological Society of America (ESA). The meeting's theme of the transdisciplinary nature of ecology included talks on such unusual topics as urban ecology and fisheries economics. But there was also plenty of solid ecological fare on tropical forests and evolution.

Forest Fragments Favor Frogs

One of the most common landscape alterations in the world today is the conversion of continuous forest into a patchwork of forest fragments surrounded by pasture, farmland, and secondary growth. Ecologists have warned for years that such fragmentation not only wipes out the organisms that lose their habitat, but also harms those trying to survive in the fragments.

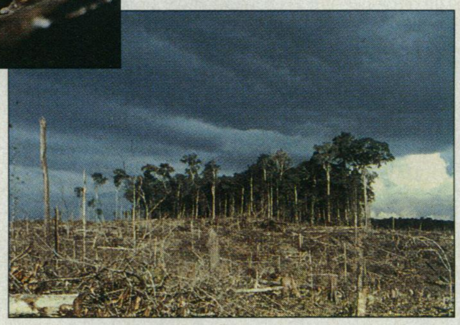

W. HODL AND M. TOCHER

So it comes as a surprise to find that in a 10-year experiment in the Brazilian Amazon, frogs—a group thought to be sensitive to disturbance—actually became more diverse after patches of forest were isolated. Results presented at the meeting by Mandy Tocher of the University of Canterbury in Christchurch, New Zealand, showed that in smaller forest patches, the number of frog species roughly doubled after isolation, with an average of 10 new species entering each patch. Frog breeding showed no obvious decline, and only one of four species studied showed a drop in population. In sum, says co-author Barbara Zimmerman of Conservation International, after 7 years of isolation, frogs seemed to do just fine in forest fragments.

The new data haven't turned scientists into advocates of fragmentation. Indeed, the same experiment has shown that in other species, isolation leads to a severe loss of diversity. But this unexpected resilience in a group known to be in worldwide decline may be good news for conservation. The new data bolster the view that what's outside a reserve is crucial to the health of species inside. "Patches are rarely surrounded by completely nonforested areas," says Rob Bierregaard of the University of North Carolina, former field director of the project. "There's secondary growth outside, and it may serve some conservation purposes."

The frog data are part of the Biological Dynamics of Forest Fragments Project (BDFFP) near Manaus, Brazil, begun in 1979 by Tom Lovejoy, now of the Smithsonian Institution, and managed through the auspices of the Smithsonian and Brazil's National Institute for Research in Amazonia (INPA). Lovejoy wanted to find out how large a reserve must be to save the species in a given area, so he and colleagues marked off forest patches ranging in size from 1 to 100 hectares. Ranchers and farmers cleared surrounding land and isolated the patches, although tall secondary growth now adjoins some fragments.

Tocher presented 10 years of frog data, gathered before and after isolation by herself, Zimmerman, and co-author Claude Gascon of INPA, who coordinates the field operations of BDFFP. The researchers surveyed frogs by sight and sound (frog mating calls are distinctive), and also surveyed tadpoles in breeding ponds.


ROB BIERREGAARD / WWF

Tree-mendous diversity. Fragmentation of this Amazonian forest gave frogs a surprising boost.

Because Amazonian frogs typically have strict physiological and breeding requirements, researchers predicted lower frog diversity, abundance, and breeding success, especially in small fragments. But they were wrong. Although larger patches did have more diversity than smaller ones, all fragments had more frog species after isolation than before.

This is all the more surprising given that BDFFP and other experiments have already shown that isolation is usually bad for diversity. At the symposium, Gascon presented published and unpublished summary data from various BDFFP researchers showing a diversity decline after isolation in birds, beetles, bees, and wasps. Ecosystem processes were altered in fragments, too—wind damage was much higher, and decomposition was slower. Even species that presumably require only a small area, such as dung and carrion beetles, were hit hard by fragmentation.

Why did the frogs thrive? Researchers suspect that the land outside the fragments (which ecologists refer to as "the matrix") was hospitable to the amphibians, so that the "isolated" fragments weren't really fragments from the frogs' point of view. "We wouldn't have predicted seeing lots of frogs in pasture, but that's what we're finding," says Gascon. "They're moving through it and also even breeding there." This idea is supported by the fact that frog diversity was higher in patches surrounded by high and shady secondary growth, says Tocher. Similarly, butterflies increased after isolation because light-loving species flocked to the edges of the patch. And another BDFFP study showed that small-mammal diversity depended on the nature of the outside matrix, not on the size of the patch.

However, those at the meeting cautioned that the increase in frog diversity could be a temporary blip, caused by migration of frogs from cleared areas. "The weakness of the project is that the fragments are only about 15 years old. That time frame is pretty short," says Bill Laurance of Australia's CSIRO, who helped to arrange the symposium but doesn't work on this project.

The real import of the findings, researchers say, is the crucial role of the matrix and how it interacts with the ecology of different species. For example, few would have predicted that frogs but not bees would travel through pasture, says Bierregaard. "The question becomes, 'How permeable is the matrix to migration by key organisms?' " he says. His own work shows that most birds declined sharply after isolation. But certain types, such as those that follow army ants, were able to recolonize forest patches—if the patches were surrounded by secondary growth, not pasture. Although pristine forest still fosters more overall diversity than any kind of matrix, says Lovejoy, the good news is that for some species, the matrix may serve as a steppingstone to safety.

Mutual Satisfaction

Insects pollinate plants, and plants reward insects with nectar or other treats. It's obviously a good deal for both organisms, but how do such mutually beneficial relationships arise? Biologists once thought the answer lay in successive rounds of coevolution, in which each player gradually adapts to the other's needs. But at a symposium at ESA, Olle Pellmyr of Vanderbilt University and John Thompson of Washington State University offered evidence that chance and preexisting conditions may be more important than a long history of togetherness.

This work has general implications for the evolution of new traits, says Scott Armbruster of the University of Alaska, Fairbanks, who co-organized the symposium with Sharon Strauss of the University of California, Davis. "The take-home message is that co-opting existing functions is the key to the evolution of novelty," he says. "This has implications for how we view evolution more generally."

Pellmyr, Thompson, and co-workers study yucca plants and yucca moths, an extreme case of mutualism one remarked upon

OLLE PELLMYR

Double duty. Moths deposit eggs and pack pollen onto the yucca flower in a classic case of mutualism.

by Darwin himself. While most insects pollinate flowers passively, by accidentally transferring pollen, the yucca moth uses special tentacles to collect pollen from the male parts of yucca flowers and deposit it onto the female parts. The female moth lays her eggs in the flowers, so her offspring reap the rewards of her labor: The pollinated flowers develop fruits with seeds, which the caterpillars eat. Because the yucca has no other pollinators, this relationship is called obligate mutualism: Neither species can reproduce without the other's help.

The research team, which includes Jonathan Brown of Grinnell College and Richard Harrison of Cornell University, employed a combination of methods. They used mitochondrial DNA and morphological features to analyze the genealogy of the entire family that contains the yucca moths; this family, the Prodoxidae, contains an array of moths associated with a wide variety of plants. The researchers also did field research to identify several features crucial to the mutualism. For example, the moth must visit only a single yucca species in each locality to keep the pollen pure; to ensure that its offspring's survival is linked to pollination, the moth must lay its eggs in flowers. In addition, the caterpillars must leave enough yucca seeds uneaten to bring forth the next generation of plants. And, of course, the moth must actively pollinate the plant, which requires the evolution of tentacles.

Pellmyr and Thompson then mapped these key ecological traits onto the moth family tree. Because they knew the evolutionary history of the moths, and they knew which moths had the traits, they could infer the order in which these features evolved. A scenario that emphasizes coevolution would predict that the mutualistic traits appeared after the relationship between plant and moth was already established; the traits would then be honed by successive generations of interaction. "We had all assumed that with this level of specialization and mutual dependence, we would be looking at extensive coevolution," says Pellmyr.

Instead, they found that most of the key elements of the mutualism were present long before the yucca moth split off from its relatives—and long before the moth or its ancestors formed an intimate relationship with the yucca plant. Before the yucca moth evolved, other members of its family were already singling out one plant, laying eggs in flowers, and consuming only some of the plants' seeds. "These traits did not evolve in the moth after it started actively pollinating yucca plants," says Pellmyr. "They came first."

All this set the stage for the obligate mutualism itself to arise, which presumably happened after one of the ancestral moths colonized the yucca plant. This event was linked to the evolution of a single novel trait: active pollination and its attendant special tentacles. So only that trait could have been shaped by coevolution with the plant. Overall, the mutualism arose because of a chance combination of life history traits in the moth family, which predisposed the entire family for such a specialized relationship.

The new work adds to a slender file of ecological studies showing that such "preadaptation" is crucial to the origin of novel relationships, says Armbruster, whose own work has shown the importance of this in the evolution of a tropical vine and its pollinators and predators. In this view, "traits necessary to the relationship arise prior to the ecological association and are then co-opted," he explains. "The groundwork is in place, so that all it takes is a few minor changes."

Pellmyr also struck a blow to the yucca moth's status as a model mutualist by identifying two new groups of moth species that cheat—they lay eggs in the plant but don't bother to pollinate it. Each group evolved the cheating habit separately, which reinforces the main message, says Armbruster: Once the stage was set for cheaters, their origin was a relatively simple step—and so it was repeated. Indeed, says Pellmyr, these events support the theory that it's chance and preadaptation, not only coevolution, that are important in molding relationships among organisms.

–Elizabeth Culotta