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The Secret Lives of Wild Animals

Home

From the Rocky Mountains to the Jersey shore, and from African savannas to Antarctica's frozen waters, scientists are collecting new information about the secret lives of wild animals. Field glasses and makeshift perches have given way to sophisticated new vantage points. Modern technologies like global tracking systems and ultra-miniaturized sensors now provide researchers with intimate glimpses of rarely seen behaviors. These efforts lead to a better understanding of the myriad interactions between land and beast, and the very balance of nature, as well as new ideas about how we live together on a shrinking planet.

Image: Animal montage Illustration
Credit: Nicolle Rager Fuller. National Science Foundation

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The Secret Lives of Wild Animals

Introduction

The National Science Foundation supports many projects to develop new technologies and equipment to observe and track animals in real-time in their natural environments—even as the beasts remain completely undisturbed by the inquisitive scientist. Multidisciplinary teams of biologists, computer scientists and engineers are designing innovative tracking and information-management systems to learn exactly how animals spend their minutes, days and years negotiating within an ecosystem for food and mates, to survive predators, or to adapt to human encroachment.

Scientists call this area of research 'landscape ecology,' because it looks at the complex web of relationships among plants and animals, the land, & increasingly, humans as the world population surpasses well over 6 billion people who crowd not only each other, but also Earth's wildest terrain. Knowledge gained from these studies provides wildlife managers, land developers, city planners and communities with valuable information about options for creating and maintaining a healthy, sustainable environment.

Image:
NSF-supported scientists, including Princeton University's Jamie Mandel, are developing new technologies to unobtrusively follow the movements of wild animals.
Credit:
Christian Ziegler, Smithsonian Tropical Research Institute

Deer

Overview

Burgeoning white-tailed deer populations across the United States have resulted in increased contact with other animals—including humans. Such now-common encounters can affect the health and environment of both the deer and their neighbors, with potentially serious consequences. There are an estimated 1.5 million vehicle-deer collisions in the United States each year, for example, resulting in 150 motorist deaths and $1.1 billion in vehicle damage.

To help establish sound programs to safeguard man, beast and property, wildlife biologists need better ways to directly observe deer movement and other activities over long periods, as well as a better understanding of the factors that influence their habits.

Direct observations over time—though often impractical—give the most accurate picture of an animal's daily routine. Now, using a miniature, wireless video system mounted to the antlers of white-tailed deer, scientists can see the world almost literally through the animals' eyes and remotely record and transmit the images for hundreds of hours.

The DeerNet research team, composed of wildlife biologists, electrical engineers and computer scientists, tested the system on deer that lived in a 10-acre, fenced conservation area. After the team attached the system to the antlers of male deer, or neck in the case of females, the device transmitted a video signal to a nearby base station. The researchers collected over 200 hours of "deercam" video that provided them with an undisturbed view of deer life while as they ate, fought, groomed, played and slept.

While proving the system worked, the unique video also yielded new insight into deer behavior. The team saw almost constant touching between the animals, for example, including mouth-to-mouth contact and grooming—actions that could play an important role in disease transmission. They also remotely cataloged the deer's food preferences for more than 1 week.

The team is currently optimizing the state-of-the-art monitoring system and extending their studies to animals living in the wild.

Images:
1. Deercam footage revealed almost constant physical contact between deer, a finding that helps scientists better understand how diseases may be transmitted from animal to animal.
Credit: Hal Korber, Pennsylvania Game Commission
2. By watching video obtained from the animal-mounted deercam, researchers are observing a deer's natural habits firsthand. The new look into a deer's decision-making process may help reduce the 1.5 million deer-related vehicle accidents that occur annually in the United States.
Credit:
PD Photo

Deer

Tracking Technology

The DeerNet system consists of a miniature video camera in a weatherproof shell, a battery system that allows hundreds of hours of operation, and a UHF transmitter to relay data. The cameras mount temporarily to the animals' antlers and necks and images are sent to the receiving and recording station in real time.
The camera is light-activated to conserve
battery power at night.

Images:
A male white-tailed deer—one of several Missouri deer researchers used to test deercam capabilities—carries the system mounted to his antlers and neck. Researchers confirmed the deer were not adversely affected when outfitted with the camera.
Credit:
Missouri Department of Conservation

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Deer

Movie
See the world through a deer's eyes as he moves through forest and field.

MALE AND FEMALE DEER TOUCHING HEADS
NARRATOR: Wildlife ecologists are addressing several critical issues that affect whitetail deer, including an

DEER FORAGING AT EDGE OF ROAD
alarming increase in deer-vehicle collisions.

JOSHUA MILLSPAUGH
Professor of Wildlife Conservation, Joshua Millspaugh.

MILLSPAUGH: The current technologies

DEER IN FIELD
that we have available limit us

DEER LOOKING AT CAMERA
to placing dots, essentially, on a map showing locations of deer.

FACE OF DEER
We don't have any sense of what the deer actually see at those points

DEER AT EDGE OF HIGHWAY
and how they're responding to roads, for instance. It's very likely there are certain habitat

DEER BY CURVE IN HIGHWAY
conditions and landscape configurations around roads that might actually funnel deer toward them.

MALE AND FEMALE DEER IN FIELD
So the opportunity to see what they see at those points is
critical, we think, to our understanding of how they respond to roads.

INSET: VARIOUS SCENES FROM DEER'S POINT OF VIEW
NARRATOR: Enter DEERCAM—created to allow researchers to see the world from a deer's perspective.

MALE DEER WEARING MOUNTED CAMERA
MILLSPAUGH: We mounted the camera itself on the deer's head — the male deer — and we had an antenna that was up about 10 meters high.

INSET: SCENES FROM DEER'S POINT OF VIEW
The video was transmitted directly from the camera, detected by the antenna, and then recorded on a TV-VCR combination. So, we obtained real-time video information that was recorded automatically, 24 hours. It was just a continuous process.

The research that we've conducted thus far has all been within captive facilities within 10-acre enclosures, so they were not free-ranging deer. Within the next couple of years, we're going to take this in the wild.

The exciting thing about this is with the new technologies, smaller cameras with lighter weight cameras, we really will have the opportunity to study the other wildlife species as well. This is not just about white-tail deer, but it's about further Opportunities, at least to understand wildlife in their natural habitat, we've never had before.

Researchers have dreamed of this day, where we would have the opportunity to see what wildlife see.

Movie Credits

CONTENT
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Hal Korber, Pennsylvania Game Commission
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PD Photo

PRODUCTION
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S2N Media, Inc.

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Deer

Quick Facts

WHITE-TAILED DEER
(Odocoileus virginianus)

SIZE
Mature deer are 31-40 inches tall at the shoulders, 51-83 inches long and weigh 110-300 pounds. Females are usually smaller than males.

HABITAT AND RANGE
White-tailed deer are found in almost every part of the continental United States, except California, Nevada and Utah. Their range extends north into most of Southern Canada and south into Central America and Bolivia.

Ideal habitat for white-tailed deer consists of forested land containing dense thickets with surrounding fields or croplands.

DIET
White-tailed deer feed on grasses in the spring and summer, mast—including acorns and apples—in the fall, and twigs, buds and leaves in the winter. They can cause significant destruction of crops, fruit trees and flower or vegetable gardens.

CHARACTERISTICS
White-tailed deer generally feed from before dawn until several hours after, and from late afternoon until dark. They raise their namesake white tail as an alarm signal. Bucks shed their antlers every winter and grow them back in the spring.

Images:
Wildlife biologists are directly observing deer movements using a miniature, wireless video system to study factors that influence their behaviors.
Credit:
Nicolle Rager Fuller, National Science Foundation

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Deer

Location

In Boone County, Mo, researchers are following deer movements by outfitting them with miniature video cameras.

Credits: (Above) Nicolle Rager Fuller, National Science Foundation. (Right) NASA World Wind

National Science Foundation
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Deer

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- Dapeng Wu, University of Florida
- Jeff Beringer, Missouri Department of Conservation
- Joel Sartwell, Missouri Department of Conservation

Support Sources

- National Science Foundation,
  Directorate for Biological Sciences
  Division of Biological Infrastructure
- Missouri Department of Conservation

Images:
1. Joshua Millspaugh, University of Missouri, Columbia
2. Zhihai He, University of Missouri, Columbia
3. Yuguang Fang, University of Florida
4. Dapeng Wu, University of Florida
5. Jeff Beringer, Missouri Department of Conservation
6. Joel Sartwell, Missouri Department of Conservation

Credits:
1: University of Missouri, Columbia
2: Wenye Cheng, University of Missouri, Columbia
3: David Blankenship, Engineering Publications, University of Florida
4: Howard Leung, Carnegie Mellon University
5: Tami Meyer
6: Courtesy of Joel Sartwell, Missouri Department of Conservation

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Ocelot and Agouti

Overview

Not long ago, the jaguar reigned king of the Central American jungles. Jaguars are now extinct from more than half of their historic range and scientists are using new devices to track the activities of other animals to learn if loss of the dominant predator has upset the natural order. Or, has a new beast assumed the throne? Researchers are particularly interested in the predator-prey relationship between the leopard-like ocelot and a 6-pound rodent called agouti—a seed-burying animal that may hold the key to the forests' future.

Using what they term a 'macroscope'—an automated radio telemetry system that continuously monitors vast movements of multiple animal species—researchers are following the diabolical dance between ocelot and agouti step-by-step. They are now convinced the smaller cats have successfully filled the jaguar's role in keeping the rodent population in check.

But as in all ecosystems, interrelationships among the animals and plants ripple throughout the landscape. Scientists now realize the animals' new relationship affects the entire forest's ecology, in particular, the future of its trees. The agouti it turns out, plays a major role in regulating new tree growth by dispersing its own major food source—the spiny palm tree seed.

Scientists have adorned the seeds with motion sensors to monitor their whereabouts as agoutis gather the seeds and store them in caches throughout the forest. As researchers learn more about the animal's seed-foraging habits, they will be better able to assess the proper balance between ocelots and agoutis, not just to keep the forest from being overrun by the rodents, but to keep the ecosystem from losing the roof over its head.

Images:
Ocelot: A young female ocelot on Barro Colorado Island, Panama, returns to retrieve a kill. Night sightings of ocelots are rare. Agouti: The agouti, a tropical rodent, feeds on spiny palm fruit. Researchers are using a new tracking system to track both the agouti and seeds it buries to learn how they affect the forest ecology.
Credit: Christian Ziegler, Smithsonian Tropical Research Institute

The Secret Lives of Wild Animals — Text-only

Ocelot and Agouti

Tracking Technology

The automated radio telemetry system (ARTS) consists of seven permanent radio towers that continuously relay location data collected from dozens of transmitter-tagged animals to a base-station computer. The automated system allows biologists to collect more data, more frequently, on more individual animals than standard telemetry methods.

Images:
Researchers are using a new tracking system to follow the movements of animals including this ocelot on Barro Colorado Island, Panama, in order to learn more about its habits and interactions with its prey.
Credit: Christian Ziegler, Smithsonian Tropical Research Institute

The Secret Lives of Wild Animals — Text-only

Ocelot and Agouti

Movie
Learn about the cat-and-mouse games Central America's ocelots and agoutis play, their predator-prey relationship and its effects on the ecosystem.

MONTAGE OF GROUNDHOGS, CAMEL, ALLIGATOR, RODENT

Understanding aspects of animal mortality is important, not only for understanding and studying the evolution of that species in particular, but also for understanding some of the broader impacts that species has on its ecosystem.

AGOUTI GOING INTO UNDERBRUSH

For example, the agouti

OCELOT CARRYING AGOUTI AWAY

that you see in this video that has just been killed. Before,

AGOUTI ON OPEN LAND, EATING BERRIES, BURYING FOOD

when it was living, it was running around taking seeds, eating some of them, and burying some of them in caches under ground for later. And the research that we're doing is trying to

AGOUTI CARRYING FOOD

test the idea that the only way a seed can survive agouti is if the agouti itself dies,

AGOUTI BURYING SEEDS

so an agouti would bury the seeds and before it can go back

OCELOT CARRYING AGOUTI AWAY

and dig them all up, it would get predated by something such as the ocelot in this video. And these seeds probably have a better chance of surviving and growing into trees than seeds that are buried by agoutis that do not die.

AGOUTI WEARING RADIO COLLAR

Getting live data from radio-tagged animals is a new development. It's something that's really exciting

COMPUTERS INSIDE LABORATORY, SHOWING TRACKING SYSTEM

because it allows us to see from the lab and actually get alerted when an animal dies by the change in pattern of their activity,

SCIENTIST CHECKING TALL OUTDOOR ANTENNA

and then we can ourselves run out into the forest. And in this case, we saw the animal had been predated and was not fully consumed, so we left a motion sensitive video camera there and went away, and as soon as the sun set, the presumed

OCELOT CARRYING AGOUTI AWAY

predator came back to the scene of the crime to finish its meal. And so you can see the ocelot here coming back and dragging the carcass of the agouti away from the scene of the crime.

VARIOUS SCENES OF AGOUTI IN FOREST

Predation is important, not only because of its role in controlling populations, such as populations of rodents, but also in affecting their behavior – when they're active, where they're active on the landscape, and can even affect their ecosystem role.

AGOUTI WITH LARGE SEEDS

In this case, agoutis bury seeds, and if they're killed by ocelots, the seeds that they buried are more likely to survive than if the agouti survives for a longer period of time.

OCELOT IN WOODS

So, in this case, predation may even have an impact on

FOREST SCENE – ZOOM OUT AND SLOW FADE OUT

the whole forest ecosystem and the regeneration and diversity of tree species.

Movie Credits

CONTENT
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Ocelot and Agouti

Quick Facts

OCELOT
(Leopardus pardalis)

SIZE
Mature ocelots are 36 to 40 inches in length, 18 inches in height, and 20 to 40 pounds in weight. Females are smaller than males.

HABITAT and RANGE
Ocelots live in a variety of forested habitats found in Arizona, Texas, Mexico, Central America, and South America, including northern Argentina, Ecuador and Paraguay.

DIET
Ocelots feed on almost any prey they can overpower, including birds, small- to medium-sized mammals, monkeys, frogs, reptiles and rodents.

CHARACTERISTICS
Ocelots are largely nocturnal and generally solitary, except during mating and when females have cubs. They prefer dense cover and sleep mostly in shady thickets. Ocelots are good swimmers and live 12 to 15 years.

AGOUTI
(Dasyprocta punctata)

SIZE
Agoutis are about 18 inches long and weigh about 6 pounds.

HABITAT and RANGE
Agoutis are found in the forests of Central and South America and the West Indies.

DIET
Agoutis eat fruits, nuts, roots, seeds and leaves.

CHARACTERISTICS
Agoutis are generally solitary rodents, coming together only to breed. They are fast runners and good swimmers and are attracted to the sound of ripe fruits hitting the ground. They make burrows under rocks and trees, where they bury food when it is abundant. Agoutis are very important in seed dispersal, as some of the buried seeds are forgotten and germinate into new trees.

Images:
With the extinction of the jaguar in Central American jungles, ocelots have now become a primary predator of the rodent-like agouti.
Credit:
Nicolle Rager Fuller, National Science Foundation

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Ocelot and Agouti

Location
Researchers are following the movements of rainforest animals on Barro Colorado Island, Panama.

Credits: (Above) Nicolle Rager Fuller, National Science Foundation. (Right) NASA World Wind

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Ocelot and Agouti

Researchers and Support

Principal Investigators

- Roland Kays, New York State Museum
- Martin Wikelski, Princeton University

Support Sources

- National Science Foundation,
  Biology Directorate;
  Division of Biological Infrastructure
- Levinson Family Foundation
- Smithsonian Tropical Research Institute

Images:
1. Roland Kays, New York State Museum
2. Martin Wikelski, Princeton University
3. Christian Ziegler (Photographer), Smithsonian Tropical Research Institute

Credits:
1, 3: Christian Ziegler, Smithsonian Tropical Research Institute
2: Tony Borries, Automated Radio Telemetry System

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Dragonfly

Overview

Large-scale insect migrations have been noted since biblical times, and recently, major progress has been made in understanding how and why hoards of insects move from one geographic location to another. But now, scientists have successfully tracked the migration of individual insects in an effort to learn more about the factors affecting their movements.

The studies pioneer a new era of migration research that takes advantage of miniaturized radio transmitters. In the future, signals from these and similar devices could be detected by satellites. So, small birds, bats and insects could be tracked over continental distances, which would allow better studies of disease transmission and new strategies to control migrating insects that are considered to be pests.

In one example, researchers developed the tiny transmitters and attached them to wild Green Darner dragonflies using a mixture of eyelash adhesive and superglue. After verifying the transmitters did not alter the insects' flight characteristics, the team tracked the dragonflies as they migrated south from northern New Jersey during the fall months. Each individual was tracked for the life of the transmitter—about seven days.

Scientists surmise that by migrating and laying eggs in more southerly ponds, the Green Darner's offspring can emerge earlier the following spring and then migrate north to occupy ponds that are still too cold to allow local dragonflies to emerge.

Like migrating songbirds, the dragonflies would travel some days—generally every third day—and rest on other days. When on the move, they flew an average of 7.5 miles per day; one intrepid flier logged an astounding 100 miles in one day!

Winds on flying days blew less than 15 mph. A flying day always followed a night that was colder than the previous night—a sign of a prevailing cold front in which winds blow generally from the north. That meant the dragonflies often took advantage of tailwinds as they made their way south.

Images:
1. Using miniature tracking devices, scientists found that Green Darner dragonflies migrate similarly to songbirds. They traveled an average of 7.5 miles per day—moving some days and resting on others, depending on the weather. Credit: Dave McShaffrey, Marietta College
2. Researchers recently tracked individual Green Darner dragonflies as they migrated south from northern New Jersey during the fall months by attaching miniature radio transmitters to them. The tiny beacons, which weigh about as much as a paper clip, were affixed to the dragonflies using a mixture of eyelash adhesive and superglue. Credit: Christian Ziegler

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Dragonfly

Tracking Technology

To precisely track the movements of an individual insect, scientists use a miniaturized radio transmitter that attaches to the insect's body with a combination of eyelash adhesive and superglue. The transmitter signal is detected by a mobile receiver located either in a vehicle or airplane. The system could also be used in conjunction with satellite receivers for global surveillance of small organisms.

The transmitter weighs 0.01 ounces—about the same weight as a paper clip. Even though this is approximately 25 percent of the dragonfly's total weight, it caused no apparent flight problems.

Images:
1. To track individual dragonflies, a miniature transmitter is attached to the underside of their abdomen. Credit: Christian Ziegler
2. A coastal New Jersey dragonfly prepares for takeoff with its newly attached transmitter. The Green Darner is known for its excellent flight capabilities and was seemingly unaffected by the added weight of the transmitter. Credit: Christian Ziegler

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Dragonfly

Movie
Watch scientists attach miniature transmitters to dragonflies to learn more about their migratory habits.

BIRDS MIGRATING, CAMERA MOVES ALONG RIVER COASTLINE

NARRATOR: The migration of birds and monarch butterflies are natural phenomena studied worldwide. Now, for the first time, scientists are able to study migration in individual insects—

CLOSEUP OF GREEN DARNER DRAGONFLY

green darner dragonflies. Professor

MARTIN WIKELSKI WORKING ON SMALL AIRCRAFT

Martin Wikelski.

WIKELSKI: There are millions of dragonflies migrating every year,

CLOSEUP OF DRAGONFLY

probably up to about 50 species, and virtually nothing is known about these migrations.

HAND HOLDING RADIO TRANSMITTER-ZOOM IN FOR CLOSEUP

NARRATOR: Now, that's changing.

WIKELSKI: Our collaborator, Jim Cochran, from Sparrow Systems has developed small radio transmitters at a weight of between 250 and 300 milligrams that allow

CLOSEUP OF DRAGONFLY ON LEAF

us to study at least large insects during their migratory flights.

CLOSEUP OF SCIENTIST HOLDING DRAGONFLY BY WINGS

So, we teamed up with Rutgers University and caught a total of 14 dragonflies in the fall, in New Jersey, and we know that those animals are on their way south.

CLOSEUP OF DRAGONFLY-TRANSMITTER ATTACHED TO UNDERBELLY

We attached transmitters to their thorax using superglue and eyelash adhesive.

DRAGONFLY RESTS ON MAN'S FINGER, THEN FLIES AWAY

And then, we let these animals go. They take off and then

SCIENTIST ON BEACH WITH TRACKING ANTENNA

we track them from the ground or

WIKELSKI PILOTING SMALL AIRCRAFT
EXTERIOR OF PLANE SHOWING STRUTS

from small airplanes with antennas attached to the struts.

SIDE VIEW OF DRAGONFLY RESTING ON LEAF

NARRATOR: What they found was that the dragonflies have migratory behavior similar to that of birds.

DRAGONFLIES IN FLIGHT

They fly some days, rest on others. And like birds,

DRAGONFLY ON RESEARCHER'S FINGER AT BEACH LOCATION

the decision "to fly or not to fly" seems to be based on temperature and wind speed.

TWO RESEARCHERS CHECKING DRAGONFLY

The darners only migrated when the wind speed was less than about 15 miles an hour

TWO CLOSEUP SHOTS OF DRAGONFLY WITH TRANSMITTER ATTACHED

and when a night was colder than the one before it—signaling a cold front with winds from the north.

DRAGONFLY TAKES FLIGHT FROM RESARCHER'S HAND

It looks as if these kind of migratory rules, these simple rules, that potentially could be innate, as has been shown by birds,

AERIAL SHOT OVER FARM LAND

are sufficient to help these darners go south. We calculated that

CLOSEUP OF DRAGONFLY WITH TRANSMITTER ATTACHED

within about a month or two-month period, they can get a southward advance on a population level of about 700 miles. The longest flight we had was about 100 miles per day.

CLOSEUP OF DRAGONFLY ON TREE STUMP

NARRATOR: Dragonfly and bird migration do differ in one important way: dragonflies migrate in one direction only,

DRAGONFLY ON BRANCH CLOSEUP - SLOW ZOOM OUT

with the next generation making the return trip. The dragonfly study

SCIENTIST USING TRACKING SYSTEM ON BEACH

demonstrates the viability of radio tracking of large-scale insect movement.

EARTH FROM OUTER SPACE

In the future, transmitter signals could be picked up from space by special satellites.

AERIAL SHOT OVER FARMLAND

Birds, bats and insects could be tracked over huge distances,

BIRDS MIGRATING

with implications for anticipating the spread of diseases and for pest control.

DRAGONFLY RESTS ON RESEARCHERS FINGER AT BEACH LOCATION

Movie Credits

CONTENT
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Christian Ziegler
Dave McShaffrey, Marietta College
Lori Dieter, Gray Lodge Wildlife Area
Dave Moskowitz, EcolSciences, Inc.
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PRODUCTION
Cliff Braverman, National Science Foundation
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Dragonfly

Quick Facts

GREEN DARNER DRAGONFLY
(Anax junius)

SIZE
The Green Darner is one of the largest dragonflies; it is about 3 inches long, has a wingspan of 4 inches and weighs approximately 0.04 ounces.

HABITAT and RANGE
Green Darners are found throughout North and South America, the West Indies and Asia.

DIET
Green Darner nymphs (the larval stage that lives in the water) feed primarily on aquatic insects, fish eggs and tadpoles. Adults eat insects including bees, butterflies, mosquitoes and moths.

CHARACTERISTICS
Green Darner dragonflies are nicknamed darning needles, mosquito hawks or Lords of June.

Green Darner nymphs hatch near ponds from eggs laid in rotting wood or aquatic plants. The nymphs can take up to 4 years to reach maturity and then survive only 4 to 7 weeks as adults.

Enabled by their excellent flight capabilities and nearly 360-degree eyesight, dragonflies easily capture and kill prey larger than themselves. The Green Darner can fly at speeds exceeding 50 miles per hour.

Green Darners are migratory. In the Northern Hemisphere, they move north from March to June and south from August to November.

Images:
Scientists can now track the movements of individual insects, including green darner dragonflies, with the help of tiny locating beacons.
Credit:
Nicolle Rager Fuller, National Science Foundation

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Dragonfly

Location
The migratory habits of individual dragonflies are being studied near Cape May, N.J.

Credits: (Above) Nicolle Rager Fuller, National Science Foundation. (Right) NASA World Wind

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Dragonfly

Researchers and Support

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- Michael May, Rutgers University
- David Moskowitz, Rutgers University
- David Wilcove, Princeton University
- Christian Ziegler (Photographer)

Support Sources

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- National Geographic Society

Images:
1. Martin Wikelski, Princeton University (left)
David Moskowitz, Rutgers University (right)
2. Michael May, Rutgers University
3. David Wilcove, Princeton University
4. Christian Ziegler (Photographer)
Credits:
1, 2, 4: Christian Ziegler
3: Nathan Gregory, Princeton University

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Zebra

Overview

Land-use decision makers are increasingly faced with the difficult task of safeguarding animal habitats while addressing the needs of a growing human population. To accurately assess an animal's environmental requirements, it is necessary to know when and where they move—over periods ranging from minutes to months.

The ZebraNet project is an interdisciplinary effort between computer scientists—who are designing a global positioning system (GPS)-enabled animal tracking system—and biologists—who need answers to long-standing questions about animal migrations, inter- and intra-species interactions and nocturnal behaviors.

ZebraNet scientists recently developed extremely energy efficient tracking collars that can monitor, almost continuously, an animal's location for nearly a week without recharging. The tracking system uses mobile receiving stations that eliminate the need for permanent research dwellings.

Currently monitoring the movements of Africa's plains zebras, the team will ultimately deploy collars on other species that share the ecosystem, including elephants, hyenas and lions.

In addition to knowing when and where animals move, knowing why they move can also influence land-use decisions. Scientists working in coordination with ZebraNet are monitoring zebras and other animals using video surveillance to better understand their behaviors during normal and experimental conditions.

Water availability, for example, is particularly important in the semi-arid African study area due to competition between humans and wildlife. Accordingly, the researchers are investigating what happens when a usual water source is removed. How do animals choose where to go next? Will they go to the closest alternative even if there is some danger associated with it? Or will they opt for one remembered by dominant individuals?

Images:
Scientists are tracking Plains Zebras to learn when, where and why zebras move from one place to another. This new knowledge will help decision-makers who are faced with the difficult task of balancing the needs of wildlife with the ever-increasing human population.
Credit:
Ilya R. Fischhoff, Princeton University

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Zebra

Tracking Technology

ZebraNet is an extremely energy-efficient system that uses global positioning system (GPS)-enabled collars to track networks of animals. Each ZebraNet collar functions as a wireless computer that logs and transmits information about its wearer's location, movements and encounters with other collared animals every eight minutes. As two collars come into close proximity, they transmit all of their stored information to each other. By sending and receiving data from other tracked animals, each collar acts like a mobile base station. Information from one collar yields data from many animals.

For watering trough surveillance studies, researchers designed a camera system with deep-cycle batteries for power, infrared illumination for nighttime recording and time-lapse VCR for image recording. A metal housing protects the components from curious animals.

Images:
A Plains Zebra wears a ZebraNet tracking collar around its neck. The collar's batteries recharge using embedded solar cells.
Credit:
Pei Zhang, Princeton University

The Secret Lives of Wild Animals — Text-only

Zebra

Movie
Learn more about how scientists are gaining insights into zebra decision-making.

MANY WILD ANIMALS AT WATER HOLE

ILYA FISCHHOFF: When we see animals on a landscape, we often wonder, how did they choose this place?

ZEBRA STANDING ALONE IN OPEN FIELD
Like people, animals must choose where and when

ZEBRAS GRAZING
to eat,

ZEBRA LYING IN FIELD
to rest,

ZEBRAS AT WATER HOLE
to drink,

SEVERAL ZEBRAS TOGETHER
and who to be with,

LION WALKS UP TO ANOTHER LION
all while avoiding dangers.

ZEBRAS MINGLING IN GROUPS
We are studying animal decision-making on real landscapes.

MAP OF AFRICA; ZOOM IN TO SHOW EXACT LOCATION
We focus on plain zebras, living in Kenya. Our population lives in Laikipia, a biologically rich ecosystem, where people and wildlife

SHOT OF SKY, MOVING DOWN TO ZEBRAS WALKING IN LINE
SHOT OF LEOPARD
coexist….and sometimes conflict.

ELEPHANTS WITH YOUNG
One of our field sites is Ol Pejeta Conservancy, the wildlife preserve which supports its operations

CATTLE
through cattle ranching and tourism.

RESEARCHERS EXAMINING ZEBRA, ZEBRAS GRAZING
There, we observe the movements and behavior of zebras directly from a car,

ZEBRA WITH GPS COLLAR WALKS THROUGH FIELD
or remotely using GPS radio collars and

VIDEO: SHOT OF BIRD AT MAN-MADE WATER HOLE
video cameras that we set up at water holes in the four areas of the reserve.

ZEBRA LOOKING DIRECTLY AT CAMERA
One of our main questions is,

VIDEO: ZEBRAS AT MAN MADE WATER HOLE
how do zebras decide when and where to go to drink? As zebras come to water, they are captured on video. We can recognize each individual by its distinctive stripe patterns.

VIDEO: CATTLE DRINKING
Understanding how animals like zebras make decisions about water is essential to wildlife being able to share limited water sources with people and their livestock.

VIDEO: MAN WITH DOG ON FARM
In Laikipia, rainfall is low, and droughts are frequent.

VIDEO: ZEBRAS DRINKING AT WATER HOLE IN DAYTIME
Our videos give us a far more complete record of individual drinking decisions than has been possible before. We now know that zebras prefer drinking in the morning

VIDEO: LIONS SECLUDED BY DARKNESS
and rarely come at night, when lions are more active. We can identify especially dangerous times and locations from lion visits to the water holes.

VIDEO: ZEBRAS AND WILD BOARS AT EMPTY WATER HOLE
Having collected baseline data, we do experiments. If we temporarily take water away from a site, then zebras show us by their next move how they choose among water holes.

ZEBRAS WALKING IN LINE
As one might expect, zebras prefer to walk less to reach an alternative water site.

ZEBRAS COME TO ANOTHER WATER HOLE
We often observe them walking directly to the closest water hole. In choosing the closest option, zebras may go to a water hole they would otherwise rarely use.

ZEBRAS KNEE DEEP IN WATER
In some cases, the water hole closest to the one we've just emptied is in a dangerous place,

ZEBRA WALKS PAST HEAVY BRUSH
surrounded by bushes where we know lions rest and hide.

ZEBRAS RUNNING FROM HEAVY BRUSH
Zebras experience conflict in choosing between this close but dangerous option or a safer place that is a farther walk.

LIONS NEARBY
They sometimes come very near to the risky option before

ZEBRAS IN OPEN LAND, LOOK BACK AND FINALLY FORGE AHEAD
backing away, and continuing on to drink at a safer alternative.

ZEBRAS GRAZING. .
These experiments open a new window into the working mind of animals in the wild.

FADE TO MANY WILD ANIMALS AT WATER HOLE

Movie Credits

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The Secret Lives of Wild Animals — Text-only

Zebra

Quick Facts
PLAINS ZEBRA
(Equus burchelli)

SIZE
Plains zebras are 47-55 inches tall at the shoulder and weigh about 650 pounds.

HABITAT and RANGE
Plains zebras are abundant in the grassy plains of eastern and southern Africa.

DIET
They feed mainly on a variety of grasses and occasionally on leaves and twigs.

CHARACTERISTICS
Plains zebras are very social animals. They live in family groups with one dominant male, several females and their recent offspring. Several groups often come together to form a herd, which may associate with other species, including wildebeests.

A zebra's stripe pattern is unique and can be used for identification throughout its life.

Images:
Researchers are using newly developed global positioning system (GPS) tracking collars and video surveillance to learn more about the environmental needs and habits of Plains Zebras in Africa.
Credit:
Nicolle Rager Fuller,
National Science Foundation

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Zebra

Location
Researchers collaborate with the Mpala Research Centre and Ol Pejeta Conservancy in Kenya, Africa to evaluate zebra behavior.

Credits: (Above) Nicolle Rager Fuller, National Science Foundation. (Right) NASA World Wind

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Zebra

Researchers and Support

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- The Pew Charitable Trusts

Images:
1. Margaret Martonosi, Princeton University
2. Daniel I. Rubenstein, Princeton University
3. Ilya Fischhoff, Princeton University
4. Ilya Fischhoff, Princeton University (left)
Christopher M. Sadler, Princeton University (right)
5. Pei Zhang, Princeton University
Credits:
1: Pei Zhang, Princeton University
2: Omni Productions
3: Justine Cordingley, Princeton University
4, 5: Margaret Martonosi, Princeton University

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Seal

Overview

They say if you really want to get to know a place, let the locals show you around. So, researchers at Antarctica's McMurdo Sound are doing just that by equipping Weddell seals with underwater cameras and data recorders.

By using the seals as research partners, the scientists are learning not only about seals—as they dive some 2,000 feet below the icy waters in search of food—but also about the habits of two ecologically important fish species. The Antarctic silverfish and Antarctic toothfish play major roles in the food web but are hard to study because they live out of sight beneath the ice pack.

Most knowledge about these fish species comes from information gleaned from the trawl catches of commercial fishing boats and the stomach contents of predators. Now, using the 'seal cam'—a video camera mounted on the seal's head and attached to sensing devices—researchers get a firsthand look at the fish in their own habitats as seals search them out.

Even with little change in the amount of daylight—the sun is up 24 hours a day in the austral summer—seals found silverfish at average depths of 1,135 feet during the day and 827 feet at night. Toothfish, thought to be bottom-living fish, generally hung around at depths of 55 to 550 feet and also seemed to move deeper during the day.

Both fish and seal proved to be fast. During one particular two-and-a-half minute pursuit, the two animals reached speeds of 7 miles per hour.

Scientists say such sampling devices attached to predators could help study other marine mammals that are particularly hard to study in the open ocean.

Images:
1. Researchers are using Antarctica's Weddell seals as research partners by equipping them with underwater cameras and data recorders. Credit: Commander John Bortniak, NOAA Corps
2. Scientists are learning more about the Weddell seals' diving characteristics and feeding behaviors by temporarily attaching cameras and other data recording instruments to them. Credit: James Hebrlee, National Science Foundation
3. Weddell seals are generally calm, sedentary animals, but they are highly adapted to hunt for fish beneath the extensive ice of Antarctica's McMurdo Sound. Credit: Mike Cameron, National Marine Mammal Laboratory

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Seal

Tracking Technology

Scientists temporarily equip adult Weddell seals with a video camera, near-infrared light-emitting diodes (LEDs) and data recorders to record encounters with prey as well as the seal's position, depth, compass heading, flipper stroke frequency and swimming speed. The LEDs are invisible to the seals and their prey, but allow the camera to capture images up to three feet away in total darkness.

Images:
A Weddell seal displays the 'catch of the day,' an Antarctic toothfish. Researchers are using the 'seal cam,' which is attached to the seal's back, to see what goes on underneath the Antarctic ice.
Credit:
Randall Davis, Texas A&M University; images under authorization of Marine Mammal Permit No. 821-1588-01

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Seal

Movie
Join Weddell seals as they search for food and help researchers learn more about the marine life in the waters surrounding Antarctica.

VARIOUS SCENES—SEALS ON ANTARCTIC SHORE

NARRATOR: *Weddell seals—amazing animals…*

SEAL LOOKING AT CAMERA

incredibly well adapted to hunting in the

SEAL EMERGING FROM ICE

ice covered waters of Antarctica.

SEAL UNDER WATER

The seals feed on fish; in particular,

ANTARCTIC SILVERFISH

Antarctic silverfish and

ANTARCTIC TOOTHFISH

toothfish.

LEE FUIMAN

Professor Lee Fuiman.

SEAL WITH CAMERA MOUNTED ON HEAD
INSET: SEAL RELEASED INTO OCEAN
FUIMAN: We designed a study which used specially built equipment attached to the seals that enabled us to not only visualize

INSET: UNDERWATER SCENES FROM SEAL'S POINT OF VIEW
the water in front of the seal with a video camera placed on the head of the seal, but also reconstruct the movements of the seal throughout its entire dive, because on the back of the seal, we had a computer
SENSORS ATTACHED TO SEAL'S BACK
with a lot of sensors attached to it that included the depth, the speed and the compass direction of the seal.
INSET: ANIMATED SWIMMING PATH CHART
And from this information, we were able to reconstruct the three-dimensional swimming path of the seal from the start to the end of the dive and know exactly where the capture of the prey occurs.

SEAL EMERGES THROUGH HOLE WITH CATCH

Perhaps what was particularly unique about our work is the fact that we used a predator as a sampling device.

SILVERFISH

And because of the new approach, we were able to learn new things about

TOOTHFISH

the species upon which the seals prey.

SILVERFISH
INSET: FISH SWIMMING IN ANIMATED DEPTH CHART

NARRATOR: They found that Antarctic silverfish swim deeper in the daytime than at night.

FUIMAN: Now, that's not particularly odd for open water fishes, to be deeper in the daytime than they are at night, but what's really interesting is that these fishes are doing that

SUN SHINING ON ANTARCTIC TERRAIN

in the Antarctic at a time of year when there is no sunset, that is, the sun is up 24 hours a day.

SILVERFISH NEAR SEA BOTTOM

And so, if these fish are responding to light intensity on the surface, by the time it gets down to the depth where they are, it's a very, very small amount of light and a very small difference in light between midday and midnight, so that's very interesting. They are shoaling fish—that is, they swim in groups.

INSET: SEALCAM RECORDS FISH CAPTURE

NARRATOR: The researchers know this because the seals often caught at least five silverfish in a single dive. .. and sometimes, up to twenty. And

VARIOUS SHOTS OF ANTARCTIC TOOTHFISH

what did the study show about Antarctic toothfish--another ecologically important fish species in McMurdo Sound, Antarctica?

FUIMAN: Prior to this study, it was thought that Antarctic toothfish are bottom living fish. Well, it turns out that although we saw a relatively small number of toothfish,

INSET: SEAL SWIMMING UNDER WATER

these occurrences all were in very shallow water. Our seals never encountered toothfish at great depths. We can gain a lot of useful information about prey distributions and prey behavior from this approach of using predators as guided high-speed sampling devices,

SEAL UNDERWATER, APPROACHING HOLE IN ICE

and this approach could help us with other species of marine animals that are particularly difficult to study in the open ocean.

CLOSEUP OF TWO SEALS ON SHORELINE

Movie Credits

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Seal

Quick Facts

WEDDELL SEAL
(Leptonychotes weddellii)

SIZE
Adult Weddell seals are about 10 feet long and weigh 850 to 1,100 pounds. Seal pups weigh about 60 pounds at birth and nearly 300 pounds by the time they are six weeks old.

HABITAT and RANGE
Weddell seals inhabit the waters and ice surrounding Antarctica. They are the southernmost-ranging mammal permanently inhabiting the continent.

DIET
Weddell seals feed on fish and squid. They may eat over 100 silverfish in a single dive. A Weddell seal has been reported attacking an Antarctic toothfish that weighed over 100 pounds.

CHARACTERISTICS
Weddell seals can stay underwater for more than an hour, while diving to depths of over 2,000 feet. During the winter months, when Antarctic waters freeze over, seals keep a breathing hole open by gnawing through the ice. They are generally calm, sedentary animals that are easily approached by humans.

ANTARCTIC SILVERFISH
(Pleuragramma antarcticum)

SIZE
Antarctic silverfish are six to eight inches long.

HABITAT and RANGE
Antarctic silverfish inhabit the Southern Ocean surrounding Antarctica.

CHARACTERISTICS
Antarctic silverfish are very important in the Antarctic food web as a major food source for other fish, seals, whales and seabirds.

ANTARCTIC TOOTHFISH
(Dissostichus mawsoni)

SIZE
Antarctic toothfish reach six feet in length and can weigh over 165 pounds.

HABITAT and RANGE
Antarctic toothfish inhabit the Southern Ocean surrounding Antarctica.

CHARACTERISTICS
Antarctic toothfish take seven to 10 years to reach sexual maturity and can live for over 40 years. They are closely related to the Patagonian toothfish, which is popularly known as Chilean sea bass.

Images:
Weddell seals are the southernmost-ranging mammal to permanently inhabit Antarctica. During the winter months, when Antarctic waters freeze over, seals keep a breathing hole open by gnawing through the ice.
Credit:
Nicolle Rager Fuller,
National Science Foundation

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Seal

Location
At McMurdo Station, Antarctica, scientists are attaching underwater cameras and multi-sensor data recorders to Weddell seals in order to learn more about the seals' diving and hunting behaviors.

Credits: (Above) Nicolle Rager Fuller, National Science Foundation. (Right) NASA World Wind

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Seal

Researchers and Support

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- Terrie Williams, University of California, Santa Cruz
- William Hagey, Pisces Design, San Diego, California

Support Sources

- National Science Foundation, Office of Polar Programs
- National Oceanographic and Atmospheric Administration, National Undersea Research Program
- Texas A&M University, Office of Research

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Credits:
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2: Texas A&M University
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