ENTOMOLOGIST'S PARA

Yet another continent of life remains to be discovered, not upon earth, but one to two hundred feet above it . . .
—William Beebe, New York Zoological Society, 1917

G. Kristine Jensen

In a swampy part of Peruvian tropical forest, Terry L. Erwin and Linda Sims shoot a line high into the treetops as the first step in insect collection.

By JULIE ANN MILLER

Rustlings in the branches have long intrigued biologists. But the tree trunks swarming with fierce ants and the logistics of making observations more than 15 meters above ground in a dense tropical forest have kept earthbound researchers from the teeming, mysterious world of the forest canopy. Now ingenious scientists have developed a way to bring the insects of the canopy down to earth, so that entomologists can examine the treetop dwellers' physical characteristics, habitats and distribution in space and time.

"A survey of the canopy has never been done before," says Terry Lee Erwin of the Smithsonian Institution's National Museum of Natural History in Washington, D.C. "We have the method perfected and it's just working fantastically."

The scientists are now in the midst of a four-season survey, but preliminary results already indicate that they have struck entomological gold. They are collecting a quarter million to a half million insect specimens each season.

"We've got a whole bunch of new things," Erwin says. "Most of the things we get out of the canopy are new. About 80 percent of all the groups we collect haven't been seen anywhere else."

This bountiful harvest is the result of a remarkable site and a powerful collection method. The site is a Peruvian state wildlife reserve, called Tambopata, in the Amazon basin. This reserve has an exceptionally diverse assortment of plants and animals. Only two square miles in size, the reserve has within it seven different types of forests, including swamp, sand, cyclically flooded and non-flooded areas.

"This place has the world record in everything," Erwin says. Exceptionally high numbers of plant, bird, butterfly, as well as ant and beetle species are being reported. The number of bird species already sighted on the reserve almost equals the number that inhabit all of North America.

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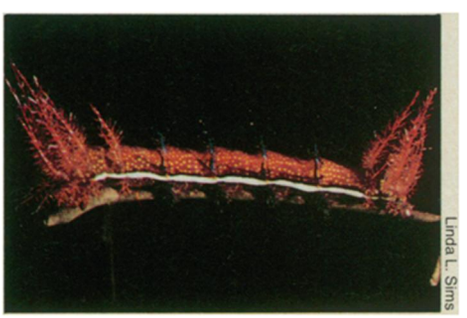
Charlotte Burnett


Linda L. Sims


Linda L. Sims

Yellow collecting nets, here reflected in water on the forest floor, catch the rain of dead insects that falls from the trees after an insecticide fog. Among the inhabitants of the canopy, defined as branches more than 15 meters above the ground, are Vespidae *wasps, shown here on their nest, and an as yet unidentified caterpillar.*

The insect collection method Erwin and colleagues have developed over the past 10 years began with a strategy long used in mosquito control — spraying an area with an insecticidal fog. Erwin chooses a plot, 12 meters by 12 meters, that has in each corner a tree with large upper branches. The scientists then use a line-throwing gun to set up a rope-and-pulley system high in the trees. The system is used to hoist a fogging machine, which can be turned on and off by remote control and swung in an arc from each of the four corners to produce a dense fog of insecticide throughout the canopy.

The insecticide, resmethrin, is a synthetic form of pyrethroid, a chemical originally extracted from chrysanthemums. "This insecticide only affects arthropods," Erwin says. "And it breaks down in just two hours." It does not affect the birds, monkeys, snakes, frogs and lizards that also inhabit the tropical canopy. Preliminary experiments indicate that within 10 days after a spraying, substantial numbers of insects from adjacent areas have repopulated the test plot.

The "rain" of dead insects that results from the fogging operation is collected in 28 collapsible nylon trays suspended on "clotheslines" strung among the trees about two meters above the ground. Each tray is funnel-shaped, so that the insects slide to a hole at the center and then drop into a pint jar containing alcohol preservative.

"Then there is the big job of processing," Erwin says. The samples are taken back to the museum for sorting, measurement and description.

At Tambopata, the canopy survey includes three duplicate plots of each of the seven forest types sampled at four different times of year. Each fogging of a plot produces about 10,000 specimens. Computers are used to analyze the distribution of insects by forest type. Because the scientists record into which tray each insect fell and what tree canopies extended over each tray, the type of tree each insect inhabits can also be surmised.

Most tropical-canopy insects, 87 percent, are restricted to a specific forest type. This is the most important conclusion of the studies to date, Erwin says. In addition, many of the insect species, about 13 percent, are confined to just one species of tree.

This finding has practical implications for preservation of tropical wildlife. "Just setting aside a piece of land doesn't work unless all forest types are represented," Erwin says. He estimates that there are 40 types of tropical forests, including dense vine forests, mosquito-infested swamps and other locales unpopular with tourists. When reserves are chosen on the basis of the best land to set up picnic tables, much plant and animal diversity is lost. In fact these perfect picnic areas probably have the poorest representation of wildlife, Erwin suggests.

Speaking of picnics, Erwin has found that ants are the dominant insect group, both in number of individuals and in biomass, in all tropical forests sampled with the fogging technique. "There is just an incredible amount of ants," he says. "It is clear that ants are the dominant driving force in the treetops."

The canopy is home to spiders, wasps, bees, moths, butterflies, katydids and cicadas — "the works," Erwin summarizes. But beetles, Erwin's special interest, have the greatest number of species inhabiting the canopy, with weevils and leaf beetles, both herbivores, dominating. There are also a great variety of beetles that prey on other insects, eat dead or dying insects and eat fungus.

Because of their hard, shell-like covering, beetles are less vulnerable to predators than are such soft-bodied insects as moths, Erwin says. Beetles are an extremely old group of insects, going back 250 million

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years, so they have had much time to diversify.

The recent measurements in Peru support Erwin's 1982 calculation that there are about 30 million insect species on earth. Earlier estimates had been much lower, about 1.5 million to 10 million species. Erwin based his number on a study of beetles found on a medium-sized evergreen tree in Panama's lowland forest, and extrapolated to the approximately 50,000 species of tropical trees. Now he thinks that his proposed number of insect species may still be low. "For a ballpark figure, I'd go up to 50 million," he says.

He expects to have a better estimate of the diversity of the world's insect species when the analysis of the canopy survey is completed. But that analysis could take 10 years. "Right now most things are still in bottles," Erwin says.

To speed and condense the reporting of new species, Erwin has devised a series of matrices, in computer-accessible form. The descriptive phrases which must be repeated so often, and thus take up so much room, in a standard description are reduced to one entry at the margin of a table of characteristics. In a set of tables, each sex in each species is scored with a 1 or 0 according to whether it shows the given trait. He has used this procedure in a published report of 16 new species of *Agra* beetles, predators that run along the canopy's leaves. About 500 species have been described so far, and more are found in each canopy sample. "There are probably thousands of species," Erwin says.

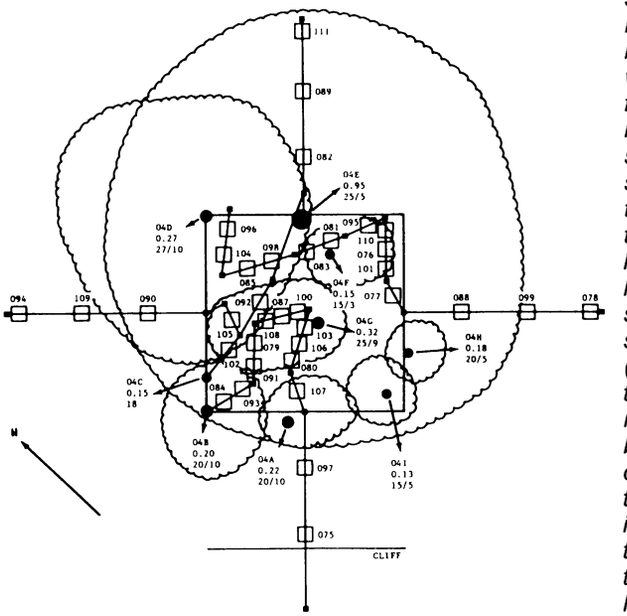
The many species of *Agra* beetles, once their distributions are known, will provide a test of hypotheses explaining why forests of the Amazon basin are so incredibly rich in life forms. A major hypothesis is that the richness stems from drastic Ice Age climate changes that periodically converted most available water into glacial ice. During the five glacial advances, each lasting several hundred thousand years, the Amazon forest was replaced with grassland except along major rivers and in the patches with the greatest rainfall. Plant and animal populations on these isolated stands of forest differentiated, as island populations do, creating new species. Eventually the forest coalesced, only to be broken up again during the next glacial advance. Erwin pictures the area as an epoch-spanning kaleidoscope, with forests blinking in and out of view.

In addition to providing new tests for evolutionary speculation, Erwin expects important practical spin-offs. For example, new understanding of the different forest areas and their plant-sustaining powers is suggesting improved agricultural methods for local inhabitants.

The many plant and animal species being collected for the first time may have properties valuable in forestry, agriculture or medicine, Erwin says. He suggests there may be insects, or natural chemicals, that will be useful in biological pest control, as well as potential pharmaceuticals.

"It seems that humanity has copied nature, adapted nature, even directly used nature throughout history, and for the most part it has been beneficial, at least to humankind," Erwin says. "With the entomological richness now being discovered by canopy sampling, it seems it is time to broaden our approach and strengthen our efforts of study, so that the potential of the last biotic frontier is also developed beneficially, both for humanity and for the perpetuation of natural habitats." □

George Venable



The power of the insect collection method relies on precise mapping of the spot where each insect falls. The researchers record for each plot sampled (large square) the location of trunks (solid circles), their canopies (scalloped circles), the collecting trays (open squares) and the lines suspending them (straight lines). Each tray and tree is identified with a number or a combination of numbers and letters. The last number in the tree identification gives, in meters, the canopy depth and height.