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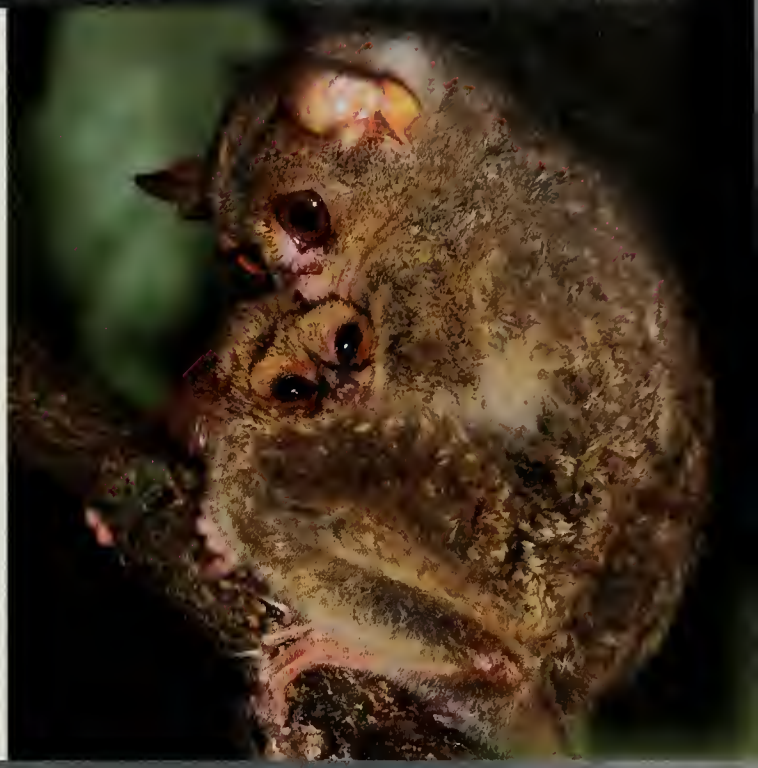
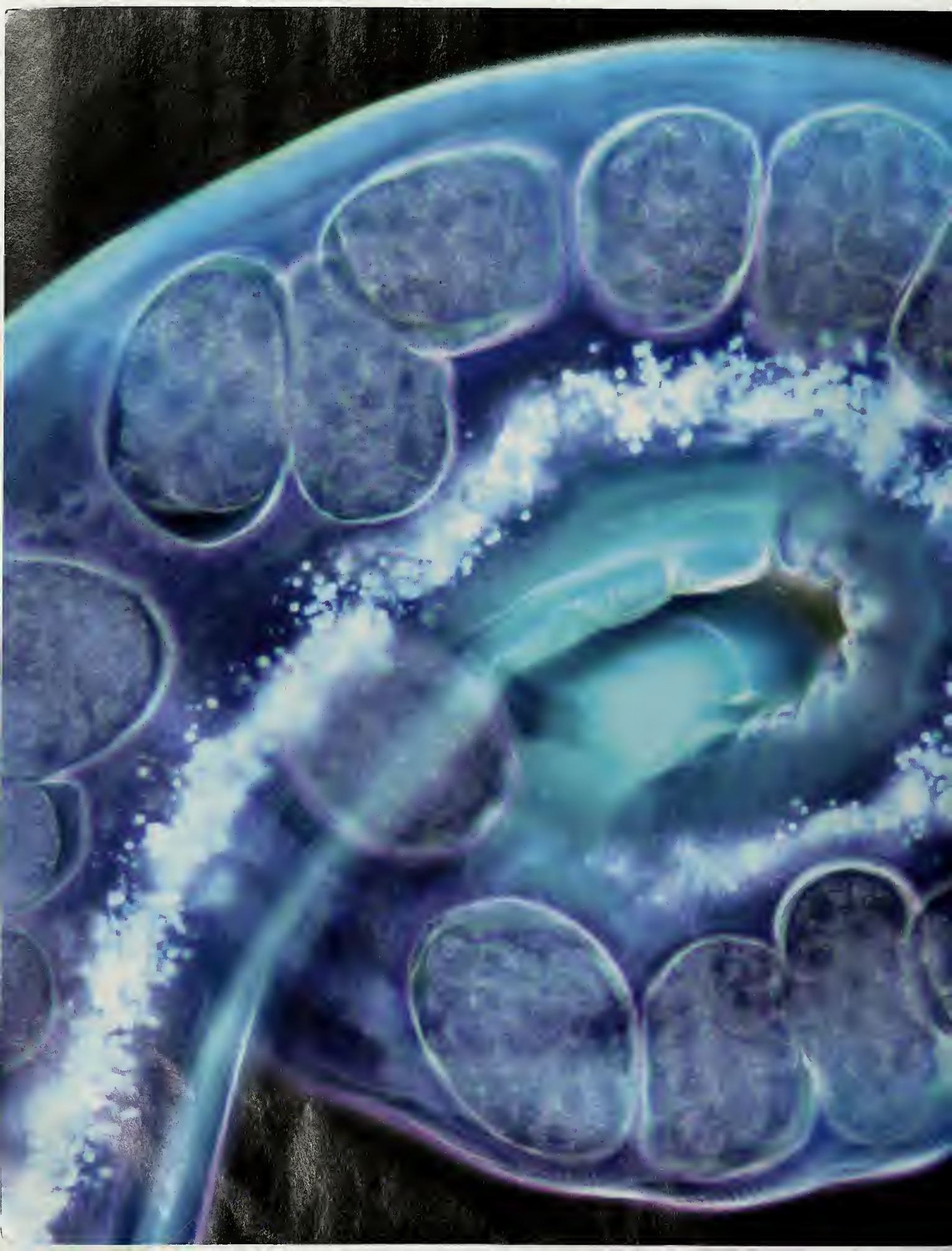


FEATURES

DEPARTMENTS

ON THE COVER: *Spectral tarsier in Tangkoko Nature Reserve, Indonesia, eats a cockroach.*
Image by Tim Laman



THE NATURAL MOMENT

WORM RING

Photograph by J. Claire Hoving

◄ *See preceding two pages*

THE NATURAL EXPLANATION BY ERIN ESPELIE

For a worm the length of this ! exclamation point, a wardrobe of 20,000 protein-coding genes seems excessive. People, after all, likely possess no more than 25,000. Nematode worms come in more guises than we yet realize—some 24,000 species and quickly counting. They ply ocean floors, plow soil, pock potatoes, plague pine trees, rage in human guts, and more. They now account for an estimated four of every five multicellular animals on the planet.

The worm pictured on the preceding two pages, *Nippostrongylus brasiliensis,* inhabits the innards of rats. Like many a nematode, it serves as an experimental model for understanding related organisms, in this case, human hookworms (also nematodes). Hookworm larvae often enter through the skin of a person's feet and travel the vascular system until they reach the lungs, where they get coughed into the trachea and swallowed. In the gut they mature, feed on blood, mate, and expel eggs to the outside, where the cycle begins anew. Some 740 million people worldwide are losing blood to adult hookworms.

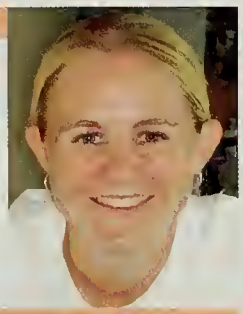
Female N. brasiliensis *worms stained with iodine*

Light micrograph of an unstained nematode

Although infections are rarely fatal, they pose a substantial danger to pregnant women and children.

Photographer J. Claire Hoving studies mammalian immune responses in Frank Brombacher's laboratory at the Institute of Infectious Diseases and Molecular Medicine of the University of Cape Town, South Africa. She used a Nikon light microscope to capture the (stained) tail end of a pregnant female *N. brasiliensis*—then color-reversed the image to blue. The eighteen round globules are eggs, shown at 1,200 times life size.

One of Brombacher's research aims is to understand how the mammalian immune system ultimately rids the body of adult worms. On the flip side, several research groups are *intentionally* infecting people with hookworms. As it happens, people with worms in residence are less prone to allergies, asthma, hay fever, and other disorders of hypervigilant immunity. Thus, some portion of the worms' lavish gene collection must be distracting—if not disarming—the hosts' immune cells.



J. Claire Hoving, who is completing her PhD in immunology at the University of Cape Town, South Africa, hopes to continue investigating the immune effects of infectious diseases. In her microscopy work, Hoving has gained an eye and appreciation for capturing the fascinating sights she encounters. Her images have appeared on the covers of *PloS Pathogens* (January 2007) and *EMBO Journal* (April 9, 2008). The Nikon Small World Photo competition has twice recognized her photographs, including the one featured here, which was cited as an "image of distinction" in late 2009.

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FROM THE PUBLISHER

To Our Readers

After a hiatus of seven months, *Natural History* is back in print. A series of events triggered the temporary suspension of the magazine, and there were other contributing factors that prevented us from resuming publishing sooner. Many of you were extremely frustrated in your attempts to find out what had happened to your subscription and disappointed that we did not find a way to keep you informed—a card, a letter, a notice on our website, a response to your phone calls, anything. I was able to write some of you and speak with others, but our staff was on leave, our offices in New York were closed, and our phones were forwarded to an answering service. The process of restarting the magazine took many twists and turns, with several false starts and dashed hopes.

Throughout this interruption, you as readers demonstrated your loyalty and your passion for the subject matter that *Natural History* has been publishing for the past 110 years. We don't take your goodwill for granted. It inspires us to do everything we can to assure the publication of this venerable magazine for another 110 years.

—*Charles E. Harris*

nature.net by robert anderson

GROUND WELL

RECENTLY ON THE TED (Technology, Entertainment, Design) Web site, I watched Anupam Mishra, a founding member of the Gandhi Peace Foundation, talk about the centuries-old engineering projects that are still used to collect and store water in the driest parts of India (see www.ted.com/talks/anupam_mishra_the_ancient_ingenuity_of_water_harvesting.html). With passion and humor, he demonstrated how those structures are often superior to modern water megaprojects. Mishra's talk reminded me of the natural aquifers beneath us, which store about 30 percent of the freshwater on Earth—at least thirty times as much as in all the world's lakes and rivers (ice caps and glaciers lock up the rest). In many places this precious supply is being extracted faster than natural processes can replenish it. For my guide to Web sites exploring groundwater resources, please visit the magazine online (www.naturalhistorymag.com).

ROBERT ANDERSON is a freelance science writer who lives in Los Angeles.

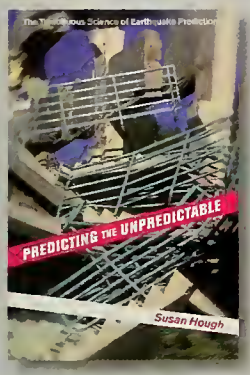
WORD EXCHANGE

Going Viral

In Druin Burch's article "The Virus Within" [10/09], he reports that "small genetic mutations in regulator genes can have major dramatic effects," but observes that the notion that such effects "could prove adaptive is questionable, given the complexity of biochemical systems." He then suggests that when viruses merge with cellular genomes, those

Continued on page 38

Natural Selections



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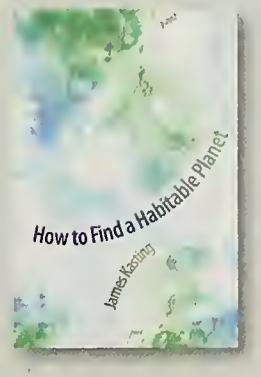

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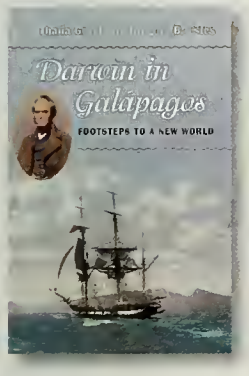

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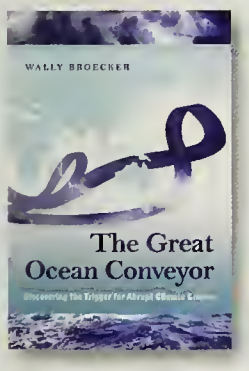

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JANNE BRODIN, NORWEGIAN UMB

In a Pig's Eye

Researchers have long used mirrors to gauge self-awareness in animals. (So far, dolphins, magpies, some primates, and an elephant have passed the test.) But mirrors can also test the ability of animals to learn Physics of Light Reflection 101—a different but still impressive achievement that was mastered, most recently, by pigs.

Donald M. Broom and two veterinary students at the University of Cambridge started by letting penned pigs look at themselves and their surroundings in a large mirror for five hours. Then, without the pigs looking, they positioned the mirror so it showed a bowl of food otherwise hidden behind a barrier. Seven out of eight pigs went around the barrier and found the bowl in just twenty-three seconds, on average, showing that they could learn to use a mirror to gather information about their surroundings.

In contrast, nine of eleven pigs that had never before encountered a mirror wrongly looked *behind* it in their search for food. (The tenth pig just walked around aimlessly, while the last one simply knocked over the food-obscuring barrier.)

Pigs are already known to be pretty smart, and this study neatly confirms it—though it remains to be seen whether they can pass the mirror test for self-awareness. (*Animal Behaviour*)

—*Stéphan Reebs*

Vertebrate Bias

Can invertebrates feel pain? "No" is the scientific consensus thus far on all but octopuses—but that may just reflect an ingrained human bias against "simple" animals. Last spring, Robert W. Elwood of Queen's University Belfast and graduate student Mirjam Appel caused ripples when they reported that hermit crabs—those little crustaceans that live in salvaged seashells—appear to experience pain. The two biologists subjected each crab to a slight electric shock delivered by wire through a hole in its shell. The shockee hastily exited its shell and rubbed its abdomen where it had been zapped—much as we and other vertebrates respond to painful stimuli.

Now Elwood and Appel have gone further, showing that hermit crabs not only seem to feel pain, but can remember it, too. The team's shocked subjects usually reenter their mobile homes, but during the twenty-four hours following the bad experience they are more likely than unshocked crabs to inspect an empty shell nearby. In fact, a half hour after the shock, they're also more likely to abandon their old shell altogether and trade it in for the new one.

Scientists usually invoke reflex, as opposed to pain sensation, in explaining invertebrates' responses to noxious stimuli. One key criterion they use to identify pain objectively in vertebrates is the creation of memories that affect such decisions as the hermits' shell swap. By that measure, Elwood and Appel argue, hermit crabs—and perhaps other crustaceans—probably do feel pain. (*Animal Behaviour*)

—*S.R.*

Captive hermit crab inspects a prospective new home.

ROBERT W. ELWOOD

Sailing Ancient Seas

Paleontologists have long noted that pterosaur wings were like sails, being membranes that could flex in either direction. The resemblance may prove to have been more than passing: preliminary research suggests the piscivorous reptiles sailed the seas as well as the skies during their extended reign from 220 million to 65 million years ago.

Sankar Chatterjee, a paleontologist at Texas Tech University in Lubbock, and three colleagues (one an aeronautical engineer) studied fossils of the crow-size pterosaur *Tapejara wellnhoferi*. They reconstructed the animal and made a series of models to examine its range of motion, then analyzed its aero- and hydrodynamics with a biomechanical computer simulation.

Landing at sea, a foraging pterosaur could raise its wings to catch a breeze, the team thinks. Strong collagen fibers—much like sail battens—maintained the wings' shape in the wind. *T. wellnhoferi*, like many pterosaurs, possessed a huge membranous head crest that the team likens to a jib. And the reptile's sternum and legs would have contacted the water much as a trimaran's hulls do. Rigged thus, the team reasons, pterosaurs could skim across the surface with minimal effort, probably for short distances between bouts of fishing.

The researchers plan to test their ideas with wind-tunnel experiments next year. In fact, they're developing a robotic drone based on *T. wellnhoferi* that they expect will be able to fly, walk, and sail. (Annual meeting of the Geological Society of America)

—*Rebecca Kessler*

Computer rendering shows how Tapejara wellnhoferi *might have sailed, catching the wind with its head crest and wings.*

SHANE NEUFELD PHOTOGRAPHY

Reverse Transmission

About forty years ago in Poland, an adventurous strain of the bacterium *Staphylococcus aureus* made a seemingly unprecedented move, a new study shows: it crossed over from humans to chickens and settled in to stay. *S. aureus* has since spread worldwide to become the leading cause of lameness in broiler chickens.

J. Ross Fitzgerald and graduate student Bethan V. Lowder of the University of Edinburgh, along with eight colleagues, discovered the big jump and reconstructed the pathogen's diversification and pandemic spread. To do so, they compared DNA sequences from fifty-seven *S. aureus* samples isolated during the past half century from poultry living on four continents. Remarkably, the team found, most poultry-infecting strains belong to a single genetic group and are closely related to a few human strains that circulated exclusively in Poland in the 1990s. That suggests a single, recent, human-to-poultry host switch.

The poultry strains subsequently lost genes involved in human pathogenesis and acquired ones that confer virtual imperviousness to attack by chicken immune cells, the team found. Thus, the avian strains seem to have adapted to their new host. That's a first from the short list of pathogens that animals can pick up from humans (usually we hear about animal pathogens adapting *to* humans).

In the human-to-poultry case, the conditions seem uniquely optimal for spreading infection: a few multinational companies distributing huge numbers of live chickens worldwide. But microbes are resourceful; most likely, epidemiologists haven't looked hard enough for other cases. (*PNAS*) —*Graciela Flores*

A Sticky Puzzle

GARY H. DICKINSON

Amphibalanus amphitrite

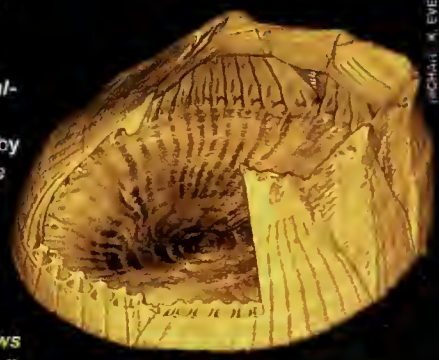
Barnacles make their living clinging to one spot and filter-feeding on plankton. The virtually insoluble, protein-rich cement that anchors them in place has been tricky to study, though not for lack of interest: scraping the crustaceans from ships' hulls and other marine gear is a huge expense.

"No one ever thought to ask the simple question . . . *what is [the] glue related to?*" says Daniel Rittschof of Duke University, who, with his then doctoral student Gary H. Dickinson and several colleagues, recently discovered the glue's surprising biochemical origins. Since compounds essential to survival can be evolutionarily conserved over millennia, Rittschof and Dickinson hypothesized that barnacle glue shares a curing mechanism with another sticky bodily fluid: clotting blood.

Working with the *Amphibalanus amphitrite* barnacle, Dickinson collected its glue by pricking the base plate of the shell and gently squeezing out droplets. Investigating the glue's components, the team detected a protein-cutting enzyme, or "protease," known to be involved in human blood clotting. Then, closely examining cement proteins, they found amino acid sequences that, despite a billion years of evolution, exactly matched sequences in a human blood-clotting protein that cross-links fibers during scab formation.

Rittschof suspects that barnacle-cement bonding is an evolutionary modification of wound healing, and that many other marine invertebrates use the same chemistry to get a grip. (*Journal of Experimental Biology*)

—*Lesley Evans Ogden*



MICHAEL K. EVERETT

X-ray tomographic image shows section of an A. amphitrite shell.

Citizen Maya

Very old artworks provide a fascinating glimpse of ancient life, but not without limitations: they typically portray the lifestyles of the rich and famous (rulers, royals, generals, and priests), abandoning the masses to the mists of history. That's why the recent discovery of a 1,300-year-old mural at Calakmul, Mexico, is so significant. It is the only known pre-Columbian artwork depicting ordinary Maya engaged in everyday activities, rather than serving the wealthy.

Archaeologists first unearthed the pyramid bearing the painted exterior walls in 2004 and are still in the process of restoring it. The murals show Maya of both sexes preparing and dispensing food, or carrying baskets, sacks, and large vessels. (Previously discovered images mainly show men.) The women wear face paint, and both sexes sport broad-brimmed hats, earrings, necklaces, and pendants. Hieroglyphic captions identify some people by their trades: salt person, tobacco person, and maize-gruel person, for example.

CALAKMUL ARCHAEOLOGICAL PROJECT

1,300-year-old mural portrays a Mayan porter carrying a large vessel.

Ramón Carrasco Vargas, of the National Institute of Anthropology and History in Campeche, Mexico, directed the excavation with two colleagues. The trio report an intriguing observation: the original pyramid was expanded over the centuries, but its murals were preserved with packed mud before being built over. The Mayan builders may have had to cover the murals—you can't stop progress—but they were apparently still reluctant to destroy such exceptional artwork. (*PNAS*) —*S.R.*

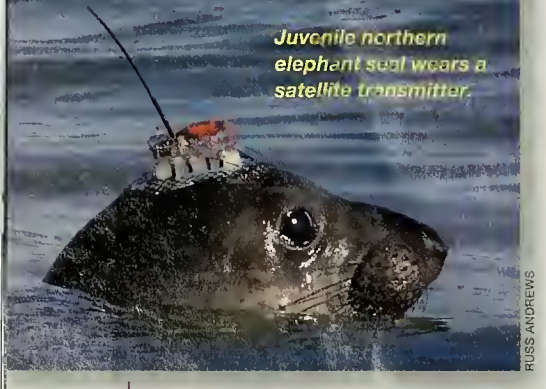
Deep Sleep

When northern elephant seals (*Mirounga angustirostris*) migrate between their breeding and foraging grounds, they spend as long as eight months at a time at sea. They're almost always underwater, devoting only a few minutes to breathing at the surface between dives—hardly long enough for a nap. After a sip of air, they often sink quickly to 500 feet, then drift farther down in a shallow descent. Some experts have suggested that the drift is when the seals catch their Zs.

To find out, a team led by Yoko Mitani of Hokkaido University in Japan fitted six juvenile elephant seals with satellite transmitters and newfangled data loggers capable of recording such information as body position, flipper strokes, and the 3-D path of movement. They tracked the seals for up to eight days off the California coast. The resulting data revealed that drifting seals usually rolled over on their backs, stopped stroking, and spiraled peacefully down for a dozen minutes or so. (The team dubbed it the "falling-leaf phase" of the descent.)

The belly-up position is consistent with slumber: ventral blubber tends to flip an unresponsive seal's body. What's more, a few animals that drifted in shallow areas hit the seafloor without reacting.

The initial rapid descent is important, Mitani's team points out. It takes the seals below the usual cruising depths of their main predators, killer whales and white sharks. And their slow sinking thereafter makes for a relatively short ascent for air once they awake. (*Biology Letters*) —*S.R.*



Juvenile northern elephant seal wears a satellite transmitter.

RUSS ANDREWS

Great Basin bristlecone pines grow amid dead wood near tree line in Nevada.

Fine Times for Pines

Great Basin bristlecone pines, *Pinus longaeva*, are the Methuselahs of the living world. Many live trees are several thousand years old, and the record holder clocks in at around 4,840 years. The pines, which subsist high on the mountain slopes of the western United States, grow very slowly. But, old age be hanged, those at the highest elevations are now having the time of their lives, thanks to global warming.

Trees leave a record of their growth in their annual rings—the wider the ring, the greater the growth that year. A team of dendrochronologists four strong, headed by Matthew W. Salzer of the University of Arizona in Tucson, reports that pines high up near the tree line in California and Nevada developed wider rings during the second half of the twentieth century than during any other fifty-year period of the past 3,700 years.

That's probably a consequence of milder temperatures, because only pines close to the tree line—those most limited by cold—exhibit the effect. If the growth spurt were caused by more-abundant carbon dioxide boosting photosynthesis, or by a wetter climate, then lower-elevation trees should have wider rings too. They don't.

In fact, over the past century (for which good weather records exist), there is a significant correlation between tree-ring width at the tree line and mean air temperature—further support for the notion that the venerable trees are long-lived indicators of warming in western mountains. (*PNAS*) —*S.R.*

MATTHEW SALZER, LABORATORY OF TREE-RING RESEARCH, UNIV. OF AZ

Great Basin bristlecone pine

Rising Waters

Since 1900, global sea levels have crept upward about seven inches. Rising temperatures are melting glaciers and ice sheets, as well as warming the oceans directly, which causes them to expand. Various researchers have attributed only a portion of the rise in water level to carbon dioxide (CO_2) released by human actions—and blamed the rest on natural factors such as solar activity. The latest study goes much further, faulting people for more than three-quarters of the sea-level change during the past century.

Records of tide height have been kept for centuries at several seaports (Amsterdam since 1700, Liverpool since 1768, Stockholm since 1774, and many other places since 1850). Such long records have enabled Svetlana Jevrejeva, of the British government's Proudman Oceanographic Laboratory in Liverpool, and two colleagues to statistically model the influence of various factors on sea level during the past three centuries, and to extrapolate the findings over the past millennium.

The team found that up until about 1800, sea levels actually fell owing to volcanic eruptions that periodically injected ash into the atmosphere, veiling the Sun and cooling the Earth. But as the waters rose after 1850, the biggest contributing factor was increasing atmospheric CO_2.

Significantly, Jevrejeva's team calculated that without the ongoing, mitigating effects of volcanic activity since 1880, sea levels would now be about three inches higher than they are. (*Geophysical Research Letters*) —*S.R.*

Considering it took 485,000,000 years to create, it's hardly surprising what you'll find here. Not the least of which is perspective. It tends to happen when you're standing two thousand feet up, seeing things more clearly on the edge of an ancient glacier-carved fjord. A vantage point, one would think, that could only exist for two reasons: for the view itself, and the inescapable feeling that washes over you. The feeling you get when once again, anything's possible. (Not bad for a three-hour flight.) **To find your way to the edge of Canada, call Kelly at 1-800-563-6353 or visit NewfoundlandLabrador.com**

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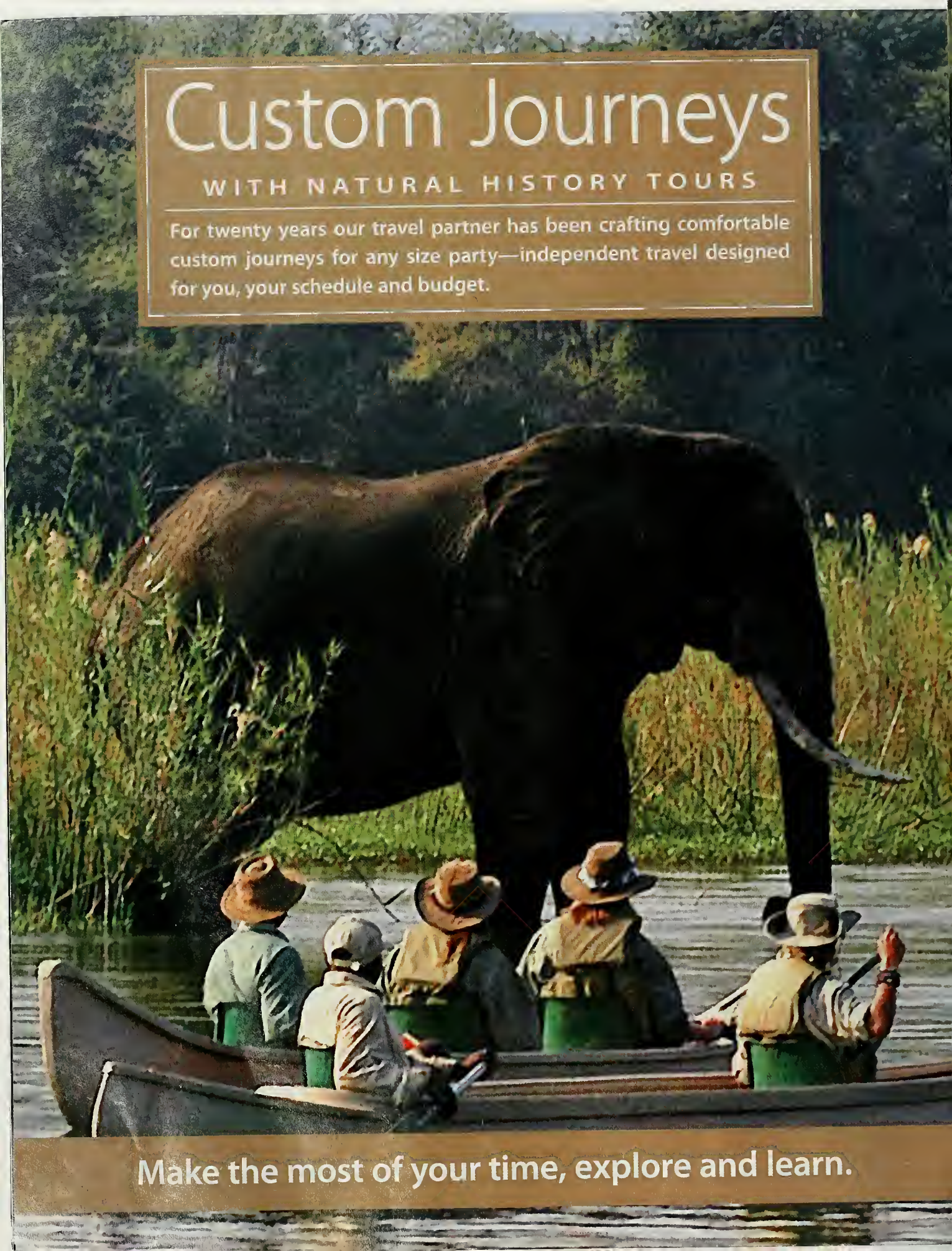
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The Next Wave

What makes an invasive species stick?

COLONISTS OF ANY ERA—and of any species—meet with failure more often than not. It is almost the rule. Yet failures seldom garner the same attention as successes, particularly in hindsight. Europeans, for instance, tried to establish themselves in North America at least eighteen times before Jamestown eventually flourished. Likewise, another set of colonists probably made many attempts before gaining a foothold on the continent: Argentine ants (*Linepithema humile*).

The first of those ants to have survived in the United States, perhaps a few related queens and their attendants, arrived no later than the 1890s, when colonies were reported in Louisiana. It is hard to imagine a creature more fragile than one of those queens, her exoskeleton not much thicker than the film on a soap bubble. She may have come on a ship bringing coffee or some other product. Or perhaps she drifted across the sea on a scrap of floating debris. After the long journey north, she would have been slow, weakened by hunger, and bereft of army or armor—hardly the circumstances from which an empire might rise. And yet one did.

The precise trajectory of those first queens went unnoted, but analysis of the mitochondrial genes of the Argentine ants now in California and the southeastern U.S. suggests that a single clump of queens and workers made it to Louisiana and from there to California and elsewhere in the warm parts of the U.S. By 1900 the ant was in Portugal, by 1905 in France, by 1926 in Italy, and then things sped up. By the 1940s it had made it to Australia, the Azores, and on. The Argentine ant is now found in hot areas of more than 320 countries. And so far, genetic data seem to indicate that many, if not most of the introduced populations of Argentine ants might descend from the original clump of workers and queens.

What distinguishes such a success from the countless failures? The differences might be due simply to chance. But might there not also be rules of success and failure—rules that could be decoded from the husks of abandoned towns and unsuccessful queens? No one knows why Roanoke became the Lost Colony and Jamestown didn't, though many have looked for an explanation. The record of failure is sparse: marks on a tree, an axe head, a bit of brick. Nor do we know how many birds arrived in the Galápagos and failed before the finches arrived and succeeded. Nascent populations of species that people have inadvertently carried to new lands are easier to find and observe. Such introductions of ants resemble scientific trials, as they have been repeated with every possible permutation—different weather, different species, different places. At least forty-seven ant species have become established just in Hawaii (whose islands have no native ants).

A 1999 review by Terrence P. McGlynn, an entomologist now at California State University, Dominguez Hills, identified 147 ant species that had been introduced—always accidentally—to new regions around the globe. A decade later, so many more ant species have been trafficked by people that the actual number may be two or three times as great. McGlynn used to keep track of the new arrivals on a Web page, then lost count. Each day ants are moved around the world. Each shipment is, like the first line of a novel or the first small steps of a nation, a beginning with a far-off and unknown end.

LIKE MANY BIOLOGISTS, Andrew V. Suarez, of the University of Illinois at Urbana–Champaign, struggled for years with the question of which colonizing organisms fail and which succeed. He studied it the hard way—with fieldwork and lab experiments—until 1999, when he found some brown jars. He found them the way a child hopes to find treasure, accidentally. He had gone to the Smithsonian Institution National Museum of Natural History's National Insect Collection to look for early samples of Argentine ants collected in the United States or at its borders. He hoped to find out how vintage specimens of Argentine ants were related to the existing populations: would they be kin to the first successful queens—or, perhaps, evidence of other, less successful attempts?

Ted R. Schultz, a myrmecologist who works in the museum, pointed Suarez to samples that had been collected throughout the twentieth century. There, among many thousands of jars of insects labeled with taxonomic notes, locations, and dates, Suarez ultimately found relatively few samples of Argentine ants. But what he found besides them was, to his mind, far more interesting: some of the ethanol-filled jars were jammed with vials of ants collected at ports of entry in the eastern U.S. from 1927 to 1985. They were ants that border agents, tired, overworked, and overwhelmed, had picked from plants being shipped into the U.S. Could those ants be identified as members of species that had failed or succeeded as colonists, and if so, could the specimens be used to compare the two groups? As curious as Pandora before him, Suarez opened the jars.

In the jars and vials were 394 separate samples of ants. Suarez solicited the help of two friends, ant ecologist David A. Holway of the University of California, San Diego, and Philip S. Ward, guru of ant gurus, at the University of California, Davis. Altogether they identified 232 distinct species, many of them completely new to science. Twenty-eight of those species had survived and established themselves somewhere in the U.S. (from separate introductions that occurred either before or after the arrival of the interdicted ants). The rest, as far as was known, had never made it through.

Suarez considered the traits possessed by each of the ant species in an attempt to see what might have predisposed some of them to survival. He measured whether they were big or small. He examined whether each lived in the canopy or on the ground, and whether they were from one subfamily or another. He also looked at a simpler possibility: that "survivor species" tended to be those introduced more than once. The evidence in the jars showed, for example, that Argentine ants had arrived at least twice. Were successes just a consequence of the number of tries? Might history, at least of ants, be a consequence of persistence—try and, as your mother might have said, try again?

The theory that surviving species tend to be those that were introduced more than once held up, on average. There were also other patterns. Ants that live exclusively in tree canopies, for example, were very unlikely to succeed unless they were versatile in their choice of host trees. But one conclusion seemed inescapable: the more species we move around the Earth, the more will escape into new habitats and have a chance to survive.

Surviving is just the beginning

of the story, however. When a pioneering group sets up camp and starts living in a new place, possible futures diverge. One species might be wiped out within a generation or two. A second might survive, but never become common. Yet another species might thrive, eventually spreading across states, continents, and even the world! Even if surviving in a new environment is sometimes a matter of being introduced again and again, thriving is a different story. Relatively few invasive species truly prevail.

One of the most prominent explanations of why an ant empire rises has its roots, not in a brown jar, but in a hole. In the late 1980s, biologist Ted J. Case and zoologist Robert N. Fisher at the University of California, San Diego, were studying coastal horned lizards (*Phrynosoma coronatum*). The two put out lizard traps—small equivalents of holes dug to catch, say, African lions—all over southern California. They wanted to see where the lizards were doing well, declining, or just plain gone. Case and Fisher knew when they began the work that certain lizard populations were dwindling, an observation corroborated when the trap results started to come in. As the project continued, it became more and more clear that the horned lizards were on the decline because of Argentine ants. It turned out that the native ants on which the lizards fed were being displaced.

One curious thing about Argentine ants is that they are, despite their apparent meekness, ecologically dominant. They are squishy, small, stingless wimps, as ants go, yet somehow they have managed to overpower the big, tough native ants. It's almost as if they are a force out of a Gabriel García Márquez novel: ethereal things unperturbed by the ordinary rules of cause and effect, strength and weakness.

There's another strange thing about Argentine ants, as Suarez and Holway discovered in collaboration with evolutionary ecologist Neil D. Tsutsui, now at the University of

California, Berkeley (the three have gone on to become myrmecological supercollaborators of a sort). If you take an Argentine ant from what looks like one colony and put it together with one from a distant colony, they accept each other. In fact, you can perform that trick over much of California and very few of the ants will fight. It is as though all of the Argentine ants in California are part of a few huge colonies—"supercolonies," they've come to be called. Although "super" refers to the underlying unity of multiple individual colonies, it also seems to imply superpowers: the possession, perhaps, of thousands of tiny red capes.

Ted Case joined forces with Holway and Suarez for an experiment to test whether the lack of aggression among those ant colonies somehow helped them to compete with other species. Might it simply be that by not fighting with their neighbors, the Argentine ants wasted less energy on war and could spend more time on the good stuff—sex and finding food? Does such peace pay? It turned out that, yes, aggressive ants wasted energy fighting (and dying), and so gathered less food and fared poorly, in general. Peace pays (at least peace with one's kin), and so Argentine ants have made bank everyplace they have moved.

In fact, it isn't just for the Argentine ant that peace seems to pay. Supercolonies and the unicolonial populations they create look to be common among invasive ants. Just last year, big-headed ants (*Pheidole megacephala*)—a species probably from southern Africa, now introduced across much of the tropical world and thriving—were found to form supercolonies. Other supercolonizers include the little fire ant (*Wasmannia auropunctata*), the European fire ant (*Myrmica rubra*), the garden ant (*Lasius neglectus*), three species of the genus *Monomorium* and six of the genus *Cardiocondyla*—none of them yet awarded common names—and more.

In warfare, be it urban or myrmecological, identifying one's enemies is key to besting them. The Bloods and Crips flash gang signs as symbols of their allegiance. Ants flash chemical badges identifying their home nest. Without such markers, no one knows who is friend or foe. When the clarity of "us versus them" breaks down, peace breaks out among colonies of an ant species. Different nests swap workers and queens, and the term "colony" becomes fuzzy. Experiments seemed to show that one conglomeration of Argentine ants stretched the length of California, another from Italy to Portugal . . . until, in 2009, workers from those two "colonies" (along with a third from Japan) were put together, and they didn't fight. Thus, across the entire globe, a few peaceful supercolonies could exist and expand.

ANSWERING THE QUESTIONS of why and how supercolonies form has provoked wars of a different kind, among scientists who mark territories on conceptual ground. Literally hundreds of ant biologists (and now even a few termite and wasp biologists) have studied supercolonies and their origins. Behavioral ecologist Deborah Gordon and colleagues at Stanford University have argued that supercolony formation is a consequence of many ant colonies having similar diets and consequently smelling the same, thus being incapable of distinguishing nestmates from outsiders. In contrast, Tsutsui, Suarez, and Holway have argued that ants' chemical "signature" is at least partly inherited, so when all the individuals in a population are descended from a common ancestor, they don't identify each other as "other" because in a genetic sense they *aren't* "other." Or maybe certain species are predisposed to form supercolonies, regardless of geography. At the messy boundaries of those debates, consensus even breaks down in formulating a definition of "supercolony." Yet regardless of how supercolonies emerge (and it may differ from species to species), it seems true that they are disproportionately common among invasive ants.

A handful of other traits found in many invasive ant species seem to relate to supercolony formation, such as having multiple queens (polygyny) in each nest. And the males are apt to mate with their sisters, enabling an ant colony to reproduce on its own—a handy trait in a new realm where mates are scarce. In addition, many invasive ants seem to rely on hemipteran husbandry. That is, the ants care for hemipterous insects, such as scale insects and aphids, which produce sugary food in exchange for protection and other favors.

Yet not all invasive ants fit that mold. Take the Asian needle ant (*Pachycondyla chinensis*)—so called for its painful sting. Native to Japan, the needle ant is now widespread in the southeastern U.S. It dominates and drives out many native ant species, with all the possible ecosystem-wide ripple effects that implies; yet it does not appear to form supercolonies. Nor do its colonies tend aphids. To explain such an exception, and perhaps the broader rule as well, let's return to the jars of ants Suarez found at the Smithsonian. The bigger story, the scoop from those jars, is the great

Continued on page 40

Married to the M

Brave in the face of predators and flexible in their family arrangements, tarsiers offer clues to the origins of sociality in primates.

By Sharon Gursky-Doyen

It may be two o'clock in the morning, but that's the middle of the workday when you are monitoring a nocturnal animal. I am on a mountainside in Tangkoko Nature Reserve on the Indonesian island of Sulawesi, using a flashlight and radio-tracking device to keep tabs on a diminutive primate, a spectral tarsier (*Tarsius spectrum*). All of a sudden I hear high-pitched shrieks from higher up the mountain. Following those sounds, I pick my way up the steep, forested slope as fast as I can. Somewhere a group of tarsiers is upset, and I want to know why. As I get closer to the commotion, I slow down, not knowing what awaits me. Cautiously, I scan the foliage for tarsiers and for whatever threat has caused them to call with such urgency. Then I see it: a large python coiled up in a tight ball. Four, five, no, six spectral tarsiers—each no bigger than my hand—are sounding the alarm. And they are all leaping *toward* the python.

The tiny tarsiers repeatedly lunge so close to the intruder that I think they are about to become snake dinner, and then they leap out of reach. One individual is truly brazen: he jumps onto the python's back and bites it! The snake's muscles ripple as it tries to capture and strangle the animal on its back. But the daring tarsier is too quick, and darts away. For nearly thirty minutes, the tarsiers lunge and retreat; even the individual I was following earlier arrives to join in the mobbing. Finally the python uncurls—it must be twelve feet long—and slithers away. After calling for another twenty minutes the tarsiers move off. But they remain skittish throughout the night, breaking out into alarm calls and frequently returning to the scene of the face-off.

The spectral tarsiers' mobbing of a predator is a total surprise. What might have prompted such brazen—and coordinated—behavior? I know that a male-female pair and two offspring, a juvenile female and an infant, sleep during the day near the site of the incident. But on my nightly "focal follows," the excursions in which I track the activity of one individual, I rarely encounter more than one or two tarsiers in any one place. Yet I've just seen at least six adults join together in attacking a python. Maybe the species is more gregarious than anyone has realized. And the incident is significant in another way: the vast majority of species known to mob predators are diurnal, not nocturnal.

Mobbing is but one of the enigmas about spectral tarsiers that have captured my attention over the past two decades. Another puzzle is why some individuals choose to be monogamous and others polygynous (one male mating with several females). Few species have such a variable mating system. By exploring those and other tarsier behavioral traits, and the ecological and social factors at play, I hope to shine a light on how group living evolved in primates.

Tarsiers, of which there are at least six living species, stand out in numerous ways. Their saucerlike eyes are larger, relative to the head, than those of any other mammal. The animals boast two or three pairs of nipples, even though a female gives birth to only one infant at a time (apparently not all of the nipples are functional). And they are the most carnivorous of the primates, with a diet consisting entirely of insects and, in some cases, small vertebrates.

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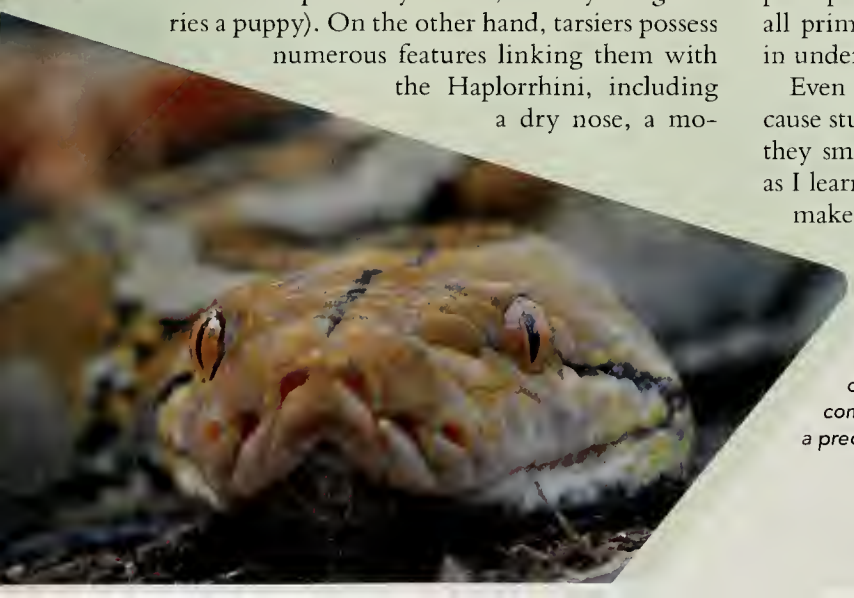
Spectral tarsiers and all the other living tarsier species are classified in the genus *Tarsius.* Beyond that, their taxonomic position has been a source of dispute. The eighteenth-century French naturalist Buffon, who, upon examining a juvenile tarsier, thought it might be a kind of opossum, was not the first to find them a bundle of contradictions. While other living primates fall fairly neatly into two main groups—the Strepsirrhini (the suborder that embraces lemurs, lorises, and galagos) and the Haplorrhini (the one that includes monkeys, apes, and humans)—tarsiers seem to belong to both at once.

A variety of characteristics mark tarsiers as Strepsirrhini: their small body size, grooming claws, nocturnal habits, and two-horned (as opposed to single-chambered) uterus, as well as aspects of their parental care (a mother will park her infant in a tree while she forages, and infants are transported by mouth, the way a dog carries a puppy). On the other hand, tarsiers possess numerous features linking them with the Haplorrhini, including a dry nose, a mobile upper lip that is not attached to the nose, a *fovea centralis* (a depression in the middle of the retina that increases visual acuity), and a hemochorial placenta, which provides close contact between the mother's blood and the fetal circulatory system. Certain skeletal traits, most notably an eye socket backed by bone, also seem to favor a haplorrhine connection, but they may have evolved independently.

Most taxonomists today assign tarsiers to their own infraorder within the suborder Haplorrhini, but their unusual combination of traits shows that their lineage branched off long ago from the rest of the suborder. Fossils representing *Tarsius* and closely related genera, found in North America, Africa, and Asia, date as far back as 45 million years, and their lineage is believed to have separated from all the other Haplorrhini as early as 71 million years ago. Strepsirrhini and Haplorrhini diverged perhaps 78 million years ago, not long after the origin of all primates. Consequently, modern tarsiers are pivotal in understanding the roots of primate evolution.

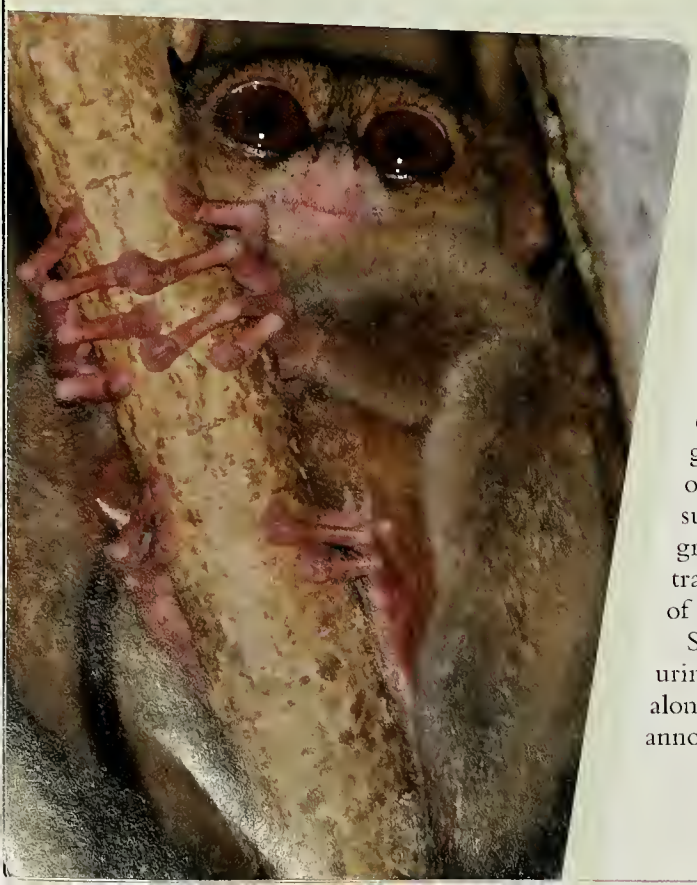
Even living tarsiers remain shrouded in mystery, because studying their behavior is no easy feat. Not only are they small nocturnal forest-dwellers (bad enough!), but, as I learned early on, some of their most peculiar features make them hard to track. To begin with, they are extreme leapers—indeed, they are named for an



Opposite page: Having leapt from the tree where it sleeps during the day (background), a spectral tarsier reaches for the first meal of the evening. Above: In spite of a reputation as solitary animals, spectral tarsiers are commonly found in family groups and will even gather to mob a predator, such as a python, left.

BOTTOM: SEAN CRANE; TOP: MICHAEL & PATRICIA FOGDEN/MINDEN PICTURES

Tarsier carries an infant by mouth, above, a form of behavior common in lemurs, lorises, and galagos. Possession of grooming claws on the second and third digits of the feet, below, is another feature tarsiers share with those primates. Monkeys, apes, and humans have only nails.



unusually long tarsal (ankle) bone that acts as their launcher. They are reportedly capable of leaping as far as eighteen feet; as a result, they can travel through the forest a lot faster than I can.

Then, tarsiers have the owl-like ability—shared with no other mammal—to rotate their heads backward 180 degrees. Often when I am out in the jungle tracking a tarsier, it will look in one direction, but then leap the opposite way! That makes it very easy to lose the individual I am following. And unlike the majority of nocturnal mammals—but like all haplorrhines—tarsiers lack the light-reflecting layer of tissue behind the retina known as the *tapetum lucidum*. In low light, that "bright carpet" improves vision and, as a byproduct, renders an animal's pupils visible as "eyeshine." Absent any eyeshine, the strikingly large eyes of tarsiers do not broadcast their location as one might hope.

When I first began studying tarsiers in the 1990s, they were considered solitary creatures, like most other nocturnal foragers. But when I started tracking them using radio telemetry, I learned that sometimes other tarsiers were not so far away. The conventional approach is to put a radio collar on an individual and track it over the course of one night, picking different nights to watch different individuals. To determine whether tarsiers might be more social than they were reputed to be, I tried a new technique. I would radio-collar a pair of tarsiers and perform "simultaneous focal follows" with an assistant: the two of us would synchronize our watches, each take a radio receiver, and then note our respective tarsier's location every five minutes over the course of twelve hours. So, for example, I might observe a mother while my assistant would simultaneously track her offspring; or we might track two mates this way. Then we would compare our notes.

Once we started watching pairs rather than individuals, we discovered that spectral tarsiers are far from solitary. A majority of the sexually mature adults are monogamous, and mates often stay together for most of their lives, which average seven years. With their immature offspring (as many as two per female) they occupy home territories in small family groups. Although direct paternal care is rare, it is common for a member of the group other than the mother—typically an adolescent sister of the infant—to help with the caretaking. Examples of such "allomothering" include sharing food, babysitting, grooming, and playing. An adolescent female will also transport a young infant by mouth if, say, it falls out of a tree where the mother parked it.

Spectral tarsiers are territorial. They use their urine and various body glands to scent-mark along the boundaries of their home range; they announce their claim with early-morning

family choruses; and they vocally confront and chase any members of neighboring groups that threaten to intrude. They exhibit tremendous attachment to a particular site, with individuals and sometimes family groups continually using the same sleeping tree for years.

How might those patterns of behavior have evolved? When I surveyed the primate literature, I found that three main factors had been hypothesized to lead to sociality, or gregariousness, in primates. One is infanticide: if outsiders of their own species pose a threat, relatives stick together to defend their offspring. Another is food abundance: the patchier the distribution of food in the habitat, the more a group may need to come together to share and defend their resources. And finally there is predation pressure: members of a group cooperate to warn and defend against common enemies.

Infanticide has been observed in captive tarsiers, but does infanticide—or the threat of it—play a role in wild tarsier sociality? I kept track of how much time males spent near females, noting whether or not the females were pregnant or lactating. When a female was lactating—that is, had an infant—the average distance between the male and female of a pair was significantly less than when the female was pregnant or at some other point in her cycle: 85 feet versus 135 feet. By remaining near and traveling with the female and the new infant, her mate could prevent neighboring males from getting too close and killing the infant.

Given the exceptionally large prenatal investment tarsier females must make, it is not surprising that males must help protect the infant. Newborn infants weigh about a third of the mother's weight—imagine a 120-pound woman producing a 40-pound baby! However, the presence of an infant only explained a small proportion of the gregariousness exhibited by spectral tarsiers, since the majority of social interactions did not involve infants.

Infant shows the tarsier's owl-like ability to swivel its head backward.

I therefore began examining the role of food abundance. To record insect distribution on the ground and in the air, I began collecting insects by means of pitfall traps (holes in the ground), sweep nets (similar to butterfly nets), and Malaise traps (stationary nets named for the Swedish entomologist René Malaise). I found that individual tarsiers were more likely to remain near other group members when insect abundance was high rather than low: the average distance between group members was 87 feet compared with 175 feet.

Although the level of sociality was increased by food availability, as it was by the presence of an infant, it did not even come close to the coordinated mobbing behavior that I had observed during the python incident. Obviously, I needed to explore the effect of predators.

As you might imagine, interactions between tarsiers and their predators are relatively rare and difficult to

TOP AND OPPOSITE PAGE: SEAN CRANE; BOTTOM: BERNDT FISCHER

Tangkoko Nature Reserve embraces a dormant volcano whose 3,770-foot peak is regularly enveloped by clouds.

observe. I thus looked for ways to mimic the presence of predators. First, I used physical models of predators, such as carved wooden civets, rubber snakes, and plastic birds of prey; and second, I recorded the vocalizations of predators at zoos and then played them back in tarsier territory.

In 74 percent of encounters with a rubber python, the tarsiers alarm-called, and in 42 percent of the incidents, once joined by other individuals, they also mobbed the snake. Such an encounter had a measurable effect on their social behavior throughout the night. The average distance between group members when no rubber snakes were present was 135 feet, but when rubber snakes were planted within the group's territory, that distance shrank by about half, to 67 feet. Upon encountering the model bird of prey (a falcon), their response a little more than half the time was to freeze, on average for twenty-one minutes. On other occasions they both mobbed and alarm-called.

IMAGE COURTESY OF MARK A. KLINGLER OF CARNEGIE MUSEUM OF NATURAL HISTORY

Fifty-million-year-old fossil of Shoshonius *(left), found in Wyoming, resembles that of modern* Tarsius *(right), evidence that the two are closely related. But tarsiers, which leap from tree to tree, are adapted to holding their bodies vertically, whereas skeletal features of* Shoshonius *suggest it may have walked on all four limbs.*

And when raptor vocalizations were played back, the tarsiers responded in 42 percent of the experiments by alarm-calling, and in 38 percent by both alarm-calling and mobbing the speakers.

The model civet often elicited harsh alarm calls, but it was mobbed in only about 10 percent of the encounters. Thinking the experimental setup might be overlooking the tarsiers' well-developed sense of smell, I organized a new set of tests. I observed the reactions of twenty different adults as each was exposed to four different situations: a wooden civet model covered in civet urine, a wooden civet without urine, a stick covered in civet urine, and a stick without urine.

Above:
Tarsier tails, often as long as their bodies, provide balance when the animals leap in their characteristic upright posture. Below: Asian palm civet is a skillful climber and dangerous to the tree-dwelling tarsiers. The author's experiments show the predator's scent, sight, or call may independently elicit tarsier alarm calls and mobbing responses.

The results were revealing. The tarsiers never ignored the wooden model with civet urine: it provoked alarm calling every time, and they mobbed it in 77 percent of the encounters. In contrast, when exposed to the wooden civet model without urine, the tarsiers responded with alarm calls 39 percent of the time and with both alarm calls and mobbing 15 percent of the time; during 46 percent of the trials, they ignored it. In response to the stick with urine, the tarsiers alarm-called during 93 percent of the trials, but never mobbed; they ignored it in 7 percent of the trials. Unsurprisingly, the stick without urine provoked no response at all.

Mobbing is obviously a risky tactic, yet in both sets of experiments, more adult tarsiers mobbed the ostensible predator than resided in the local territory. What drove other adults to get involved? I observed that adult females regularly attended mobbings, but they were usually passive participants, alarm-calling nearby and watching from a safe distance. The aggressive participants, those lunging at the predator and then retreating, were usually adult and adolescent males. That was an important clue.

To my knowledge there were a number of common hypotheses to explain mobbing behavior, all suggesting some practical, protective outcome, such as driving away the predator. I returned to Sulawesi in 2004, 2006, and 2008 to test which of them might apply to spectral tarsiers.

One rationale, known as "infant silencing," suggests that mobbing distracts predators from young offspring, which learn to remain silent during the exchanges. That hypothesis predicts that mobbing will be restricted to groups with young infants. However, I found that mobbing occurred just as often in groups without immature offspring, thus

knocking a hole in that explanation. Another idea is that mobbing instills "site avoidance." That is, individuals will avoid a locale where a predator was previously encountered and mobbed. But tarsier mothers apparently had no qualms about parking an infant in or near a tree where they were previously exposed to a rubber snake. The data did not support that hypothesis.

According to the "perception advertisement" hypothesis, the potential prey animals, by openly identifying themselves (in this case through mobbing), inform the predator that it has lost the advantage of surprise. Discouraged, the predator then leaves. Naturally, the opportunity to test that was limited to when an actual snake appeared. But based on preliminary observations, the hypothesis fell flat: there was little evidence that the snake spent significantly less time in the area after being mobbed than when the tarsiers only emitted alarm calls or just ignored it. The same set of observations also rejected the "move-on" hypothesis, which states that because it is discomforted by harassment, a predator entering an area will leave sooner the more intensely it is mobbed.

Finally, the "cultural transmission" hypothesis states that an individual learns to fear an object when it witnesses other animals mobbing it, and thus learns to avoid it or mob it in the future. However, when studying the response of infants, I found that nursing infants, even in their first week of life, alarm-called when exposed to a model snake, despite never having seen a snake previously. Their awareness of danger from snakes was not culturally transmitted, undermining that hypothesis.

Because none of the above hypotheses seemed satisfactory, I proposed a new one: spectral tarsiers mob predators as a "costly signal." In effect, the signaler advertises that it can afford to perform an otherwise detrimental act—something that a weaker competitor cannot do as effectively. The classic costly signal is the peacock's tail. The tail makes the bird more vulnerable to predators, but the message to the potential mate is, "I have survived in spite of this huge tail, hence I am fitter." Similarly, while aggregating around a dangerous snake, tarsier males may demonstrate their current physical condition, agility, and speed—and therefore suitability as a mate. According to this hypothesis, the trait of mobbing behavior has evolved in males because it is attractive to females, thus increasing a male's chances of procreating. The driving force is a type of natural selection known as sexual selection.

Because spectral tarsier groups contain only one adult male, any additional males that show up at a "mob scene" must come from other groups. But I observed that males did not show up at all such events. In 80 percent of the cases, including both experimentally elicited and naturally occurring events, males preferred to join groups that contained adolescent females—they came to impress the gals! By observing the males mobbing, young females can evaluate the ability and willingness of males to protect them and their future offspring against predators.

Mobbing, then, seems to be a way for a male to get an adolescent female to leave her group and form a new pair. That conclusion naturally made me curious about why tarsiers join groups, leave groups, or remain in their parental group. To this end, I started to explore dispersal—the permanent departure of an animal from its original home.

Because dispersal involves leaving the protection of a familiar group and territory, an animal that takes the plunge increases its risk of predation and takes a gamble on finding food resources. Therefore the payoff needs to be significant. In mammals, males tend to be the ones to seek new territories. One of the most widely accepted explanations for that is the preponderance of polygynous mating systems—one male siring the offspring of several females in a group. In a polygynous group, the females invest more time and energy in their offspring than the male does. Consequently, they usually have a greater stake in a home range proven to have sufficient resources for successful reproduction, and the males are the ones likely to strike out on their own.

Starting in 1994 and continuing through 2008, I tracked seventy-four banded individuals, noting their location relative to their initial sleeping trees. Both sexes proved equally likely to disperse from their natal territories, but males dispersed significantly farther than females, an average of 2,165 feet away, compared with 873 feet for females. One possible explanation for the difference in distance may be that it reduces the chances of inbreeding.

Like many territorial primates, spectral tarsiers return to the same tree when it is time to sleep. They prefer hol-

lowed-out fig trees with multiple entrances and exits. These typically form when a "strangler" fig tree grows around another tree, kills it, and the dead supporting tree rots away, leaving an empty space. In measuring the diameters (at "breast height," 4.5 feet aboveground) and heights of their sleeping trees, I was able to demonstrate that individuals residing in larger sleeping trees were more likely to be found at the same site in later years, while individuals residing in smaller trees were more likely to move. I also discovered that polygynous groups were more likely to have the larger sleeping trees.

While there are a few primate species that vary in their mating patterns, rarely has the variation been observed within a single population, such as that inhabiting the Tangkoko Nature Reserve. Consequently, I wanted to know what led individual tarsiers to choose monogamy or, much less frequently (about 15 percent of the time), polygyny. In some species, the male's help is required in order to successfully rear offspring, and that favors what Devra G. Kleiman, an ethologist and conservation biologist affiliated with the Smithsonian National Zoological Park and the University of Maryland, has called "obligate monogamy." But spectral tarsiers don't provide much direct paternal care, so that is not a factor. Why, then, were polygynous groups not more common?

I decided to examine possible ecological factors, specifically variation in insect abundance, size of home territory, sleeping trees (size and species), and habitat quality (number of trees, number of tree species, number of large trees). After a field assistant and I spent more than a thousand hours following the movements of adult individuals in ten groups, we were able to conclude that polygyny is not limited by insect biomass, insect abundance, or territory size, but primarily by access to high-quality sleeping sites—that is, tall, wide fig trees. Real estate ruled!

Groups that were fortunate enough to possess territories with large fig trees for sleeping sites were significantly more likely to be polygynous than were groups whose sleeping trees were smaller or of another species. While monogamous groups consistently used only one sleeping site, polygynous groups tended to have multiple sites, giving them more options if something were to happen to one of their sleeping trees. That is a significant issue, because tree falls are frequent, owing to the high winds at Tangkoko Nature Reserve and the diffuse root structure of the fig trees. Although fig trees are fairly common within the reserve, those making the best sleeping sites are relatively rare, which is why

Having grown from above downward to the soil, the roots of a fig tree wrap like vines around another tree. If killed by the strangler, the supporting tree will rot away, leaving a comfortable hollow that enhances the fig tree as a sleeping site for tarsiers, birds, and rodents.

polygyny is so much less common than monogamy.

In choosing a mate, a female spectral tarsier apparently looks not only for a male whose mobbing displays demonstrate his readiness to defend her and her offspring against predators, but also, where possible, for one whose territory includes at least one high-quality sleeping site. Why would such a sleeping site—namely a large, hollow fig tree—be so important? One possible explanation is that its numerous entrances and exits provide more avenues of escape if a predator invades.

My observations of living spectral tarsiers suggest that polygyny—one form of sociality—may have arisen in primates when females chose to be with a male that controlled the best territory. A safe sleeping site could be one measure of the "best" territory, but that is only an example. And the tarsiers' mobbing behavior may be comparable to the way their ancestors and other early primates responded to predators. Snakes are persistent predators of modern placental mammals, and according to Lynne Isbell, an anthropologist at the University of California, Davis, they may have been major driving forces of evolutionary change in mammals. Their ability to hunt, moving silently even in the trees, was and remains a major threat to primates. Mobbing behavior may have evolved as a survival tactic in the face of that threat and, in turn, been a major leap toward group living.

Sharon Gursky-Doyen is an associate professor of anthropology at Texas A&M University. She received her PhD from the State University of New York at Stony Brook and has been studying tarsiers throughout Sulawesi, Indonesia, since 1990. While continuing her work on spectral tarsiers, she is also investigating the effects of altitude on the recently rediscovered pygmy tarsier (*Tarsius pumilus*). She is the author of *The Spectral Tarsier* (Prentice Hall, 2007) and coeditor (with K.A.I. Nekaris) of *Primate Anti-Predator Strategies* (Springer, 2007).

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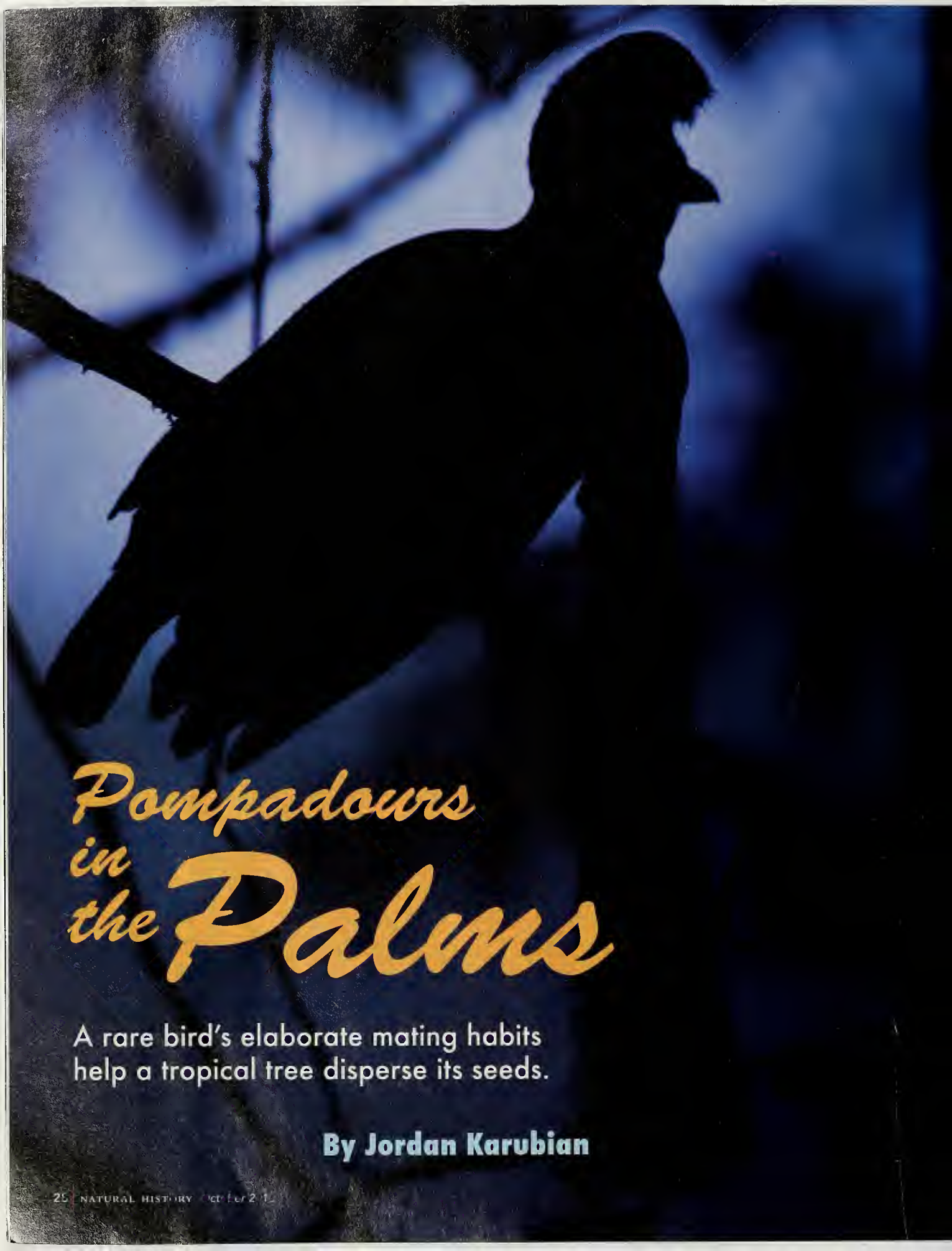


Pompadours in the Palms

A rare bird's elaborate mating habits help a tropical tree disperse its seeds.

By Jordan Karubian

A full-grown chapil palm tree can reach 110 feet tall, its corona of forty-foot fronds stretching skyward above the surrounding canopy. Competition for space and light can be intense among rain forest trees, and every mature, fruit-producing chapil that towers overhead had countless less-fortunate siblings that perished during the long journey from seed to adult. But what determines the winners and losers in that lottery? In the case of the chapil, part of the answer may lie in the social behavior of a curious endangered species known as the long-wattled umbrellabird.

The chapil (*Oenocarpus bataua*) is widely distributed—and widely consumed—throughout the South American tropics. Mammals such as tapirs and peccaries rely on the palm's date-size purple-black fruits for food. Indigenous people use the fruits for medicine, food, and to make a thick, rich, nutty-tasting beverage. Birds that feast upon the chapil's protein-rich fruits and seeds include some of the Amazon rain forest's biggest and most brightly colored species, such as macaws and toucans.

But on the other side of the Andes from the Amazon Basin the chapil palm serves the long-wattled umbrellabird—perhaps its most unusual avian patron—and benefits in return. There lies a distinct biogeographic zone called the Chocó, which extends down the mountains' western flank to the coast in Colombia and Ecuador. That zone is characterized by rain forests even more humid than those of the Amazon, and harbors a distinctive and largely endemic flora and fauna. Thomas B. Smith, a biologist at the University of California, Los Angeles, and I have been studying long-wattled umbrellabirds and other endangered species in the Ecuadorian Chocó for several years. We initiated a conservation program that provides training, education, and sustainable alternatives to locals and Ecuadorian university biology students who assist in our research.

In our neck of the Chocó, the long-wattled umbrellabird (*Cephalopterus penduliger*) lays claim to the title of best-dressed dinner guest at fruit-bearing chapils. It is a large, charismatic, midnight-black bird, with a maximum wingspan of about two feet. Males have long crest feathers that, depending on their mood, they can retract like slicked-back pompadours (cool, relaxed) or expand to completely cover their heads (amorous, aroused). With his crest retracted, a male looks like Elvis on a bad hair day; with it expanded, he looks like Liberace on steroids. The crest accounts for the "umbrellabird" part of the name. Every male also has a thin, feather-covered flap of skin known as a wattle that hangs from his neck down past his tail. About eighteen inches long, the wattle looks rather like the ruffle on a tuxedo shirt, but functions more like a gold chain in the sexual lexicon of the species. Females are smaller than males and much more restrained in their appearance. Ecuadorians call the bird the *pajaro toro*, meaning bull-bird, because the male's song resembles nothing so much as a lost bovine mooing in the forest. The calls travel more than half a mile, to attract females.

In spite of its outlandish appearance and trademark calls, not much is known about the long-wattled umbrellabird. It's not an easy bird to see in the dark foliage; few birders and even fewer biologists have spotted it. It relies on pristine Chocó forests—habitat that is threatened by rampant deforestation. When the forest disappears, the umbrellabird is never far behind. Today it is in danger of extinction, its population having declined by at least 30 percent in the past decade—to less than 10,000 birds.

The loss of the umbrellabird would be a shame, of course, and particularly so for the chapil trees of the Chocó. My research shows that the chapils depend upon those flying fashionistas to disperse their seeds throughout the forest. At first glance, that service may seem trivial. But in fact,

Chapil palm tree grows in the Chocó rain forest of Ecuador, where the long-wattled umbrellabird is one of the main consumers of its fruits. Opposite page: A male umbrellabird, flaunting his trademark wattle and crest, begins the day at a lek—an area in the forest where males gather to woo visiting females.

THIS PAGE: JOHANN KARJALAINEN; OPPOSITE PAGE: MICHAEL DEFFER

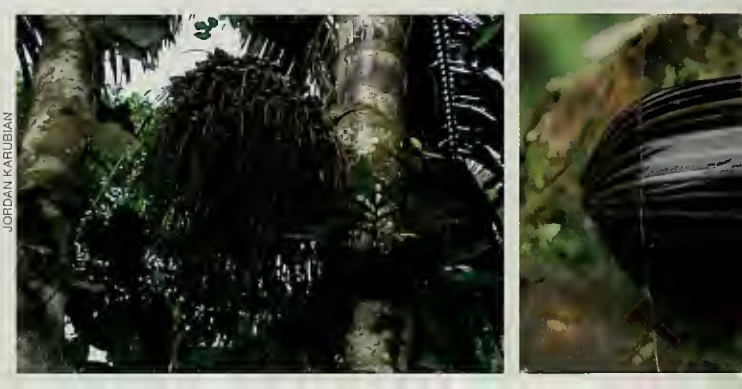
©MURRAY COOPER

Male long-wattled umbrellabird puffs, fluffs, preens, and generally shows off for the benefit of any females passing the lek.

the importance to a rain forest tree of its seeds being carried to a favorable location cannot be overstated. Transportation away from the parent tree is key to a seed's chances of survival to adulthood. Other birds and mammals eat chapil fruits, but in the Chocó nothing seems to eat more of them than long-wattled umbrellabirds, which flock to a fruiting tree and remain in the area for hours. When an umbrellabird feels peckish, it approaches one of the bundles of fruits that hang off the tree like horses' tails, and hovers in front of it like some Daliesque hummingbird. Finally the umbrellabird plucks a plump morsel, swallows it whole, and returns to its perch to digest.

The fruit remains inside the bird's belly for about an hour, we discovered (as I'll explain), where its rich oils are stripped from its seed. When the seed has been cleaned of nutrients, the bird regurgitates it and spits it out onto the ground. Once the bird has eaten its fill of chapil fruits, it flies off, usually carrying a few not-yet-fully-processed seeds inside. Wherever the bird happens to be an hour or so after consumption, there the remaining seeds come out. A given seed may be dropped on rich soil, where it takes hold and begins the long and uncertain march toward adulthood. Or it may perish before germinating, if insects or other seed-destroying predators attack it, or if it lands in the middle of a cleared pasture and desiccates. Either way, the long-wattled umbrellabird plays a pivotal role in determining a seed's fate.

In addition to eating the fruits of chapils and other trees (along with the odd lizard, frog, or insect), male long-wattled umbrellabirds have one overriding preoccupation: sex. During the August-to-February mating season, groups of between five and fifteen males gather every morning and afternoon at special sites called *leks*, each of which typically covers about 4.5 acres. Most males stake out their own territories within a lek. Beginning in the predawn darkness, the males sit on their favored perches and bellow their moo calls out into the forest around them. As the day breaks, they begin to extend and retract their crests. They ruffle the feathers on their wattles and bob them up and down. They spread their wings out in a vulture-like pose and make a strange gurgling sound. They briskly beat their wings against their



JORDAN KARUBIAN

bodies, making a sound like the ears of a wet dog shaking its head dry. Sometimes they pull small branches off their perching trees and beat them against the limbs or trunk. They spend hours each morning and afternoon in such elaborate displays, often nearly falling off their branches from the exertion.

Singin', dancin', lookin' fine . . . the males are, of course, trying to impress females! For their part, female umbrellabirds spend most of their time away from leks, and rarely intermingle with males. But each year, when it comes time for a female to reproduce, she visits the leks to find a sire for her offspring. Each male wants to convince every visiting female to copulate with him, and not with the guy down the hill. But females don't rush headlong into romance. They shop around, extensively.

At first, a female may pass close to a lek without entering, listening to the different males sing. After a day or two of that, she may visit a male that sounds particularly good to her. She flies in silently and perches ten or fifteen yards away. When he notices her, he kicks his efforts into overdrive and begins an energetic sequence of singing, head bobbing, wattle ruffling, wing spreading, and whatever else may occur to him. She sits on her perch, apparently absorbed in preening her feathers, but really all eyes and ears, as he fires up his one-man show.

If she's making her first visit, she will invariably fly off after a few minutes, as quickly and quietly as she came. She will definitely drop in on many males, and perhaps several different leks, before picking a mate. Sometimes she'll return to the same lek for several consecutive days. Sooner or later, however, she settles on one male and begins to spend more time on his turf. Whenever she is near, the male feels compelled to ruffle, fluff, gurgle, and moo, pulling out all the stops.

Finally, the moment arrives, and she flies over and perches about a foot away from him. He slowly works his way toward her until he is by her side. He pauses. Crest flared and wattle ruffled to the max, he moos once or twice, maybe throwing in a gurgle for good measure. He then performs what my assistants refer to as "the deal-closer"—the umbrellabird equivalent of dimming the lights and putting on some Barry White. He vigorously sways his head away from the female and then back toward her, causing his wattle to swing up around her neck and come to rest on her back, like a feather boa. Her eyelids lower at such an intimate embrace, and he seizes the moment,

Female long-wattled umbrellabird, top two photographs, dodges defensive spines to pluck ripe fruits from a chontilla palm. Above: The female sports only a nominal wattle, and her head crest is tamer than that of the male.

hovering up behind her on the wing to consummate their brief union. Although the courtship takes several days, the sexual act lasts just seconds. Before you can say "long-wattled umbrellabird," the male is back by her side and she jolts back to attention, preens a bit perhaps, and then flies away without a backward look.

And that is the extent of their relationship. The female is now on her own. She flies back to her home area in the forest, sometimes a few miles away, and proceeds with the business of nesting. My team and I haven't been able to document whether she builds her nest before mating or after, or how long she can hold sperm before fertilizing her eggs. (Some female birds can store sperm for months before they use it.) Sometime after copulating, however, the female lays a single egg. She alone then incubates the egg; feeds, broods, and protects the chick until it leaves

Ripe fruits hang from a chapil palm, far left. About an hour after a long-wattled umbrellabird eats a chapil fruit, it regurgitates the seed, middle left. Where seeds land, chapil seedlings may sprout, near left.

BOTTOM PHOTO: JORDAN KARUBIAN; TOP PHOTO: ©MURRAY COOPER

Male umbrellabird takes flight, top. Above: A juvenile chapil palm grows in a remnant scrap of Chocó rain forest; local people cleared the surrounding area to make way for agriculture.

the nest; and continues to care for it until it can fend for itself, a few months later.

The male's life, conversely, remains centered on the lek. For several months of the year he spends most of his time there, leaving only to eat. He will never see the nest where his offspring is raised, and most likely wouldn't know his own son or daughter if they met beak to beak. Such deadbeat-dad behavior may not provide a good example of responsible parenting by human standards, but it is part and parcel of the lek mating system as practiced by many bird species.

My team and I hypothesized that the mating behavior of umbrellabirds might have important consequences for chapils and other plants whose fruits they disperse. Males, we thought, might bring a high proportion of the seeds they eat back to their lek sites. To test that idea, we trapped umbrellabirds of both sexes, attached lightweight, temporary radio transmitters to their tails, and released them unharmed. We then noted their locations over the course of several months as they traveled in search of food or displayed at their leks. A few of the birds we held in aviaries and fed chapil fruits, recording how long it took them to regurgitate the seeds—that's how we arrived at the figure of one hour. Armed with those new data on movement patterns and seed-retention time, we were able to estimate where umbrellabirds of both sexes deposit the seeds they ingest.

Sure enough, we determined that males deposit roughly half their seeds in the lek sites. Females, on the other hand, distribute their seeds more evenly throughout the forest. In other words, the different reproductive behaviors of males and females translate into different dispersal patterns. To address how that affects chapils, we compared the rate of survival to the seedling stage for seeds deposited within and outside leks. We found no difference in the probability of survival. That came as a bit of a surprise: we had anticipated that high seedling density in the leks, and the resultant competition, would be a disadvantage. That it was not suggests that, for reasons we could not determine, the leks may be unusually favorable sites for chapil seedlings relative to the forest at large.

Working with Victoria L. Sork, a plant ecologist at the University of California, Los Angeles, my team and I are now using genetic markers to identify which adult trees the seeds arriving in umbrellabird leks came from. In addition to illuminating how umbrellabirds promote gene flow among chapil palms, that approach will tell us something about how forest fragmentation and deforestation affect seed dispersal patterns. The challenges are great, but between our research and our efforts to involve local residents in conservation work, we hope to preserve the age-old pact between a palm and its conspicuously plumed dispersal agent.

Jordan Karubian, whose research in behavioral ecology, evolution, and conservation focuses on tropical birds, lived in Ecuador's Chocó rain forest for four years, studying such imperiled species as umbrellabirds, banded ground-cuckoos, brown wood-rails, and macaws. He has also worked in Australia, with grasswrens and fairy-wrens. He conducted most of his work on the long-wattled umbrellabird while at the University of California, Los Angeles; recently he became an assistant professor of ecology and evolutionary biology at Tulane University in New Orleans (http://karubian.tulane.edu/lab). Karubian works closely with his wife, Renata Durães, who is also a tropical biologist.

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THIS LAND BY ROBERT H. MOHLENBROCK

Mickey Mitigates

In exchange for land development, a Florida preserve takes shape.

Festooned with Spanish moss, a live oak grows in a mesic hammock along with saw palmetto.

As a consequence of population growth and resource development, many wetlands that once existed in the United States have been drained or otherwise destroyed. In the past half century, however, local, state, and national initiatives have sought to slow down the loss. Perhaps most notably, as written and amended in the 1970s, Section 404 of the Federal Water Pollution Control Act, commonly known as the Clean Water Act, has guided the protection of surviving wetlands, which may not be altered or destroyed without a permit issued by the United States Army Corps of Engineers. To obtain a permit, a private or public owner must first show that impacts on wetlands have been avoided or minimized where possible. If some losses appear unavoidable, an owner may negotiate to "mitigate" (offset) the effects by restoring or creating wetland somewhere else.

Often many small wetland areas are created or restored in exchange for one large tract, but a successful initiative in central Florida took a different tack. During the 1980s, the Walt Disney World Company wanted to develop an additional 11,000 acres—including about 600 acres of wetland—within its vast complex of land. Coincidentally, the 8,500-acre Walker Ranch, about fifteen miles south of Walt Disney World, was under consideration for residential development, to include up to 9,000 homes, six golf courses, and a marina. Threatened and endangered species that lived on the ranch stood to lose. The Florida Audubon Society urged that, as a mitigation project, the ranch site be restored to its original natural conditions, including substantial wetlands. In 1991 the Walt Disney World Company offered to undertake just such a project in exchange for its own development. All the required government agencies signed on, and The Nature Conservancy was asked to develop a restoration plan and oversee its implementation.

Blazing star

Walt Disney World spent nearly $45 million to purchase Walker Ranch and to pay for habitat restoration, including the re-creation of substantial wetlands, through the year 2012. At the end of 1992, the land was turned over to The Nature Conservancy. Ultimately, more than 3,000 additional private and public acres were added to the tract, now known as The Nature Conservancy's Disney Wilderness Preserve.

The preserve property has a varied past. From 1926 to 1979 it belonged to the Candler Lumber Company (Asa Candler also founded the Coca-Cola Company). Throughout

RICHARD A. HOWARD IMAGE COLLECTION, COURTESY OF SMITHSONIAN INSTITUTION

HABITATS

Wet prairie Blue maidencane and toothache grass create a dense cover along with bulrushes, spikerushes, and other sedges. Wax myrtle is the most common shrub, but bladderpod thrives in disturbed areas. Insect-trapping plants—hooded pitcher plants and two species of sundews—are present, along with such wildflowers as bogbutton, two kinds of meadowbeauties, narrow-leaved sunflower, rose pink, southeastern sneezeweed, tickseed, white-topped sedge, yellow hatpins, ten yellow-eyed grasses, and two yellow stargrasses.

Mesic hammock Among the trees are American elm, cabbage palm, live oak, pignut hickory, southern magnolia, and sugarberry. Small trees and shrubs include common persimmon, red mulberry, and saw palmetto, while vines (species of greenbrier and wild grape) are prominent in the understory.

Floodplain marsh Bulrushes, maidencane, sawgrass, and spikerushes are common.

IAN ADAMS

that time local cypress trees were logged extensively for timber production, and into the 1940s many of the pines were damaged or destroyed by tapping for turpentine. Open-range ranching of "scrub cows" was practiced until Florida's fence law was passed in 1949, after which more intensive cattle ranching began to have a major impact on the land. To increase grazing acreage, drainage ditches and canals were dug, which lowered the water table significantly—a trend that reached its culmination under Walker ownership after 1979. Nevertheless, the tract still harbored much native wildlife and many remnants of its original plant communities.

Today, the eighteen-year-old preserve is already a showcase for the results of knowledgeable restoration and management practices. There are now good examples of a whole host of habitats. One is mesic (moist) flatwoods, also known in Florida as pine flatwoods or pine savanna, where widely spaced longleaf pine trees and a scattering of slash pine trees form an open canopy above a continuous ground cover of grasses, wildflowers, and shrubs. That habitat's flat terrain is usually poorly drained because a hardpan of clay underlies the acidic, sandy soil. At slightly higher elevations, where a substrate of white sand permits rapid drainage, is an oak scrub with several species of dwarf, evergreen oaks. In between is a transitional zone, scrubby flatwoods, with both pine and oak.

Swamp doghobble

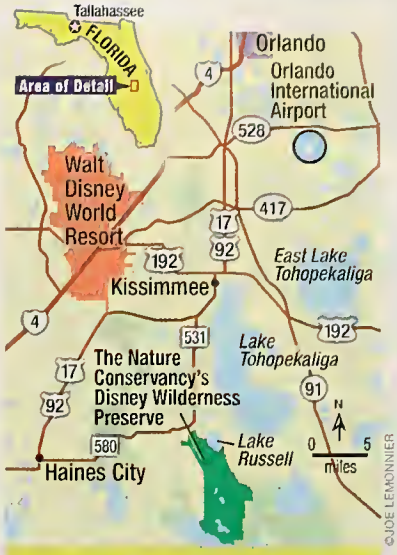
WILLIAM S. JUSTICE, COURTESY OF SMITHSONIAN INSTITUTION

The approximately 4,000 acres of wetlands, featured in the habitats listed below, include wet prairie, a flat, treeless habitat with relatively poorly drained soil that is a mixture of fine sand and organic matter. Occurring wherever the land dips slightly below the elevation of the flatwoods—in depressions and around the rims of marshes and swamps—wet prairie is inundated for two to five months each year, yet can become quite dry during the rain-poor winter.

Mesic hammock, whose occasionally inundated, poorly drained soil consists of fine sands with some organic content, supports a fairly closed canopy of live oak and other trees. Floodplain marsh, found adjacent to streams, has primarily sandy alluvial soils that are frequently inundated by river flooding. Floodplain swamp, however, is flooded to varying depths for most of the year. Found along the edges of Lake Russell, as well as along stream channels, it supports cypress and other water-tolerant trees. Bayhead—a densely forested, fire-resistant community dominated by several species of bay trees—occurs in peat-filled depressions.

The diverse habitats are favored by protected species of birds and other animals. Among them are bald eagles (mesic flatwoods), Florida scrub jays (oak scrub), wood storks (floodplain swamp), and gopher tortoises (scrubby flatwoods).

Visitors can start their tour at the Conservation Learning Center—headquarters for both public information and conservation research—and then venture forth on a hiking trail. Covering a 2.2-mile loop, the trail offers a close look at the preserve's natural communities of plants and animals. Or one can take the trail just as far as Lake Russell, a one-mile round trip to view one of the last remaining pristine lakes in central Florida.



VISITOR INFORMATION
The Nature Conservancy's
Disney Wilderness Preserve
2700 Scrub Jay Trail
Kissimmee, FL 34759
407-935-0002
www.nature.org/wherewework/northamerica/states/florida/preserves/art5523.html

Robert H. Mohlenbrock is a distinguished professor emeritus of plant biology at Southern Illinois University Carbondale.

Two kinds of arrowheads, dotted smartweed, lanceleaf primrose-willow, pickerelweed, and a tickseed are present in shallow depressions. Buttonbush is a common woody plant.

Floodplain swamp Bald cypress and swamp tupelo are the larger trees; shorter trees and shrubs include dahoon holly and wax myrtle. Laurel greenbrier is a common vine. Arrow arum, two arrowhead species, lizard's-tail, and soft rush abound along with cinnamon fern, giant leather fern, marsh fern, royal fern, and swamp fern.

Bayhead Loblolly bay, sweetbay, and swamp bay are characteristic trees, but pond cypress, swamp tupelo, and sweetgum are also present. Shrubs include dahoon holly, fetterbush, maleberry, swamp doghobble, wax myrtle, red chokeberry, and Virginia sweetspire. Laurel greenbrier and poison ivy are common. Among the ferns are cinnamon fern, netted chain fern, Virginia chain fern, and swamp fern.

From Eternity to Here

The Quest for the Ultimate Theory of Time

by Sean Carroll
Dutton, 2010;
448 pages, $26.95

It seems obvious that I could not have written my impressions of this book *before* reading it, but to astrophysicist Sean Carroll, of the California Institute of Technology in Pasadena, there's something profoundly strange about that. Why, he asks, can we move in any direction in space, whereas time only shuttles us from the past into the future? The key to understanding time's one-way arrow, according to Carroll, is the second law of thermodynamics, which insists that entropy, a measure of disorder in a complex system of objects, inexorably increases with time. Put more succinctly: you can't unscramble an egg, even though there's no law of physics prohibiting each atom in the scramble from spontaneously returning to its proper place in the shell. It's just supremely unlikely.

Paradoxically, when you look at a single particle, time actually *is* reversible, for all intents and purposes. Imagine a billiard ball caroming off the side of a pool table: you couldn't tell whether a film of the collision is playing forward or backward. Clearly, the same is not true for complex systems. A film of a cue ball breaking a formation of fifteen colored balls is readily distinguishable from the reverse: fifteen colored balls assembling into a perfect triangle and spitting a single white one out of their apex. While the latter scenario is physically possible, it is vanishingly improbable—there are a gazillion ways a cue could break the colored balls, but only one arrangement of the velocities of the colored balls that could bring them to a stop in triangle formation. Time, in other words, flows in the direction of maximum statistical likelihood.

Recognizing the second law in action, however, is just the beginning of understanding time, which is why Carroll has written more than 400 pages on the subject. Since the entropy of the universe has been increasing for more than 14 billion years, it must have been in an exquisitely uniform—some astrophysicists would say "orderly"—state at the time of the big bang. But how could that be, Carroll asks, if, at the atomic level at least, time can roll backward just as easily as it can roll forward? And where is all the entropy leading? Will the universe continue to become more and more diffuse and disordered until the stars all burn out, the galaxies dissipate, and the whole thing becomes cold and lifeless?

The simple answer to all those questions is that we don't know for sure. But Carroll is not one for simple answers. He examines his subject from a variety of viewpoints, writing clearly and expressively about the temporal implications of black holes, time machines, and theories of the expanding universe. He quotes liberally from such literary lights as Marcel Proust, T.S. Eliot, and the playwright Tom Stoppard. But despite its avoidance of equations, *From Eternity to Here* is not a book for the mathematically faint of heart. It presupposes a patient reader who is willing and able to follow some pretty complex logical and philosophical arguments. Still, it is one of the most lucid popular overviews of modern theoretical cosmology that I have read in recent years. And though you may not come away from it knowing exactly why you read the book from start to finish rather than the other way around, you will doubtless regard the experience as time well spent.

Fireflies, Honey, and Silk

by Gilbert Waldbauer
Illustrations by James Nardi
University of California Press, 2009;
233 pages, $25.95

Hang up that flyswatter, cap that roach spray, and join Gilbert Waldbauer as he explores the lives of insects worthy of our appreciation. It's a journey that takes the reader far beyond the domain of crickets on the hearth and butterflies in the garden. Our guide, an emeritus professor of entomology at the University of Illinois at Urbana-Champaign, is abuzz with obscure lore about a host of bugs that are as accommodating to humans as bedbugs, fleas, and mosquitoes are annoying.

There's a chapter, for instance, on insects as jewelry. Did you know that fashion-conscious Victorian ladies used to tether live iridescent bugs to their dresses with delicate gold chains? In some quarters such beetlemania is still in vogue—Waldbauer spotted a large, leashed insect resembling an Egyptian scarab crawling across the chest of a fellow traveler on a flight from Mexico. Since agricultural inspectors are notorious bug spoilsports, as any entomologist returning from abroad with a suitcase full of specimens can testify, Waldbauer doubts that the animated jewelry made it through customs.

Although it is rather unusual to stick insects on our clothes, it is not at all strange to stick them in our mouths. In modern Japan, fried rice-field grasshoppers, called *inago*, are a popular snack. Thai diners relish *mangda*, giant water bugs that reputedly taste a bit like gorgonzola cheese when served fresh out of the steamer. And I can personally recommend *escamoles*, the pupae of ants fried with onions and garlic, which I recently enjoyed at a high-class restaurant in Mexico City. (Fittingly, if memory serves, my waiter may even have been wearing a silk cummerbund—with fibers produced by the larvae of another obliging insect, the silk moth, *Bombyx mori*.)

Europeans and Americans still find insects a bit hard to stomach, but few people don't enjoy honey—which can be procured not only from bees, Waldbauer tells us, but also from so-called honeypot ants. Specialized worker ants take in plant nectar and honeydew (aphids' sweet excreta), regurgitated by forager ants, until their own abdomens become grossly distended. Immobilized, hundreds of them hang like water balloons about to burst in the colony's underground nest, serving as a food reserve. Before the advent of high fructose corn syrup, Native Americans in the Southwest used to dig the ants up to sweeten their diets, and some Australian aborigines still do.

Even insects we find repulsive can serve us well. Take maggots, the larval form of various species of flies. In 2004 physicians worldwide used more than 30,000 vials of them to assist in removing necrotic tissue from wounds. The maggots, it seems, do a much cleaner job than the surgeon's knife can, a talent that is especially important as bacteria become increasingly resistant to antibiotics. So for a few people in dire straits, insects save lives. And for all of us, as Waldbauer makes clear, insects can make life easier, sweeter, and more enjoyable.

In 1825, ten years before the fabled visit of the *Beagle*, a Hudson's Bay Company supply ship sailed into the Galápagos archipelago, en route to the Pacific Northwest. Aboard was the young Scottish naturalist David Douglas, who was employed by the London Horticultural Society to collect samples of interesting plants for their burgeoning collection. During three landings on the islands, Douglas collected 45 birds and 175 plants, most of them previously unclassified by science. The Galápagos, which were to be the high point of Charles Darwin's field experience, were only passing landmarks in Douglas's career, in part because rainy weather on the next stage of the voyage rotted almost all of the young collector's specimens.

What followed, however, is one of the classic natural history adventures of the nineteenth century. For most of the next decade, Douglas made his home primarily along the Columbia River and its tributaries—insofar as it can be said that he had a home. He seized every opportunity to explore new territory, forging deep into what is now western and central Canada and down the coast, by sea, as far as Monterey, California (which was then still part of Mexico). Everywhere he roamed he filled his journals with notes and his collecting bags with skins, seeds, and live plants. Just two years after his arrival in the region, he estimated that he had already traveled 7,032 miles by foot, horseback, and canoe.

He suffered near starvation, thirst, fever, and narrow escapes from poisonous snakes and from angry Indians (though more were friendly). His journals provide lively source material for historian and nature writer Jack Nisbet. Although not the first book to detail Douglas's life, Nisbet's travelogue both provokes and satisfies readers, like me, who envy the botanist for his wilderness adventures long before the age of road building.

Today, botanists know Douglas from the plants he collected, many of them flagged by the Linnaean species designation *douglasii*. To the rest of us, he has, like the hero Cyparissus in Greek myth, turned into a tree: Douglas fir (*Pseudotsuga menziesii*), one of the building industry's prime timber sources and a mainstay of the Pacific Northwest economy.

Had Douglas lived longer, we might remember him as the preeminent botanical collector of his era. Instead, his death at age thirty-five, on the big island of Hawaii in July 1834, adds a final mystique to his accomplishments and travails. A feral bull fatally gored him in a pitfall trap set by a local hunter. Did he slip on the muddy volcanic soil, or was he pushed in a robbery attempt? Wisely, biographer Nisbet doesn't spend much time on idle speculation. The uncommon life of David Douglas, not his untimely death, is what makes this book such a pleasure to read.

Laurence A. Marschall is W.K.T. Salm Professor of Physics at Gettysburg College in Pennsylvania and coauthor, with Stephen P. Maran, of Pluto Confidential: An Insider Account of the Ongoing Battles over the Status of Pluto *(BenBella Books, 2009).*

Continued from page 6
effects—also great—might be more likely to prove adaptive. Why so?
Richard A. Morgan
Berkeley, California

DRUIN BURCH REPLIES: I would argue that any large genetic change is far more likely to do harm than good. Thus we often find single-gene mutations that are responsible for human diseases, but we've been poor at finding ones responsible for human successes (such as spectacular physical or mental capacities). When it comes to viral invasion, the chance of viral genetic material doing more good than harm is remote. But a constellation of viral genes will already have been adapted to serve a particular function, so that remote chance of good is probably higher than that of random mutations previously subject to no selective pressures. I can't think of a practical experiment to test that assertion, but I find it suggestive all the same.

Small, Medium, or Large?

I read "Ghost of Predation Past" [in "Samplings," 11/09] with interest. However, I do not see how the experiment described proved anything other than that marmots are capable of distinguishing between large, medium, and small canid predators—and reacting appropriately to the larger, more dangerous predator. Did Daniel T. Blumstein and colleagues try showing the marmots pictures of a fox-size fox, a coyote-size fox, and a wolf-size fox? Large, medium, and small wolves? Until they can demonstrate that marmots react to the wolf in the image, and not just to the size of the predator, they have not proved that the marmots are "recognizing" wolves.
Anna Runnings
Qualicum Beach, British Columbia

DANIEL T. BLUMSTEIN REPLIES: This is an excellent question, and I refer readers to the original article that details the experiment (available on my Web site, www.eeb.ucla.edu/Faculty/Blumstein). The short answer is no, we did not present all possible stimuli. Why? Because the trials are difficult to carry out and because the animals ultimately habituate to repeated presentations—always a problem in such experiments.

Nonetheless, if size alone were the issue, we would have expected the marmots to respond more strongly to the nonpredatory African antelope than to the fox. We did not find that to be so. Moreover, the wolf and the mountain lion we showed to the marmots were of similar size, but the marmots reacted quite differently to them. After seeing the mountain lion, marmots engaged in high vigilance, and one of them alarm-called—a good strategy against that kind of stealthy predator. After seeing the wolf, marmots fled—probably the best response to such a predator, which hunts in groups.

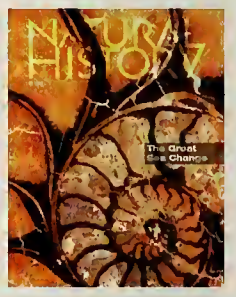
The bigger question is whether the presence of predators helps a prey species maintain its ability to react to extirpated predators. Ours is one of several studies—examining different taxa and using different methods—that show that the answer is yes. The finding has implications for wildlife conservation: it may work better to restore long-absent predators near prey populations that have ongoing exposure to similar predators than near insular, "clueless" prey populations that cannot hold their own.

Earth to Mars

In his "Skylog" column [12/09-1/10], Joe Rao indicated that Mars and Earth would be 61,720,695 miles apart at 2:01 p.m. eastern standard time on January 27, 2010. I was wondering what points on the planets that measurement reflects. Is it from their centers? Or is it taken from their nearest surfaces? If the latter, does it factor in surface variations, such as mountains, and their exact position at that precise moment in time?
Keith A. Hirt
Ellicott City, Maryland

JOE RAO REPLIES: The Mars-to-Earth distance was calculated using the United States Naval Observatory's Multiyear Interactive Computer Almanac (MICA). The value is based on the distance from the center of one planet to the other. The distance from surface to surface would be nearly the same, on average 6,074 miles less. As Keith A. Hirt suggests, however, the topography of the planets would add an extra complication.

Beware the Ides



In "The Search for Evidence of Mass Extinction" [9/09], authors Scott Lidgard, Peter J. Wagner, and Matthew A. Kosnik refer to "sulfide-reducing bacteria." In fact, a sulfide already represents a fully reduced (unoxidized) state. Instead there are sulfate-reducing bacteria, which reduce oxygen-containing sulfates to oxygen-free sulfides. Permian period sulfate-reducers took the plentiful dissolved marine sulfate and transformed it (via reduction) into the hydrogen sulfide gas that was a significant component of late Permian oceans.
Dan Dorritie
Sacramento, California

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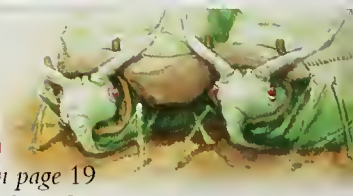

LIFE ZONE

Continued from page 19

heaps and hordes of ants being introduced everywhere.

IF HUNDREDS OF ANT SPECIES are being intercepted by U.S. Department of Agriculture agents checking just a handful of plants, how many more might be getting in? The answer is almost certainly thousands, being put to the viability test wherever they land. One hundred fifteen species of ants have been captured en route to New Zealand. Seventy-six species have cast up on the shores of the Netherlands, less than a quarter of them the same species that turned up in New Zealand. A new invasive species was recently detected in Texas; even though it infests much of the state, it has not yet been formally named (unofficially it's called the "Rasberry crazy ant"—Rasberry for its discoverer's last name and crazy for its seemingly erratic crawling). Columbia University students discovered that a nonnative ant that has never been studied outside Japan is now the most common species on Manhattan Island.

Here is my own take, based on the contents of Suarez's jars. Some ants fit nowhere. Some fit everywhere. We are, with our sloppy shipping, sampling the world of species for the toughest, the most fertile and durable. They (and other invasive species) will be the progenitors of the next dynasty. Local species, including people, must compete with invasive species for resources. If we had chosen consciously, we might have chosen to pit our native flora and fauna against the weakest invaders, but it is the strongest we have spread instead. And they keep coming, ringing in, queen by queen, the new empire. They begin weak, but they shall inherit the Earth. By most measures, they already have.

ROBERT R. DUNN *is an ecologist in the Department of Biology at North Carolina State University in Raleigh. His first book,* Every Living Thing: Man's Obsessive Quest to Catalog Life, from Nanobacteria to New Monkeys, *was recently published by Smithsonian Books/HarperCollins.*

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EST. 1900

SKYLOG BY JOE RAO

The brilliant constellation Orion lies on the celestial equator (Earth's equator projected onto the heavens), and so is visible—at one time of year or another—from every inhabited part of the globe. For viewers in northern latitudes, it dominates the winter sky. In many ancient cultures the constellation was associated with heroes or demigods. Among Europeans, Orion is the Great Hunter or Celestial Warrior. He is traditionally pictured in the stars with his club raised in his right hand and, hanging from his upraised left hand, the skin of a great lion that he has killed. Yet in contrast to such Greek mythical heroes as Hercules, who was credited with a detailed series of exploits, Orion is a vague and shadowy figure. Even the origin of his name is obscure.

The constellation, however, is perfectly clear, instantly recognizable from the row of three bright stars defining Orion's belt. Two other stand-outs are the stars Rigel, in the imagined figure's left leg, and Betelgeuse, marking the right shoulder. The two represent different periods in a star's existence. Bluish Rigel, estimated to lie 770 light-years away from us, is a blazing hot supergiant, about seventy times the diameter of the Sun and shining roughly 57,000 times as brightly. It is reaching the prime of what will be a relatively short life of only a few million years (by comparison, the Sun is about 5 billion years old and should last another 5 billion). In contrast, reddish Betelgeuse, some 520 light-years away, is an irregularly pulsating supergiant, nearing the end of its expected life span of less than 10 million years. It expands and contracts spasmodically, varying within the space of five or six years between 550 and 920 times the diameter of our Sun and shining about 85,000 times brighter.

NASA/JPL-CALTECH/STSCI

Orion Nebula (composite view of visible, ultraviolet, and infrared light)

The constellation also contains the Orion Nebula, a region of space where star formation is underway. To the naked eye it appears to be the centermost of the three stars that are envisioned as the Great Hunter's sword, hanging from his belt. But a telescope will reveal the dim, diffuse spot as a fan-shaped greenish cloud of stars and interstellar gas. Edward Emerson Barnard (1857–1923), for many years an astronomer at Yerkes Observatory in Williams Bay, Wisconsin, once remarked that it reminded him of a great ghostly bat.

The nebula, which lies 1,344 light-years away, is about 30 light-years in diameter, or more than 20,000 times the diameter of the entire solar system. Its total mass (excluding stars) is 10,000 times that of the Sun, yet because it is so spread out, its density is less than a millionth that of the best laboratory vacuum. The Orion Nebula is largely visible to us through its fluorescence: high-temperature stars entangled within it emit strong ultraviolet radiation that triggers a sort of auroral glow.

Joe Rao is a broadcast meteorologist and an associate and lecturer at the Hayden Planetarium in New York City (www.haydenplanetarium.org).

NOVEMBER NIGHTS OUT

3 Venus has lately been masked by sunlight, having gone through inferior conjunction (passed between the Sun and Earth) on October 28. Today you might spot its reappearance as the Morning Star, rising a half hour before the Sun. Viewed through a telescope, the planet shows itself as a wire-thin crescent. By the end of the month, Venus will be rising three hours before sunup.

4 Saturn rises due east, two and a half hours before the Sun. Rising about 10 degrees below and to the planet's right is the slender crescent of the waning Moon. Distinguishable through a telescope, Saturn's rings present their lighted northern face to Earth. During the month they increase their tilt toward us from 8.1 degrees to 9.3 degrees from edgewise.

6 The Moon is new at 12:52 A.M. eastern daylight time.

7 Clocks "fall back" one hour at 2:00 A.M. daylight saving time, making it 1:00 A.M. standard time. At dusk Mars may be spotted very low in the southwest, within 2 degrees above and to the right of the day-old crescent Moon. If the sky is at all hazy, you may need binoculars to see it. Two nights from now the planet will appear 4 degrees to the upper right of the star Antares, which has a similar reddish hue. Later in the month Mars is lost in bright twilight.

13 The Moon waxes to first quarter at 11:38 A.M. eastern standard time (EST).

16 Jupiter is unmistakable as the brightest point in the evening sky. By about 7 P.M. local standard time, it's high in the south, and it does not set in the west until after midnight. The Moon rides high above and to the planet's left.

18 The Leonid Meteors peak this morning. They are so named because they appear to radiate from a point within the constellation of Leo, the Lion, which is high toward the southeast at dawn. It's unlikely that more than a dozen meteors per hour will be seen this year.

21 The Moon is full at 12:27 P.M. EST.

28 The Moon wanes to last quarter at 3:36 P.M. EST.

EXPLORER GUIDE

Around the Country

Visitors can wear dolphin hats or fish costumes, and dance to Brazilian music, in the "Amazon Voyage" exhibition, now at the Denver Museum of Nature and Science.

ARIZONA

Mesa

ARIZONA MUSEUM OF NATURAL HISTORY

Ongoing: **"Therizinosaur: The Mystery of the Sickle Clawed Dinosaur."** Travel back to the Cretaceous period, a time when the Western Interior Seaway covered much of North America and was filled with fishes, sharks, sea turtles, giant marine reptiles . . . and a land-based dinosaur? See real fossils from the sickle-clawed dinosaur called *Nothronychus,* from the Therizinosaur family, that was found in an ancient marine bed; put together a puzzle of its skeleton; and discover what scientists think the animal was doing 60 miles out to sea.

53 North Macdonald
480-644-2230
www.azmnh.org

Phoenix

ARIZONA SCIENCE CENTER

Ongoing: **"Forces of Nature."** Explore—and even experience—some of the raw power generated by a dynamic Earth, including phenomena such as earthquakes, hurricanes, tornadoes, volcanic eruptions, and wildfires. An "Immersion Theater" puts you in the center of the action, and hands-on exhibits help explain the underlying causal phenomena of plate tectonics, ocean currents, wind patterns, and more.

600 East Washington Street
602-716-2000
www.azscience.org

CALIFORNIA

Los Angeles

NATURAL HISTORY MUSEUM OF LOS ANGELES COUNTY

Through November 7: **"Spider Pavilion."** See spiders spinning webs, interacting with their environment, and feeding on their prey in the first public spider-viewing center of its kind in the U.S. Gallery interpreters lead visitors on tours through the museum's greenhouse and explain habitats and behaviors of the exhibition's inhabitants, which include golden silk spiders, spiny-backed orb weavers, and other local and exotic species.

Exposition Park
900 Exposition Boulevard
213-763-DINO
www.nhm.org

San Diego

SAN DIEGO NATURAL HISTORY MUSEUM

Ongoing: **"Fossil Mysteries."** Dioramas, fossils, models, murals, and plenty of hands-on activities tell the changing story of the bioregion encompassing southern California and Baja California in this exhibition spanning 75 million years of history. Examine fossil clues—just as scientists do—to answer questions about plants and animals (including dinosaurs and mastodons), changing environments, evolution, extinction, and more.

Balboa Park
1788 El Prado
619-232-3821
www.sdnhm.org

COLORADO

Denver

DENVER MUSEUM OF NATURE AND SCIENCE

Through January 2, 2011: **"Amazon Voyage: Vicious Fishes and Other Riches."** Examine the teeth of the world's largest piranha (now extinct), test a zap as strong as an electric eel's, or discover the mythical, underwater world of pink dolphins, called *Encante,* in this exhibition that explores the biodiversity of South America's Amazon River region. Climb aboard a riverboat, see freshwater stingrays, try doing what scientists do in the field, and much more.

2001 Colorado Boulevard
800-925-2250
www.dmns.org

CONNECTICUT

New Haven

PEABODY MUSEUM OF NATURAL HISTORY

Ongoing: **"Hall of Minerals, Earth, and Space."** This geological exhibition explores the birth of the solar system and the forces that shaped the Earth's early geology: earthquakes, volcanic eruptions, and asteroid collisions. Discover how the planet's rocky surface—on land and under the oceans—interacts with the atmosphere and waters to create Earth's livable climate. From the museum's vast collections, see rare gems as well as minerals with unusual properties such as vivid colors, fluorescence, magnetism, and radioactivity.

Yale University
170 Whitney Avenue
203-432-5050
www.peabody.yale.edu

FLORIDA

Gainesville

FLORIDA MUSEUM OF NATURAL HISTORY

Through January 11, 2011: **"CSI: Crime Scene Insects."** An exploration of forensic entomology, this exhibition shows how investigators use beetles, flies and their maggots, and other insects to determine key facts about a crime, such as the time of a death. Real-life case studies, field equipment, and live insects are featured, and visitors have the oppor-

tunity to try their hand at solving crimes.
University of Florida
Cultural Plaza
SW 34th Street and Hull Road
352-846-2000
www.flmnh.ufl.edu

Tampa
MUSEUM OF SCIENCE AND INDUSTRY (MOSI) *Ongoing:* "Disasterville." Hold on tight in this new permanent installation that vividly simulates floods, hurricanes, tornadoes, wildfires, and other natural disasters in the unfortunate town of Disasterville. The interactive exhibition explains the science behind each threat, as well as constructive steps you can take to prepare your own home for nature's fury. The WeatherQuest area provides an innovative role-playing experience, in which teams form TV news crews that investigate and report on the crises as they unfold.
4801 East Fowler Avenue
813-987-6100
www.mosi.org

GEORGIA
Atlanta
FERNBANK MUSEUM OF NATURAL HISTORY
Opening October 2: "Water: H_2O=Life." Explore this essential substance in an exhibition full of hands-on activities, interesting artifacts, living animals, and captivating images—and discover its often-surprising but pervasive importance in the world around you. From its role in shaping landscapes and climate to its use in agriculture, the show documents water's history and influence on culture across the globe, including the challenges of maintaining healthy ecosystems and providing safe drinking water.
767 Clifton Road NE
404-929-6300
www.fernbankmuseum.org

HAWAII
Honolulu
BISHOP MUSEUM
Through January 9, 2011: "Creatures of the Abyss." Dive into the deep-ocean depths in this new exhibition that reveals the surprising landscapes and inhabitants found beneath the surface of the seas. See the glowing lights made by bioluminescent creatures, discover how strong water pressure can be at different depths, take a virtual tour of a deep-sea hydrothermal vent where unusual animals thrive in superheated water—and try not to get tangled up in the tentacles of a 26-foot colossal squid.
1525 Bernice Street
808-847-3511
www.bishopmuseum.org

A life-size model of a colossal squid, the world's largest invertebrate with the world's largest eyeball, is featured in the "Creatures of the Abyss" exhibition, now at the Bishop Museum in Honolulu.

ILLINOIS
Chicago
THE FIELD MUSEUM
Opening October 22: "Gold." Some of the world's largest and most spectacular gold nuggets are on display in this exhibition, along with cultural artifacts such as gold records, Oscar and Emmy statuettes, and a Kentucky Derby trophy. The show also illustrates historical and current processes of prospecting, mining, and refining. Brilliant gold objects document the various ways people have valued and used gold—in art, culture, fashion, and religion—across continents and through time.
1400 South Lake Shore Drive
312-922-9410
www.fieldmuseum.org

MASSACHUSETTS
Cambridge
HARVARD MUSEUM OF NATURAL HISTORY
Ongoing: "Language of Color." Find out what bold zebra stripes, bright butterfly wings, and iridescent beetle wings are saying in this dazzling new exhibition of real animal specimens, video presentations, hands-on activities, and interactive exhibits. Discover how different animals' bodies produce the rainbow of hues found in nature and the varied ways their eyes perceive color. Find out how color is used to conceal or communicate in this interactive show that lets you experience colors as other animals do, including parts of the spectrum that are normally imperceptible to humans.
26 Oxford Street
617-495-3045
www.hmnh.harvard.edu

FROM LEFT: CARNEGIE MUSEUM OF NATURAL HISTORY; SCIENCE NORTH

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800-456-SLSC
www.slsc.org

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NEW MEXICO MUSEUM OF NATURAL HISTORY AND SCIENCE *Ongoing:* **"Space Frontiers."** From ancient Native American observatories at Chaco Canyon to current facilities such as the Very Large Array observatory in Socorro, this new exhibition explores the human effort to understand outer space, and New Mexico's significant role in that quest. Artifacts and hands-on exhibits fill the gallery, giving visitors a chance to discover the work of such rocketry pioneers as Robert Goddard and Wernher von Braun, manipulate a model Mars rover, find out about the commercial Spaceport America facility that is currently in development north of Las Cruces, and more.

1801 Mountain Road NW
505-841-2800
www.nmnaturalhistory.org

NEW YORK

Buffalo

BUFFALO MUSEUM OF SCIENCE

Ongoing: **"Whem Ankh: The Circle of Life in Ancient Egypt."** Learn about daily life as it was lived, in rhythm with the seasons, on the banks of the lower Nile River 2,300 years ago. Meet the mummies of Neshor and Nes-min, who were priests of the Egyptian fertility god Min. Find out how different life was then, and yet, in important ways, how similar it was to our own lives today.

1020 Humboldt Parkway
716-896-5200
www.sciencebuff.org

New York

AMERICAN MUSEUM OF NATURAL HISTORY

Ongoing: **"Discovery Room."** Designed for children ages 5 to 12, this gallery covers research activities from anthropology to zoology, and can serve as a springboard for exploring the exhibitions in the rest of the building. Try to find all the birds, insects, and mammals that live in an African baobab tree; make your own collection of minerals or skulls from a specimen cabinet; put together a life-size cast model of the 14-foot-long, Triassic reptile *Prestosuchus;* and much more.

Central Park West at 79th Street
212-769-5100
www.amnh.org

Tupper Lake

THE WILD CENTER, NATURAL HISTORY MUSEUM OF THE ADIRONDACKS

Ongoing: **"The New Path."** This self-guided, outdoor exhibition gives you a behind-the-scenes view of the museum's eco-friendly features, from the "green" roofs to the waste and water recycling systems, plus ideas for how you can apply these technologies at home. The new facility is the first museum in New York State to be certified by the Leadership in Energy and Environmental Design (LEED) program of the U.S. Green Building Council.

45 Museum Drive
518-359-7800
www.wildcenter.org

NORTH CAROLINA

Durham

MUSEUM OF LIFE AND SCIENCE

Ongoing: **"Flip It, Fold It, Figure It Out!—Playing with Math."** Demystifying mathematics, this new exhibition uses everyday activities to reveal the hidden math principles we all use on a regular basis. Make a quilt, slice a pizza, create rhythmic tunes, estimate which juice container holds the most liquid, and much more. Discover how architects, craftsmen, product designers, and scientists use similar skills in their work.

433 West Murray Avenue
919-220-5429
www.ncmls.org

Raleigh

NORTH CAROLINA MUSEUM OF NATURAL SCIENCES

Opening October 2: **"Animal Grossology."** Based on a popular children's book, this exhibition's interactive stations and informative, humorous graphic panels allow visitors to discover the scientific reasons why cats cough hairballs, skunks stink, and birds regurgitate into their babies' mouths, among other fascinating biological adaptations.

11 West Jones Street
877-4NATSCI
www.naturalsciences.org

PENNSYLVANIA

Philadelphia

THE ACADEMY OF NATURAL SCIENCES

Opening October 23: **"Cruisin' the Fossil Freeway."** A few years ago, artist Ray

Visitors operate a mechanical model of a cow's ruminant digestive tract in the "Animal Grossology" exhibition at the North Carolina Museum of Natural Sciences in Raleigh.

Troll and paleontologist Kirk Johnson took a 5,000-mile, "ultimate paleo road trip" through the American West, encountering evidence of early life, evolution, and extinction along the way. This show recounts their adventures—and those of ancient ammonites, killer pigs, saber-toothed cats, and "angry bugs of Zion"—in whimsical, colorful, action-packed artworks and unusual fossil specimens. Walking through the exhibition, it's easy to imagine the diversity of geological features and animal life that were present thousands and millions of years ago near the location of today's cities and highways.
1900 Benjamin Franklin Parkway
215-299-1000
www.ansp.org

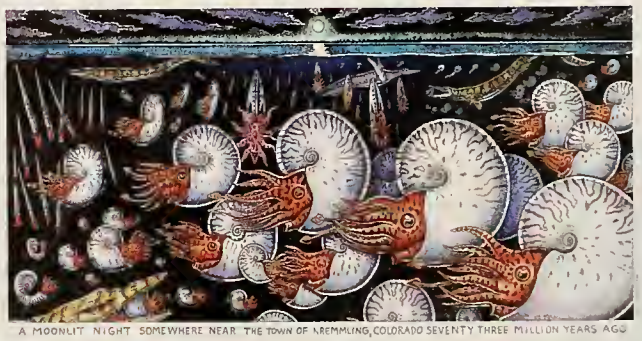
TEXAS
Fort Worth
FORT WORTH MUSEUM OF SCIENCE AND HISTORY
Ongoing: Designed by Legorreta + Legorreta, the expanded campus houses intriguing new program spaces and exhibitions covering science, technology, history, and culture. The new **"Energy Adventure"** exhibition takes you on a trip through geologic time, revealing what scientists are learning about dinosaurs and the nearby Barnett Shale; the new **Noble Planetarium** features astronomy programs on its 3D digital system with crystal-bright stars and immediately viewable events, such as new asteroid discoveries; the new **Cattle Raisers Museum** takes you into the history of ranching; and there's much more to discover.
1600 Gendy Street
817-255-9300
www.fwmuseum.org

Houston
HOUSTON MUSEUM OF NATURAL SCIENCE
Opening October 8: **"Real Pirates: The Untold Story of the *Whydah* from Slave Ship to Pirate Ship."** Starting out as a slave ship in 1715, the *Whydah* was captured by pirates, who used it to attack more than 50 other ships before it sank during a storm off Cape Cod. Now the *Whydah* reveals her secrets in this exhibition, which features real stories of the pirates' lives; gold and silver coins from all over the globe; pirates' buckles, buttons, and cuff links; clay smoking pipes; pewter tableware; and cannons, muskets, and swords. Since the *Whydah* pirates plundered so many different ships, the recovered treasure now provides archaeologists—and visitors—with a fascinating window on the intersections of the slave trade, pirates, commercial activity, and everyday life in 18th-century America.
One Hermann Circle Drive
713-639-4629
www.hmns.org

VIRGINIA
Martinsville
VIRGINIA MUSEUM OF NATURAL HISTORY
Ongoing: **"Uncovering Virginia."** This new, permanent gallery tells the story of Virginia's natural history over the course of the past 300 million years. Six exhibits focus on different geologic epochs being studied by scientists in various locations around the commonwealth. Each exhibit describes the animals and plants that lived there in the past and features a laboratory-like environment where visitors can use the same tools scientists do to interpret fossils and archaeological items. See a tropical swamp from a time when Virginia was south of the equator, visit a site occupied by Native Americans both before and after Europeans arrived, and more.
21 Starling Avenue
276-634-4141
www.vmnh.net

WASHINGTON
Seattle
PACIFIC SCIENCE CENTER
Opening October 23: **"Harry Potter: The Exhibition."** If you've ever wondered about the natural history and cultural traditions of imaginary worlds, don't miss this new show that features flora, fauna, and habitats from the famous *Harry Potter* stories depicted on film. Authentic costumes and props are displayed in galleries inspired by the film sets—including the Great Hall and Hagrid's hut. Pull a mandrake in the herbology area, see a hippogriff and a house-elf, and visit the dormitory room of those mythical creatures Ron Weasley and Harry Potter. Tools from their civilization are also displayed, including Potter's original wand and eyeglasses, the Marauder's Map, Gryffindor school uniforms, and costumes worn at the Yule Ball.
200 Second Avenue North
206-443-2001
www.pacsci.org

WISCONSIN
Milwaukee
MILWAUKEE PUBLIC MUSEUM
Through January 2, 2011: **"Frogs: A Chorus of Colors."** Hop into a herpetological world in this exhibition devoted to the evolution and biology of frogs. More than 100 living frog specimens—representing species from around the world—showcase the diversity of these animals, from the golden mantella to the Chinese gliding to the not-so-plain American bullfrog. An interactive station enables visitors to hear recorded frog calls, and a virtual dissection exhibit allows you to examine the insides of a frog.
800 West Wells Street
414-278-2702
www.mpm.edu



Night of Ammonites, by Ray Troll, is one of the many artworks in the "Cruisin' the Fossil Freeway" exhibition at The Academy of Natural Sciences in Philadelphia.

FROM LEFT: ADVANCED EXHIBITS, A DIVISION OF ADVANCED ANIMATIONS LLC; RAY TROLL

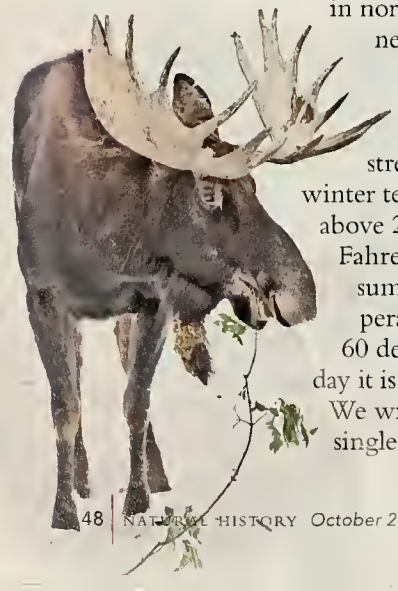
Muse of the North

By Cheryl Lyn Dybas

Hundreds of moons ago, according to Ojibwe legend, moose vanished. The Ojibwe (also known as Anishinabeg or Chippewa), a Native American tribe of the northern Midwest and Ontario, thus lost their main source of food—and a wellspring of their identity. A search party found the herd farther north and pleaded for their return. But the moose chief replied: "Without you, we can live. But without us, you cannot live."

But can the moose live with us? It is many seasons later, in 2009, and I'm accompanying biologist Seth Moore on another kind of moose quest. His team works for Minnesota's Grand Portage Band of the Ojibwe, on the tribe's reservation near Lake Superior. The researchers and I skitter along ice-crusted backcountry trails on snowmobiles, searching for what's fast becoming the state's most elusive animal—with climate change a suspect in its disappearance. "We're looking for tracks in the snow, scat left behind, or broken branches of aspen and willow trees—and hoping we see something," shouts Moore over the whine of the engines. Moose were abundant here years ago; now they are rare.

A freezing rain cut a swath across Minnesota last night, and therein lies a clue to where the moose have gone. In February, precipitation in northern Minnesota should be snow. Moose become stressed at winter temperatures above 20 degrees Fahrenheit (and summer temperatures above 60 degrees). Today it is 34 degrees. We will not see a single moose.



On a complementary mission, the Minnesota Department of Natural Resources (DNR) sends conservation officer pilots like Al Buchert to the skies in Cessna 185 planes—so-called Skywagons. Buchert's Skywagon, parked at an airfield in Eveleth, Minnesota, is outfitted with receivers. The instruments pick up signals transmitted by radio-collared moose that are part of a DNR study.

As I climb into a cramped seat alongside Buchert, he warns that "it takes a pretty strong stomach to fly in tight circles just above tree line." A whir of propeller blades, and the plane pops up like a balloon set free. A short distance above white-tipped fir trees we finally see . . . a moose. Three, in fact. "By now we should have seen thirty," says Buchert. Eveleth has been a crossroads for moose. But that, says Buchert, was once upon a time.

Moose (*Alces alces*) live only in the northern forests and wetlands of North America, Europe, and Eurasia. Minnesota's boreal forest once abounded with beaver, caribou, deer, moose, and wolf. But caribou disappeared from Minnesota in the early to mid-twentieth century, victims of overhunting and disease; now they are found only in Canada.

With caribou gone, moose reign in the Minnesota forest. Bulls may weigh 1,200 pounds and cows 900 pounds. A single moose takes about three million bites of shrubs and trees each year and eats more than 6,000 pounds of leaves and twigs, three-fourths of it in the summer, says biologist Ronald A. Moen of the University of Minnesota, Duluth. Moose spend summer days in inland lakes and bogs eating leaves and aquatic plants, storing fat for the lean winter days when they must browse the bare twigs and bark of willows, aspen, and red osier dogwood. The animal's Ojibwe name, *mooz*, means "twig eater" or "bark stripper."

Two moose populations roam Minnesota's woods, one in the northeast and one in the northwest. According to Mike Schrage, a biologist with the Fond du Lac Band of the Ojibwe, the northeast herd holds stable at about 7,500 animals. But a decreasing calf-to-cow ratio and high adult mortality bode poorly. As for the northwest population, it is already in free fall. Rolf O. Peterson, a wildlife ecologist at Michigan Technological University in Houghton who studies the predator–prey relationship between wolves and moose, reports, "Twenty years ago, the northwest herd numbered about four thousand. But by the early 2000s, there were barely a hundred."

In hotter weather, moose take refuge under shade trees and spend less time foraging for food. Seth Moore explains that because moose are well insulated, large, and dark-colored, they readily absorb sunlight and are prone to heat stress. A moose's weakened condition leaves it susceptible to lethal parasites, such as brainworm (*Parelaphostrongylus tenuis*).

Moore is one of many scientists looking into where the moose are going and why. Recent surveys on the Grand Portage Reservation, conducted by helicopter in winter when it's easier to spot animals in the forest, show that moose on tribal lands declined 64 percent between 2005 and 2008. As Norman Deschampe, chairman of the Grand Portage Band, put it: "Soon *mooz* may exist only in tales told by the fire."

Cheryl Lyn Dybas, an ecologist and journalist, covered hundreds of miles of wintry Minnesota lands on snowmobiles and in small planes in quest of moose. She has written for many national magazines, including Natural History.

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BELIZE
MOTHER NATURE'S
BEST KEPT SECRET

Over two-thirds of all people infected with HIV/AIDS live in sub-Saharan Africa, yet the continent relies on just 3% of the world's healthcare workforce,[1] a disparity that creates tremendous stress for caregivers.

The International Council of Nurses (ICN), a federation of more than 130 national nurses associations, is addressing this crisis through a program of Wellness Centers for Healthcare Workers and their Families. To learn more, please visit www.icn.ch.

BD

Helping all people live healthy lives

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ICN Wellness Centers

It is estimated that African health systems may lose 20% of their workers to HIV/AIDS in the coming years due to illness and unacceptable working conditions.[2]

BD and ICN are collaborating to establish wellness centers that provide comprehensive health services for healthcare workers and their families in countries hardest hit by HIV/AIDS and the shortage of healthcare workers.

The goal is to sustain a healthy, motivated and productive workforce, which in turn will be able to better care for patients. The program includes testing, counseling, stress management, training and treatment.

Recently, BD, ICN and PEPFAR (The U.S. President's Emergency Plan for AIDS Relief) announced a three-year public-private partnership valued at $1.25 million. The objective is to establish a new Wellness Center in Kampala, Uganda, using one constructed in Swaziland as a model.

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[1] World Health Organization, 2006. [2] Joint Learning Initiative, Human Resources for Health, 2004. [3] *FORTUNE*, March 2009. [4] Ethisphere Magazine, April 2009.