Science

TAG TEAM

Animals are often leaving researchers in the dust. A bird flies off. A crab scrambles under a rock. A whale dives and swims away. Yet migrations, dispersals, and other types of movements are important components of an organism's life history and of an ecosystem's health. To keep an animal in their sights, so to speak, researchers increasingly rely on technological innovations as diverse as miniature radio transmitters and remotely guided submersibles. As the stories on these two pages show, the technologies are imperfect, but nonetheless, ecologists are finding their way toward a greater understanding of the mobile species they study.

CREDIT: CHRISTMAS ISLAND NATIONAL PARK, AUSTRALIA

Eye in the Sky

Last fall, using a combination of eyelash adhesive and Krazy Glue, a team led by Martin Wikelski of Princeton University attached tiny radio transmitters to the abdomens of 14 migrating green darner dragonflies (*Anax junius*; lower right). Then, using receiver-equipped cars and small planes, the scientists tracked the insects through New Jersey as they made their way south. The 300-milligram transmitters worked for 12 days, sending information about the speed and timing of the bugs' travels as well as temperature and wind speed.

Now, Wikelski wants to use these "mini" tags to follow small flying animals around the world, via satellite. So far, satellite tracking has been used only on large animals, such as caribou or whales, wearing powerful transmitters with long-lived batteries. But miniaturization of the technology is now making it realistic to try to track some of the 6 billion songbirds—as well as countless bats and insects—that migrate between continents each year.

In a project he calls Icarus, Wikelski envisages placing a refrigerator-sized satellite in low Earth orbit. It would pick up signals from migrating birds, such as wood thrushes, warblers, and finches, outfitted with 2-gram sensors. It's also possible that Icarus's receivers could piggyback onto another low-orbit vehicle.

Either way, it's all very pie in the sky at the moment, says electrical engineer George Swenson of the University of Illinois, Urbana-Champaign, who has been advising the project. After all, Project Icarus lacks any funding. Among the possibilities is the United Nations, as Icarus has the potential to track pests such as desert locusts. Wikelski admits it may take a decade to get the idea off the ground. But Smithsonian Institution ornithologist Peter Marra says, "It would be tremendous" to be able to track migratory birds this way.

–C.H.

Crab Walk

Every November, the slopes of Christmas Island, an Australian territory in the Indian Ocean, develop a deep red rash. With the start of the monsoon rains, 45 million adult red land crabs (*Gecarcoidea natalis*; above) seem to boil out of the ground for a 7- to 10-day, 8-kilometer trek to the coast. At the ocean, the crabs mate. Then the males embark on the return journey. The females follow once they have incubated and laid their eggs. The larvae are confined to the salt water for 3 weeks, after which they emerge as miniature adults that head into the hills.

Through sheer force of numbers, the migration is hard to miss. The challenge has been to pin down the crabs' exact migration routes. To track the crustaceans, physiologist Steve Morris of the University of Bristol, U.K., puts small radio transmitters on the crabs and follows behind with a handheld receiver.

The job can be "a nightmare," Morris says, because of the island's topography and the crabs' habitat. "Christmas Island is shaped a bit like a tiered wedding cake," he says. "If a crab has moved over the top of one of the tiers, then we can't pick up its signal." The crabs' jungle environment also doesn't help. Signals are bounced around by dense, wet foliage, and pinnacles of rock often disturb signal transmission.

Nonetheless, through these and other tracking efforts, including using paint to color-code the shells of crabs from different locations, Morris has shown that the animals travel in a surprisingly straight line—often up and over bumps instead of around them. He has also discovered that the crabs head to a specific beach, then backtrack to their original jungle haunts. Using the radio transmitters, Morris is also following individual crabs during their daily routines once they are back in the jungle. In this way, he's learning how their bodies change as they shift from having to deal with the stresses of jungle life to the challenge of their annual journey.

–LAURA BLACKBURN

CREDIT: MARTIN WIKELSKI/PRINCETON UNIVERSITY

CREDIT: DIANE COWAN

In the Deep Blue Ocean

Radio transmitters won't work on swimming animals that never surface, but sonar does the job just fine. In Maine, marine biologist Diane Cowan of The Lobster Conservancy in Friendship, along with volunteers and fishers, uses underwater hydrophones to pick up signals from sonar tags attached to lobsters (*Homarus americanus*; left). In June, Cowan reported that her team had tagged 191 lobsters and reestablished contact with 82% of them at least once over the following year.

In analyzing these new data, she's found that not all wintering female lobsters head to deeper, warmer water to incubate their eggs. "This was a surprise," says Cowan, as eggs need at least 3°C water to develop. As expected, large females did migrate out to sea, traveling an average of 58 kilometers. But small females stayed in shallow water, which sometimes dropped below freezing. These waters warm up sooner in the spring, which may compensate for the females' failure to move, she points out. **–L.B.**

Jellyfish on the Run

If you can't tag 'em, then chase 'em. That's Bruce Robison's new motto. A marine biologist at Monterey Bay Aquarium Research Institute in Moss Landing, California, he has tried to follow jellyfish by gluing, surgically implanting, or even feeding acoustic transmitters to the animals, without much luck. He has now turned to remotely operated vehicles (ROVs; right). Because ROV pilots have a hard time following the jellies for very long, Robison has recently teamed up with Stephen Rock's aerospace robotics lab at Stanford University in Palo Alto, California. At the lab, Jason Rife has come up with a software-driven camera system that can lock in on the quarry and maneuver the ROV without human intervention. The software keeps the ROV away from a jelly and adjusts the ROV's course as needed. To date, the group's record for keeping a jelly in sight is 89 minutes.

Stanford graduate student Aaron Plotnik is developing new software that will be able to track faster, smaller jellies, says Rock. Robison envisions autonomous robots that follow the jellies for weeks and record temperature and salinity. And then, he says, we can finally answer the simple question, "How deep do jellies go?" **–L.B.**

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On the Radar Screen

A beetle's world often extends hundreds of meters into the air. When it and other insects travel in the upper air currents, they are well beyond the reach of nets, traps, and other traditional tools of entomologists. "We need to [reach] into the atmosphere; otherwise, we are missing out on an important part of their ecology," says Jason Chapman, an entomologist at Rothamsted Research in Hertfordshire, U.K. His solution: vertical radar (lower left).

Rothamsted Research's radar system, one of a handful of vertical radars currently operating around the world for scientists, has been sending a beam skyward 24/7, rain or shine, since 1999. The radar beam is cone-shaped, just a few centimeters wide when it leaves the transmitter but covering a swath a few meters in diameter at the team's recording limit, around 1200 meters high.

In the 1970s, physicist Glen Schaefer, then at Loughborough University in Leicester, U.K., pioneered the use of vertical radar for tracking insect pests, such as desert locusts. But there was no automated processing of the incoming signals, and instead, "people had to sit by the radar screens and take photos," Chapman says. "It was very time-consuming."

Now, however, computers do most of the work. The returning radar signals are continuously recorded and analyzed using specially designed software that determines the size, shape, flight speed, and direction of insects passing through the vertical radar beam. Chapman combines his radar analyses with long-term data on wind speed and direction to piece together an insect's migration path and predict where it came from.

He and his colleagues have discovered that some insects disperse much more widely than thought. Last year, they showed that a local carabid beetle (*Notiophilus biguttatus*; top left), which feasts on agricultural pest species, doesn't keep to a single field as was previously believed. Instead, the beetles showed up in aerial traps and could be detected up to 400 meters high in the radar beam, indicating that carabids were on the move. **–L.B.**

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