are crucial to the delicate task of choosing mates. Those choices—which daylight simians usually make on the basis of what they see—may well be responsible for the development of new species, concludes Bearder, who has spent two decades studying the genus *Galago* in Africa.

Galagos—called bushbabies because the cry of the largest species sounds like the bawl of an unhappy infant—call to advertise their presence, alert each other to danger, and find mates. Once the calls of two groups diverge sufficiently—whether by chance or selection—their members no longer find each other attractive, and so they may rapidly separate into two species, says Bearder.

This idea is supported by the fact that each known species of galago has a different repertoire of calls, although several species look nearly identical. To bushbabies and other nocturnal primates, says Bearder, "Sight is not that important, and so they may look almost identical and yet be different species, or they may look very different and be members of the same species. You have to know how the animals divide themselves up."

The result of all this nocturnal hooting is that the more scientists look—or in this case, listen—the more species they find. Back in the 1970s, most researchers thought all the world's primates were already recognized, remembers R.D. Martin of the University of Zurich, but since then, a number of cryptic, new nocturnal species have emerged. For example, Madagascar's sportive lemur, *Lepilemur mustelinus*, was once thought to be a single species. Now seven distinct species of *Lepilemur* are recognized in different parts of the island. Bushbabies were once divided into six species; today Bearder argues for at least 13. And many of these newly identified species are confined to small regions and are thus relatively vulnerable to extinction, says Martin.

Since humans rely primarily on vision, nocturnal species are perhaps the least understood of all primates, say Bearder and Martin. And while gorillas and chimps will probably always get top billing, the nocturnal prosimians put on a nighttime concert that is clearly worth attending. Unfortunately, as several speakers noted, if the audience doesn't pay attention, the music may eventually stop: Many prosimians, like their larger cousins, are endangered by human encroachment on their habitats. Thus behavioral research is needed now, in order to learn as much as possible before wild populations vanish, and also to improve the success of captive breeding programs. If prosimian partisans have their way, a growing number of animal behaviorists will prick up their ears and follow their noses into the darkness of the rain forest at night.

–Elizabeth Culotta

EPIDEMIOLOGY

Satellite Data Rocket Disease Control Efforts Into Orbit

Last fall in Kenya, several dozen inhabitants of the rural and wooded southern Kerio Valley began suffering the symptoms of yellow fever: elevated temperature, vomiting, jaundice, and internal bleeding. That was a surprise, since these were the first cases of the disease ever recorded in Kenya. The virus seems to have swept into the valley's monkey population from neighboring countries, and then forest-dwelling mosquitoes passed it from the monkeys to people who ventured into the forest. Things calmed down this spring—new cases have subsided, and the valley's 750,000 inhabitants have been immunized.

But yellow fever is still lurking in the forest, and it may be moving toward not-too-distant cities. All it would require is a continuous forest corridor through which the virus could travel from one monkey population to another. The snag is that no one knows whether such forest links exist, and available maps don't show enough detail to deduce the answer. "It's very important that as quickly as possible we identify areas at risk, so we can protect the population by vaccination," says Paul Reiter, a medical entomologist with the U.S. Centers for Disease Control and Prevention who was part of a team called in to investigate the outbreak.

So once the Kerio Valley situation was under control this spring, Reiter headed not into the forest with a surveying team but to the National Aeronautics and Space Administration's (NASA) Ames Research Center in Mountain View, California, in search of a satellite photo. He will soon receive a high-resolution weather-satellite image of Kenya, which he will analyze for signs of forest corridors through which the disease could spread.

Reiter is one of a small, but growing, band of entomologists and epidemiologists who believe high-tech images from space can help combat disease—especially in some of the world's lowest-tech places where even simple questions like "where does this forest end?" can't be answered from the ground. "It's difficult for us in the North or the West to appreciate the problems of scale in Africa," says Oxford epidemiologist David Rogers, who studies the African tsetse flies that carry sleeping sickness. "You simply can't visit all the places you'd like to visit, because you can't get there."

That inaccessibility often spells disaster. "When someone finally comes out of the area saying, 'My people are dying, come help us,' it's too late," says entomologist Robert Gwadz, assistant chief of the laboratory of malaria research at the National Institutes of Health. At a recent meeting in California,* Gwadz and Rogers joined other researchers and representatives of aid and funding agencies to discuss ways that satellite surveillance can provide a new avenue of attack against diseases such as malaria, sleeping sickness, and yellow fever that are spread among humans by insects. Although the satellite approach is still under development, the epidemiologists envision someday being able to predict disease trouble spots—and get to them—before the disease has broken out.

BYRON WOOD/NASA

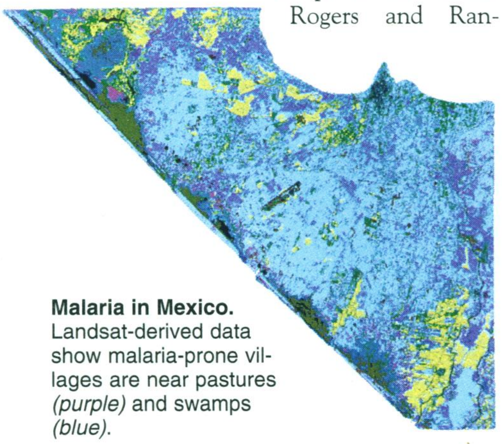
Vector vision. This Landsat image of California rice fields *(bright green)* shows that most mosquitoes live in fields near pastures and orchards, to the right.

To achieve that goal, researchers have launched a handful of pilot projects around the world to see just what satellite images can do. Rogers and his colleague Sarah Randolph at Oxford, for instance, are using a vegetation index based on satellite images to analyze the distribution of tsetse flies in eastern Africa. Tsetse flies carry trypanosomiasis, a disease that infects and kills cattle as well as humans, in which it is known as sleeping sickness. Cattle are far more susceptible to the disease, and as a result, the flies

*NASA Workshop on Remote Sensing of Vector-borne Disease Associated with Environmental and Cultural Change, 2-6 May, Marconi Conference Center, Marshall, California.

have rendered 10 million square kilometers (an area nearly 15 times the size of Texas) of the richest land in Africa off-limits to cattle raising.

Not all of that land is equally fly-infested, however. Tsetse flies breed best at certain humidity levels, and Rogers and Randolph used weather satellite data to zero in on areas with the right amount of moisture in the air. They did this by looking for vegetation that also flourishes at these humidity levels. The satellite records infrared wavelengths reflected by plant foliage and the visible red wavelengths the foliage absorbs, and a mathematical comparison of the wavelengths yields a characteristic signature for each type of plant life. Once Rogers and Randolph found signatures of plants sharing tsetse humidity preferences, they knew they had identified risk areas for sleeping sickness.


BYRON WOOD/NASA

Malaria in Mexico. Landsat-derived data show malaria-prone villages are near pastures *(purple)* and swamps *(blue)*.

This approach was most successful in Uganda, where the disease appears to be transmitted mainly by one species of tsetse fly. "We have correlates in real time between the satellite image in one month and human disease cases in the same or following month," says Rogers. In other areas where there are more than one species of tsetse fly occupying different habitats, the situation is more complicated, but Rogers says the Uganda result "suggests we can use satellites to produce direct risk maps."

Another way of figuring out just where insect vectors meet human victims is to analyze the continuously changing patterns of agricultural land use. Rice fields, for example, are a major breeding ground for malaria-carrying *Anopheles* mosquitoes worldwide. But not all rice fields bear equal responsibility. A study of 104 California rice fields found that 15% of the fields accounted for 50% of the mosquito production. The researchers, led by entomologist Robert Washino of the University of California, Davis, and Byron Wood of NASA's Ames Research Center, discovered that they could pick the major mosquito-producing fields 2 months in advance by analyzing a single Landsat photo for factors such as early development of the foliage canopy and the proximity of livestock to serve as blood meals.

While malaria isn't a worry in California, and the mosquitoes being studied were, in fact, disease free, the disease *is* a health problem in Mexico. In that country, a joint NASA-Mexican Ministry of Health team led by Mexico's Mario Rodriguez and NASA's Wood found they could use Landsat photos to pick out malaria-prone villages with 90% accuracy merely by analyzing the amount of pastureland in the vicinity, since flooded pastures are prime mosquito breeding sites. Jack Paris, a meteorology and remote sensing specialist in the biology department at California State University, Fresno, is working with the group to incorporate seasonal weather information to pinpoint the malaria-prone areas that have received enough rain to call for control efforts.

Satellite photos are not cheap, however, and their use may seem like "pie in the sky" for developing countries, says William Lyerly of the U.S. Agency for International Development. Landsat photos cost up to $4,000 apiece, and then there is the expense of the data analysis, which varies depending on the project. For developing countries that spend as little as a dollar per person annually on health care, satellite epidemiology may seem prohibitively expensive.

But those considerations don't necessarily rule the approach out. A country might need only one or two photos a year to extract the necessary information, and when the cost is compared to the expense of transporting teams between remote ground sites, those satellite photos begin to look like a bargain, says University of Hawaii malaria expert Robert Desowitz. And there may be yet other ways of cutting costs. Paris points out that weather satellite information is available for free over the Internet computer network. In addition, participants at the May workshop discussed the possibility of groups of countries and agencies forming consortia to buy and process satellite data.

Despite the growing enthusiasm, disease prevention by satellite still has to prove itself for actual disease control. "We have established the potential of [the] technology," says Rudi Slooff, a scientist with the World Health Organization (WHO) who attended the meeting. "Now we need to show that this technology can work in an operational setting.... It will need to be demonstrated that with this information you can get your control methods in place faster, or more accurately targeted. It has to be measurable in terms of operational savings." And, of course, in terms of saving lives. Within a year, Slooff says, WHO would like to get several outbreak-prediction projects off the ground in disease-prone areas to learn just where the savings are.

–Marcia Barinaga

MATHEMATICS

Fermat's Last Theorem Finally Yields

There was a moment of stunned silence in a lecture hall at the Isaac Newton Institute in Cambridge, England, last week. Then a burst of applause. The audience, which included many of the world's leading number theorists, knew they'd witnessed a historic event. Andrew Wiles, a mathematician from Princeton University, had just solved mathematics' most famous problem: proving Fermat's Last Theorem, a deceptively simple conjecture that has challenged, irritated, and daunted mathematicians for three and a half centuries since it was sketched out by the French mathematician Pierre Fermat in 1637.

Many have tried to prove Fermat right (or wrong) in saying that the equation $x^n + y^n = z^n$ has no solutions in positive integers when the exponent n is greater than 2. All proofs until now, however, have failed to hold up, so it would be natural to expect that Wiles' result would be met with skepticism. Not so. "The logic of his argument is utterly compelling," says Ken Ribet of the University of California, Berkeley. "It really is marvelous," adds Barry Mazur of Harvard University. Neither Mazur nor any of the other experts contacted by *Science* had gone over the text of the proof. He explains, though, that "the conceptual outline [in Wiles' talks] makes it very believable." Perhaps most important, it emerges from the very heart of number theory, drawing on an array of advances made over the past 30 years. Concludes Mazur, "It simply has the ring of truth."

Fermat's Last Theorem has fascinated mathematicians and nonmathematicians alike because it is so simple to state and understand, yet so hard to prove. Adding to the mystique of the problem is its history. Fermat wrote his famous assertion in the margin of a book, adding the tantalizing comment, "I have discovered a truly remarkable proof, which this margin is too small to contain." The problem is called Fermat's "last" theorem because it is the only one of Fermat's many assertions that mathematicians had been unable—until now—to either prove or disprove.

Fermat did find room (elsewhere) to write down a proof for the case n=4. Nearly 100 years later, the Swiss mathematician Leonhard Euler found a proof for n=3. And in the 1840s, Ernst Eduard Kummer initiated the study of what's now called algebraic number theory, which enabled him to prove Fermat's Last Theorem for a large number of expo-