Entomologists Wane as Insects Wax

Entomologists warn that their discipline is in decline, starved for funding and personnel, while problems caused by insects are growing

AMONG ENTOMOLOGISTS the story is something of a legend. It seems that in the early 1950s, shortly after DDT was introduced, a University of Illinois entomologist proclaimed that his discipline was about to become irrelevant. The new pesticide, he said, would eradicate all the insects whose damage to crops and to human health had made them objects of urgent study for so long. That was the kind of blithe optimism that prevailed in the early DDT era.

Four decades later, the tables have turned. DDT and its successors are more likely to be regarded as part of the problem. Efforts to control crop damage solely with pesticides have by and large failed and, in developing countries, insect-borne diseases remain as serious a threat as ever.

So nowadays entomologists, who study insects in the environment as a whole, are increasingly viewed as having the solutions to these problems. "Bugs are not going to inherit the earth," says Thomas Eisner of Cornell University. "They own it now. So we might as well make peace with the landlord."

That was the general theme of the 100th anniversary meeting of the Entomological Society of America, held at the Smithsonian Institution in late September. But the meeting also had an ominous sub-theme. Many leading entomologists took the occasion to warn that, just as demands on their discipline are increasing, some key areas are in a state of disrepair, weakened by two decades of low funding and competition from the "new biology." Genetic engineering, said Paul Ehrlich of Stanford University, while important for raising food production, is edging out other disciplines "which are even more crucial to the battle."

Similarly, changing fashions in biology have meant that systematics have been in a long-term decline. Yet people trained in insect classification are needed more urgently than ever to catalog tropical species that are disappearing rapidly as their habitats are destroyed.

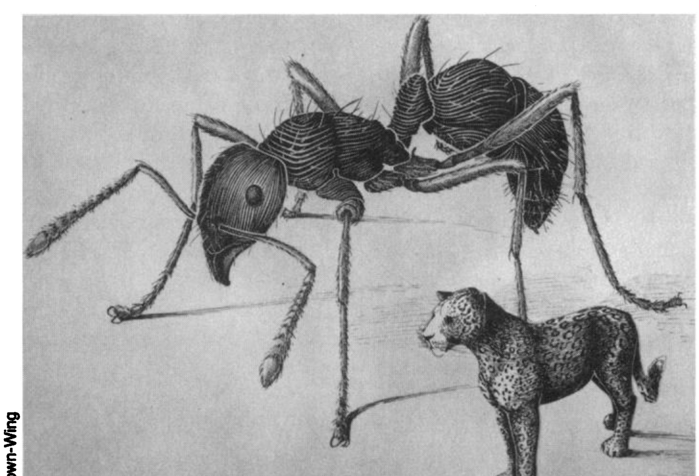
Indeed, Edward O. Wilson of Harvard University has been spending a great deal of his energy these days on advocating a "world biota survey" aimed at cataloging all the world's species before they vanish. Such a project, he says, "would be far less expensive and far more important for humanity than the human genome project, for example." Moreover, he adds, "the human genome is not going to disappear in the next 20 years." Wilson estimates that there are well over 10 million insect species, but only 750,000 have been identified so far.

A world biota survey would absorb the careers of 25,000 biologists, Wilson estimates, most of them entomologists. But he says there maybe only about 1000 people in the world capable of identifying insect species in the tropics, where most of them are.

Wilson's was not the only ambitious proposal discussed at the meeting. Eisner, who notes that "biological impoverishment is tantamount to chemical impoverishment," has been pressing for an activity he calls "chemical prospecting." He points out that many medically and economically important substances are derived from plants and microorganisms, the traditional sources of antibiotics and other drugs.

Eisner would expect similar spin-offs from a thorough study of insect species, which have been "short shrifted" in comparison. Insects, he points out, secrete a huge variety of substances for purposes of sex, food, and self-defense. For example, some millipedes emit a chemical related to Quaalude that can knock a spider out for hours. Centipede mothers spread a goo on their eggs that acts as a fungicide. Some beetles contain steroids that may lower the fecundity of predators. And firefly compounds have recently shown anti-DNA viral activity, a finding that could have relevance for diseases such as herpes.

Eisner therefore thinks insects hold the secrets for powerful new kinds of repellents, pesticides, and drugs, and he argues for large-scale surveys in tropical areas threatened by economic development.



Who runs the earth? *In this drawing, the ant represents the biomass of the ant population and the leopard the biomass of the total land vertebrate population in the Brazilian Amazon. The ants outweigh the vertebrates by about 4 to 1. The social insects (ants, termites, social wasps, and social bees), which make up about 80% of the insect biomass, outweigh the vertebrates by about 7 to 1, says Harvard's E. O. Wilson. More than 90% of insect species remain to be identified. "Perhaps in our study of ecology we have tended to look at the wrong organisms," Wilson suggests.*

The addresses to the symposium on agriculture and medicine were perhaps less visionary, but the needs are no less pressing. Robert Metcalf of the University of Illinois said the wholesale use of chemical pesticides is an approach whose time should be past. Although the amount of pesticide used on U.S. crops has increased greatly since World War II, Metcalf reported that annual crop losses to insects, which were 7% in the 1940s, rose to 13% in the 1980s.

That's partly because new hybrids are more susceptible to pests than the older, lower yielding varieties that were the results of natural selection. It's also because insects develop resistance to pesticides very quickly. According to Waldemar Klassen of the U.S. Department of Agriculture, 447 species of insects, ticks, and mites are now resistant to some or all pesticides.

The extent of the problem is "rather startling," Metcalf said. "It makes you think we're doing something wrong." What is

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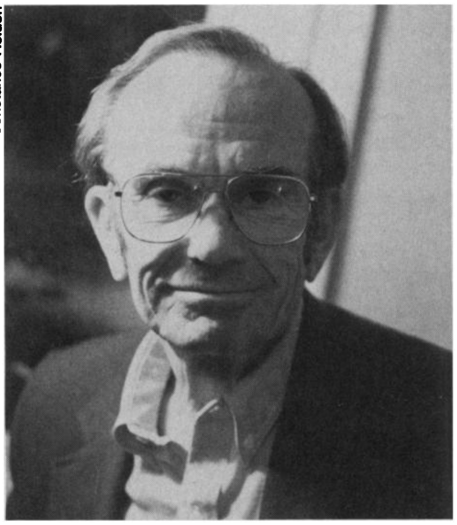

Thomas Eisner *proposes large-scale chemical prospecting in the tropics.*

needed, he said, are methods aimed not at wholesale eradication of insects but at selective inhibition based on knowledge of the insects' physiology, predators, and life cycle, an approach often called Integrated Pest Management.

Nor have pesticides eliminated insect-borne diseases, also in part because of the rapid development of resistance. "Insect vector diseases are killing more people today than ever," said Robert Gwadz of the National Institute on Allergy and Infectious Diseases. Malaria is on the rise again—in Africa it now causes 1 million deaths each year among children under 5. "DDT didn't eliminate malaria," Gwadz said ruefully, "but it did eliminate the malariologists."

Among other significant health threats transmitted by insects are onchocerciasis (river blindness), of which there are 40 million cases, mostly in West Africa, and filariasis (elephantiasis), of which there are now 400 million cases and which may be the world's fastest spreading disease. The main contribution of medical entomologists, Gwadz said, might be to tailor eradication programs based on evaluations of the specific relations among insect vectors, pathogens, and the human host. But Gwadz said, "more is known of the genetics and biology of *Drosophila* [the fruit fly used in medical research] than any other insect."

Tackling all these problems will clearly place enormous demands on the discipline of entomology. Yet research and training institutions do not appear to have produced a cadre of qualified people to meet the demand.

Until the mid-1970s, enrollments in entomology programs were healthy, but then they began to drop and some undergraduate programs were phased out. Although entomology has been rolled into biology departments, there has been a loss of "discipline identity," said Donald McLean of the University of Vermont.

The number of new Ph.D.'s in the field, averaging about 170 per year during the 1970s, fell to 123 in 1987 and 133 in 1988. (By way of contrast, annual production of Ph.D.'s in molecular biology has gone up from 136 in the 1970s to 362 in 1988, according to the Commission on Professionals in Science and Technology.)

Funding has also declined. The value of all research funds allocated to entomology by the USDA and the states has decreased by 28% since 1971 when federal and state funds were sufficient to support 755 full-time research workers. In 1988 the number was 541.

This decrease has had subtle and not-so-subtle effects. The direct result is a lack of qualified personnel. Gwadz, for example, says, "we've been forced to go outside the sphere of medical entomology and find people in other fields, such as genetics or physiology," to fill medical entomology fellowships in his unit. "These people can make valuable contributions in a specific area, but they never become medical entomologists in the full sense because they don't have that orientation or training."

The damage to insect taxonomy seems particularly severe. People are forgetting "the value of understanding a group of organisms for its own sake," says Wilson. Although insect collections in museums grew rapidly between 1976 and 1986, the number of Ph.D.'s working in them remained constant at about 110, according to the Association of Systematics Collections.

There also seems to have been a decline in insect taxonomists at land-grant universities, where many are concentrated, according to a recent survey by K. C. Kim of Pennsylvania State University. Says Wilson: "We've allowed insect taxonomy to decline to the point where it's going to be very tough to get it up to the needed level."

Wilson also sees a subtler problem relating to morale. One result of the general weakening of organismal and evolutionary biology, he says, is that "you get people who are less bold. I can't imagine a first-rate molecular biologist taking 'No' for an answer if he has a new idea in cancer research and he's looking for funding. But by now someone in insect taxonomy may be quite used to being told 'No.' "

How can these problems be corrected? Not surprisingly, each Centennial speaker has his own idea. Eisner envisions chemical prospecting as a collaboration among developing countries, universities, industry, and the banking community. Screening laboratories in developing countries might be fi-

Good News for Superconductors

What looked like a mountain 6 months ago now seems more like a molehill, as researchers from AT&T Bell Labs have found a way to mend a major problem with high-temperature superconductors. By irradiating a crystal of $YBa_2Cu_3O_7$ with neutrons, Bruce van Dover, Michael Gyorgy, and Lynn Schneemeyer increased 100-fold the amount of current the crystal could carry.

Although high-temperature superconductors have been touted for their commercial potential, they generally have been unable to carry enough current for many applications, such as magnets and electrical generators. Last spring, several researchers suggested that this flaw might be difficult or impossible to overcome (*Science*, 26 May, p. 914). The problem lay in the superconductors' flux lattices, which are quantized lines of magnetic flux that appear when the material is immersed in a magnetic field. Too much current passing through the superconductor causes the flux lines to move, creating resistance and destroying the superconductivity.

The solution, reported in the 2 November issue of *Nature*, was to put small defects into the superconductor by exposing it to high-energy neutrons. These defects snag the flux lines as they try to move past and pin the flux lattice in place, van Dover says. Before irradiation, the maximum current the Bell Labs crystal could carry without losing its superconductivity was 6,500 amperes per square centimeter at 77 K. After treatment, that jumped to 620,000 amperes per square centimeter.

Van Dover notes that the 100-fold improvement came in only one crystal, so Bell Labs researchers must learn how to do it consistently and optimally. Because the neutron enhancement method is not practical for commercial production, they will also be looking for different ways to produce the defects. And several other hurdles, such as the brittleness of the materials, still face commercial development of high-temperature superconductors. "This work doesn't mean applications are imminent," van Dover says. "It just means one problem can be solved." ■ ROBERT POOL nanced by "debt for nature" swaps that divert funds from debt payment to science. Additional money could come from profit-sharing agreements with, say, pharmaceutical companies. Some of the profits from new natural products would be reinvested in conserving natural habitat. "This is a treasure hunt in which part of the profit is put back into saving the treasure itself," Eisner says.

Metcalf thinks a way to prevent the dissipation of entomology's "core" skills would be the establishment of entomology institutes, within a university framework but free from the pressures of teaching. These, he says, would be better vehicles than university departments for conserving knowledge of specific groups of organisms. Such institutes would be "anchored at one end in agriculture and at the other in medical entomology" and would draw on many specialities in between. "But we ought to hurry," Metcalf says, "If we wait 10 years to do these things, we won't be any better off in 100 years than we are now."

Gwadz favors a program of training fellowships for medical entomologists that would make it possible for them to maintain an affiliation with a U.S. university while spending considerable time in the developing world. Gwadz has proposed such a program, funded by the U.S. Agency for International Development and administered by the National Institutes of Health. But, he says, AID wasn't interested.

Wilson takes a broader, cross-disciplinary point of view. "We need homeostatic devices," he says, "refugia, floors below which disciplines are not allowed to fall. This activity might be a function of the National Research Council conducting discipline surveys with a view to maintaining subsistence-level support for disciplines even when they appear to be wholly out of fashion. Then, when there is a scientific breakthrough or a sudden societal need, it will be possible to start up again quickly."

The picture is not entirely bleak. Eisner, for example, says that after many years of crying in the wilderness he now sees increased awareness of the problem on the part of private institutions—and even to some extent in the government—and more willingness to look for ways to finance projects related to biological surveys and chemical prospecting.

Nonetheless, the world of entomology faces the real danger of losing hard-won fundamental knowledge in the excitement of learning and applying remarkable new techniques. And the problems of food, disease, and species extinction mean that the time for resolving these issues is short.

■ CONSTANCE HOLDEN

Neuroscientists Track Nerve Development

Last week more than 12,000 researchers descended on Phoenix, Arizona, for the annual meeting of the Society for Neuroscience—a striking testament to the growth and vitality of their chosen field of endeavor. Some of the symposia provided new insights into the fundamental problems of nerve cell regeneration and development.

A Piece of the Nerve Regeneration Puzzle

Peripheral nerves, such as those in the arms and legs, will grow back after an injury. But severed spinal cord nerves will not. The $64,000 question is why not. Martin Schwab and his colleagues at the University of Zurich, Switzerland, may have found part of the answer. The new information may aid the search for ways to spark nerve regeneration in people who have suffered spinal cord injuries.

Work with rats suggests, the Zurich researchers say, that spinal neurons are unable to regenerate because their growth is inhibited by two related proteins present in the fatty myelin sheath surrounding them. In contrast, myelin from the animals' peripheral nerves lacks both the proteins and the growth-inhibitory activity. The activity is also lacking, Schwab told *Science*, in the myelin of lower vertebrates such as fish, whose spinal neurons regenerate following injury.

Schwab presented recent results indicating that partial spinal nerve regeneration can take place if the inhibitory proteins are either absent or inactivated. The researchers found that some spinal neurons would grow back in rats in which the proteins had been neutralized by antibodies or eliminated by killing the myelin-producing cells.

But this news does not mean the problem of nerve regeneration has been solved. The number of neurons that grew back was small, probably because the inhibitory proteins are only one of several impediments to

Animal Activism 101

"We're here to confront one of the most important issues our society is dealing with." So said David Hubel, president of the Society for Neuroscience, when he opened one of the best attended sessions at last week's neuroscience meeting in Phoenix.

Nearly 1000 neuroscientists had packed the lecture hall to get some practical advice on how to combat attacks by animal activists. They heard from two of their colleagues, Rick Van Sluyters of the University of California, Berkeley, and Stephen Lisberger of UC San Francisco, who know only too well how vulnerable neuroscientists are to such attacks. Their message: Prepare your case before trouble arises and enlist the support of your colleagues and your institution.

The pair had learned those lessons the hard way. In 1983, Lisberger's research on eye movement in monkeys became the target of a prolonged and personal campaign. Animal activists broke into his lab, staged a mock funeral in front of UCSF for one of his monkeys, and bombarded him with letters, phone calls, and death threats for more than a year. Van Sluyters came under attack last year when activists held a press conference denouncing his research on vision in cats as "the most cruel and worthless animal research of the year," in an unsuccessful effort to stop state funding of a new animal facility on the Berkeley campus.

Lisberger and Van Sluyters emphasized that researchers who come under similar attack should never speak in their own defense. "You absolutely cannot defend yourself," Van Sluyters said. "It is by definition self-serving and there is no way you can be credible in that situation." What helped in their cases was a swift showing of public support by their institutions and colleagues. But no defense will work, they warned, if either the institution or the researcher is guilty of not giving humane treatment to the animals used in research.

So all animal researchers, Van Sluyters said, should work to see that their institutions have sound animal care and use programs. And they should be sure their own research protocols are up to date, approved by the appropriate committees, and followed to the