



Planet of the Beetles

Marvels of diversity,
beetles inhabit rain
forests, ice fields,
and desert sands.
A wingless trilobite
beetle from Borneo
is among some
350,000 described
species, a number
that may ultimately
reach into the millions.

BY DOUGLAS H. CHADWICK

PHOTOGRAPHS BY MARK W. MOFFETT



AS MORNING SUNLIGHT breaches the peaks and slants down through the forest, an oval shape near

the tip of a branch begins to glow. The object has a gemstone hue that dances between emerald and jade, and one end is streaked with what looks like polished silver. They say Apache Indians and Spanish explorers both left plunder here in the mountains of southeastern Arizona. But this glittering bauble has a heartbeat. It is a scarab beetle, *Plusiotis gloriosa*, dining on juniper leaves. It is also, if you pause to look closely, a window into an extraordinary dimension of natural history.

North America holds nearly 1,500 different species of scarab beetles; the world has more than 30,000. And they make up just one family of beetles. More than 150 other beetle families exist, from pine-flower snout beetles to the clan called pleasing fungus beetles. In fact, about one of every four animal species known on Earth is a beetle.

We tend to assume that big, warm-blooded beasts dominate wildlife communities. Beetles, which splat on windshields and crunch underfoot, don't seem terribly significant by comparison. But the 4,000 different mammals and 9,000 birds on the planet add up to well under one percent of the 1.75 million species identified by science. Insects make up about 60 percent, and at least a third of them are in the order Coleoptera—the beetles. This group includes more species than the entire plant kingdom does, and scientists agree that many thousands, or even millions, more beetles have yet to be discovered.

When asked what his studies of nature had revealed about God, J.B.S. Haldane, the renowned British physiologist and philosopher, is said to have replied: "An inordinate fondness for beetles." My friend Michael Ivie, a Montana coleopterist, just says, "We like to think we are living in the age of

Alien samurai, a long-horned beetle of French Guiana can exceed four inches in length. Though armed with serrated mandibles, it feeds mainly on liquids. Exactly how the world appears through beetles' compound eyes is unknown.

MACROPONTIA CERVICORNIS

man, but we are obviously living in the age of beetles." I figured the least I could do was learn a little more about them, both in their own right and as representatives of all the overlooked, small creatures that together run the ecosystems that sustain us.

Soon I had met beetles that move through water by walking on the underside of the surface as though it were a glass ceiling and beetles that jet ski on top with the aid of compounds spritzed from their abdomens; beetles that wander ice fields deep in caves, stilt-legged and blind; beetles that live in beaver fur and others high in falcon nests. I came upon beetles whose young rear up and chirrup, begging for food like baby birds, and dazzlingly iridescent beetles worn as jewelry.

There are beetles that resemble bird droppings, the better to catch flies; beetles that shape manure into balls and roll them along the ground to store as food; and smaller beetles that lay their eggs on those dung balls. I saw beetles so big that early collectors knocked them out of the air by firing shotguns loaded with sand and beetles so small they hitchhike on the mouthparts of bees. There are even beetles that make their way into museums and devour beetle collections.

IN TERMS OF SHEER VARIETY, beetles may be the greatest success story in the long history of life. The obvious question is why, and the answer begins with their defining characteristic: the hard case known as the elytra that covers the wings and abdomen like two halves of a shell. Ancestors of beetles had two sets of wings, like dragonflies, and are thought to have lived mainly on the ground and under bark. Subject to constant wear and tear, the forewings evolved into thick covers for the rear pair, protecting them against abrasion and predators. Over time, these covers grew stronger and more streamlined until beetles became rambling fortresses.

As the wing covers evolved to fit together more compactly, they helped trap moist air around the wings folded underneath. This allowed beetles to expand into desert regions, where they have flourished ever since. The same ability to store air beneath

DOUGLAS H. CHADWICK and MARK W. MOFFETT, both frequent contributors, often cover the world's wild places and creatures.

Family reunion: Having fled the heat of the Arizona desert, ladybird beetles mass in the cool heights of Mount Lemmon outside Tucson. Also known as ladybugs, these beetles are voracious predators of aphids. Collectors sell them in bulk to gardeners for pest control. Beetles are both enemy and friend to agriculture. Some species devastate crops; others attack the attackers, reducing the need for chemical pesticides.

their elytra lets other beetles live underwater.

We usually think of the Mesozoic in terms of dinosaurs. But the truly colossal event during that era, which occurred between 245 and 65 million years ago, was the origin and spread of flowering plants—an explosion of fragrance and color that transformed the globe. Beetles probably fueled it, for they were the premier pollinators among insects at the time. Then, as now, the majority of beetles relied on leaves, roots, wood, fungi, or plant debris for food. New forms of vegetation meant new opportunities, and these armored insects proliferated into a superabundance of forms.

This welter of different beetles confused me at first, but there still lives in me a ten-year-old glad for an excuse to chase the likes of toads and bugs again, the weirder the better. So I looked forward to stalking species in places like Panama, where I found myself in a lowland forest one night with several researchers. We



HIPPODAMIA CONVERGENS

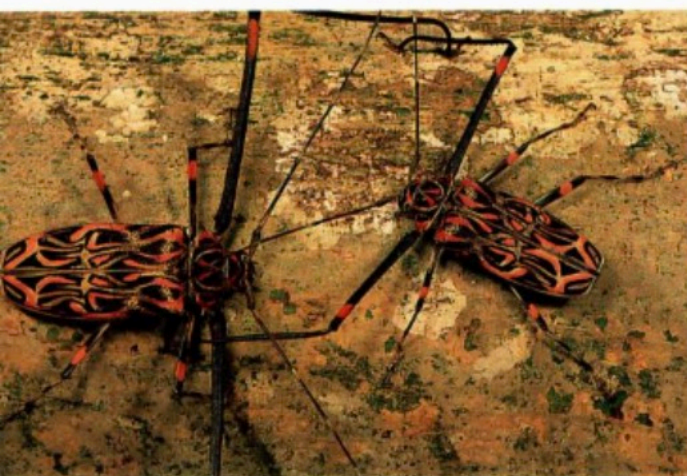
were peering at slender little rove beetles writhing among green-glowing mushroom gills. In rotting logs nearby, we located social beetles called passalids that communicate through rasps and squeaks made by rubbing their wings against their abdomens. Every so often we would hustle back to see what had been drawn to our ultraviolet light, hung in a small clearing. Hoots greeted a boat-shaped, predatory diving beetle and an elephant beetle resembling a toy tank that settled among the soft flurry of tropical moth wings.

Suddenly an engine came crashing our way through thickly knotted jungle while a powerful light beam played wildly back and forth. It was a dentist from the midwestern United States, dripping sweat and vines, holding a portable generator in one hand and a searchlight in the other. "This is my idea of a dream vacation," said David Brzoska, who was after tiger beetles, a favorite among

collectors. "I go to as many as half a dozen different countries each year. It's almost like I do dentistry to support my collecting these days."

Is it that some folks never quite grow up? Or did everyone else just give up after being told once too often: "Hey, those 'bugs' aren't really treasures"? Yet they are. Some tiger beetles on the hunt can run two feet a second. To cover the same amount of ground in proportion to its body length, a racehorse would have to hit 250 miles an hour. Some rove beetles gobble fly larvae and root-destroying worms, keeping their populations in check. Al Gillogly, who has studied passalids in Panama for years, believes those beetles may have value of a different kind. He had just shooed a snake from the entrance to a labyrinth of tunnels in a fallen tree where juvenile beetles had helped their parents rear new larvae. "These chambers seem to stay mold free for months after the passalids leave," he told me. "Apparently the

Romance begins at arm's length for two harlequin beetles, which gingerly check each other out with oversize limbs in a courtship ritual. Maternal instinct sounds an alarm in a tortoise beetle (opposite), prompting her to stand fast between her fledgling offspring and an approaching column of ants.



ACROCRIS LONGIMANUS (ABOVE); ACTOMIS SPARSA

beetles produce something that blocks the growth of fungus. We might want to investigate that chemical for our own use."

HIGH ON A RIDGETOP farther north in Panama, I placed a half-foot-long male Hercules beetle on my arm to watch for a moment. Battles often erupt when two of these tree-dwelling titans meet. They commence the beetle equivalent of roaring—loudly rubbing their wing covers—at the mere sight of each other. Each has a long horn arching forward from its head and an even longer upper horn projecting forward from its thorax. Rushing forward, the beetle maneuvers to lift its opponent between the horns and toss it to the ground below. But when I tried to lift this Hercules off me, I lost. It pulled back harder, pressing the claws at the end of each foot more tightly into my skin. I had little choice but to let the monster wander at will.

Like most people, I find it easy and natural to ascribe human qualities to various animals. Not this one. It was too cold and brittle to the touch, too robotic in its movements. Too . . . other. Waving antennae with leafy packets of receptors through the air to gather stray molecules of scent, peering out through kaleidoscopic eyes, it probably didn't perceive

the world in any fashion I would recognize.

My beetle looked like glazed porcelain. But no clay could be molded into such intricately curved patterns. Nor could I imagine any steel or modern plastic that could match the combination of strength and flexibility offered by that exoskeleton built of chitin, a polysaccharide similar to ordinary cellulose. Bronze tufts of sensory hairs sprouted from its underside and the upper parts of its legs, making some of the creature downright shaggy. As for the mouthparts beneath all that formidable battle gear, they proved to be wimpish, made for slurping soft fruit. By the time the beetle spread veined amber wings as long as a swallow's and whirled off into the jungle mists like a burly helicopter, I was beginning to hope it would stay awhile, if only as one stranger keeping another company in a vast, mostly inanimate universe.

Just how many other life-forms share the planet with us? When researchers first tried fogging the leafy canopy of tropical forests with insecticide, even the optimists were stunned by the number of unknown species that rained down. Most were very small, and most were beetles.

Terry Erwin, a biodiversity specialist from the Smithsonian Institution in Washington, D.C., counted the variety of beetles found exclusively on one Panamanian tree species, then multiplied that by the number of different kinds of trees within the tropics. The result bumped the estimate of insect species on Earth from one million to 30 million. "I wasn't trying to provide an absolute figure," Erwin explained, "so much as stimulate a healthy debate and more research into one of the most important subjects in biology."

Riding through Panama's forest canopy in a gondola dangling from a giant crane operated by the Smithsonian Tropical Research Institute, I helped a Norwegian entomologist, Frode Ødegaard, sample three of the largest beetle families: leaf beetles, long-horned beetles, and weevils. One of many scientists responding to Erwin's challenge, Ødegaard wanted to pin down the links between particular types of beetles and trees more closely. Is all the insects' food found on the host tree? Do the patterns vary from daylight to dark, from dry season to wet season? *(Continued on page 112)*





ISCROPTERA SP.

ROVE BEETLE

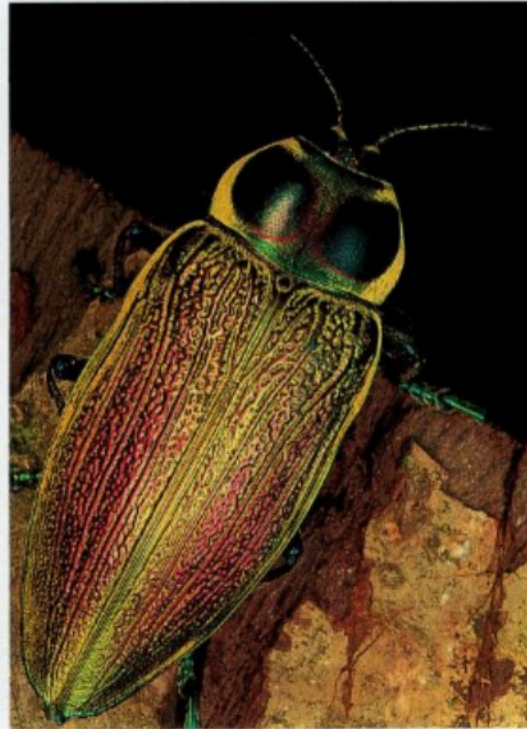
As peripatetic as their name suggests, members of this family can be found among leaf litter, under rocks, and in the mud along waterways. Many prey aggressively on other insects.

SCARAB BEETLE

Essential to ecosystems, these beetles recycle plant matter and feces. Though some are brilliantly colored, it was a black dung beetle that ancient Egyptians revered as a symbol of rebirth.

DARKLING BEETLE

Beetles, many of their darkling beetles, make up a significant portion of desert fauna. Commonly eating dead, dry vegetation, this family lives in virtually every habitat, including rain forests.



EUCHROMA GIGANTEA

METALLIC WOOD-BORING BEETLE

Often called jewel beetles because of their dazzling iridescence, this family is a favorite of collectors. Their feeding habits help speed the decomposition of wood in forests worldwide.

WEEVIL

Eight families make up the superfamily of weevils. Major crop destroyers, they chew into nuts, seeds, and plant stems. Among their vast number is the giraffe weevil of Asia.



CARABIDAE

GROUND BEETLE

A typically predaceous ground beetle prepares to use its elongated mouth to extract snail flesh from a shell. Most family members live on the ground, though some, in spite of their name, live in trees.



CHRYSOMELIDAE

LONG-HORNED BEETLE

The antennae of many long-horned beetles, like this Asian species, approach or exceed body length. Recyclers of dead plants, some also have a taste for live vegetation.

LEAF BEETLE

Plant material, preferably living, is the diet of this family. Though some are destructive pests, others are used to biologically control noxious weeds. Many are important pollinators of flowers.

A profusion of forms and functions

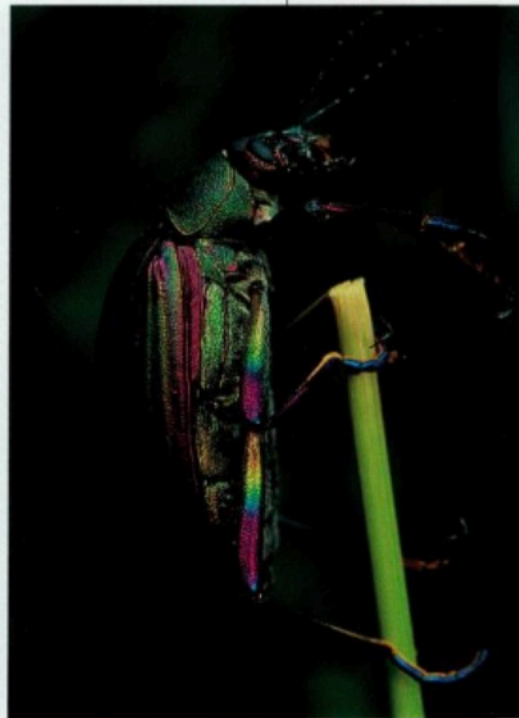
Small and mostly inconspicuous, beetles can nevertheless be viewed as evolution's biggest success story. About one-fourth of all animal species on Earth are beetles, an order that encompasses the bizarre, the destructive, the attractive, and the beneficial. The eight groups shown here account for two-thirds of all known beetles.

A key to the insect's adaptability is its elytra, a "shell" that is actually a pair of hardened wings. It protects and also serves as custom equipment, permitting some species to live in the desert by sealing in moisture and others to move underwater by trapping air.

Beetles fill critical ecological niches; their scavenging helps remove animal wastes, carcasses, and plant matter. As pollinators they aided the great explosion of flora in the Mesozoic era.



STENUS SP.



EUCNEMA SP.



ATELABIDAE, IN THE SUPERFAMILY CURCULIONOIDEA



SARCOPHAGA SP.

Disposal specialist, an African scarab beetle (below) rolls animal dung into balls, which are buried and fed upon by its larvae. A burying beetle (bottom) recycles a dead rat by laying eggs near its body, then feeding larvae bits of regurgitated carcass. Both of these beetles work in monogamous pairs, as do some bark beetles—though their work is less welcome. One species (opposite) riddles fir trees with channels where larvae will mature.



CIRCELLIUM BACCHUS



NICROPHORUS ORBICOLLIS (ABOVE); DENDROCTONUS PSEUDOTSUGAE

(Continued from page 106) Though Ødegaard was addressing some big ecological questions, the fascination for me was in the details: the convoluted origami patterns in which chubby attelabid weevils rolled leaves to seal off their eggs from predators or the way some tortoise beetles clamped their transparent armor down onto a leaf like a limpet threatened by enemies. Some tortoise beetle parents guard their young for weeks, driving off parasitic flies and using the edge of their flattened elytra like a shovel to toss away ants.

An ordinary walk through an equatorial forest can reveal beetling multitudes, provided you bring along a kite-size white cloth stretched open by sticks. Collectors call it a beating sheet. Just stop every so often, hold it out, and club the hell out of the vegetation above to see what comes showering down. More often than not, you'll have lizards leaping off the sheet between shaggy, bright-eyed spiders and wasp-size ants looking to pay you back for their tumble. But you'll also have incredible beetles scuttling in all directions. And to identify them before they fly off, you have to reach into the hubbub and grab the big ones, jam them into containers, then whip out a special jar with tubing to suck up fully grown, elaborately sculpted marvels that may be no larger than this sentence's punctuation marks.

When I literally beat the bush for several weeks in the remote Congo Basin of equatorial Africa, two things happened. First, my attention focused down from the level of splashy butterfly wings to one where an odd freckle on a leaf might stop me cold. Bark became a terrain of hillocks and gullies, and I started seeing dirt as individual grains—all habitat for my quarry. Sifting through leaf litter, I gathered a number of slow, heavyset adult darkling beetles feeding on decaying vegetation. Uniformly dull black in color, they all seemed alike—until I noticed intricate patterns of pits, knobs, grooves, and ridges embellishing the wing covers. They made the darkling beetles as different from one another as the local gorillas were from their fellow primates, the chimpanzees, whooping in the distance.

The second thing that happened was that I came home with beetles unknown to science. Not that I was able to recognize them as such; Mike Ivie and his wife, LaDonna, did when I brought the collection to their entomology lab at Montana State University in Bozeman.

Mike later showed me one of the still unnamed new species under a microscope. He said, "We think it's a type of myrmecophile," literally, a lover of ants, in whose colonies a great and bizarre assortment of beetles have carved out niches. My beetle's antenna segments looked like toddlers' play blocks strung together—cone upon ball upon rectangle and cylinder. Yet it was Mike who also taught me that you don't need to trek to feverishly exotic places to find beetles stuffed in every cranny.



For several years following a 1988 wildfire, the Ivies surveyed beetle populations on the west side of Montana's Glacier National Park. "You might expect a northern conifer forest with snowcapped peaks to have a meager beetle fauna," Mike said, "but we came up with roughly the same number of species that we've recorded in the Virgin Islands"—over 1,200.

Hiking along a wolf-tracked floodplain, Mike paused at a charred pine and pointed out the pinhole-size borings of ambrosia beetles, which cultivate a wood fungus for food and carry its spores from tree to tree in special pockets on their bodies. Peeling back the bark exposed several ground beetles, which are typically voracious hunters. Many stalk caterpillars, in effect guarding woodland foliage from outbreaks of harmful moths.

Mike told me that 55 beetle species from this part of Glacier, including one genus so far found nowhere else in the world, showed up only in the old-growth stands. Wildlife managers in the Northwest have considered pileated woodpeckers and spotted owls indicators of healthy old growth. But accurate counts can take years, and the animals often visit other types of vegetation as well. By contrast, each stage of plant succession has a very distinctive community of beetles intimately bound to it. Sampling the beetles thus becomes a much more precise and efficient way to keep track of changes within forests—and most other kinds of environments. "These critters," said Mike, "are the ultimate indicator species."

WHAT DOES IT MEAN, then, when a beetle is facing extinction? Nine U.S. beetles are on the threatened and endangered list. On Block Island, Rhode Island, dwell several hundred American burying beetles, *Nicrophorus americanus*. They constitute one of the largest single populations left of this orange-dappled, inch-and-a-half-long species once common across the eastern half of the nation.

Ancient Egyptians held another recycler, the dung beetle, to be a sacred symbol of rebirth, ever emerging from the ground. I wouldn't go so far as to worship beetles, but considering

For good or ill, some beetle species are chemical factories on legs. In Namibia the *Commiphora* tree is the host plant of this leaf beetle (below). When its larvae feed on the leaves, they produce a toxin—not found in the adults—which a Kalahari Desert Bushman squeezes onto an arrow tip. The poison on a single arrow can fell an adult antelope.



CHLAMYPHORA NIGROCORNATA

what our surroundings might smell like if those that consume carrion or animal droppings went on strike, I would definitely give thanks now and again. Among the legions of beetles that speed up decomposition and the recycling of nutrients through ecosystems, pairs of American burying beetles inter the carcasses of small mammals and medium-size birds to feed developing larvae. Where the ground is too hard, the male and female may lie on their backs underneath the body and push it along with their legs to softer dirt. They can lift animals 200 times their own weight and move them several feet.

Though no one knows for certain what caused the species' decline, some view it as an aftershock from the 19th-century slaughter that drove North America's most abundant bird, the passenger pigeon, to extinction along with the Carolina parakeet, heath hen, and other key food sources. Watching some of the scavengers in a Block Island field now protected from development, I thought of how far our society has come to bestow upon a gravedigging insect the same legal protection granted whooping cranes and humpback whales.

The most intriguing issue is not why some



beetles are in trouble but how the group as a whole continues to reign in such splendid profusion. I could hardly avoid the subject while high above Tucson, Arizona, on the summit of Mount Lemmon. The ground, tree trunks, and a growing portion of my body were orange with ladybugs, more properly called ladybird beetles. Entrepreneurs roam the countryside harvesting such mating congregations and deliver ladybirds by the bagful to companies that sell them as gardening supplies. By one estimate, the descendants of a single female can eat 200,000 aphids in one season.

Beetles have proved invaluable in the control of damaging insects and invading weeds, and they continue to be major pollinators. But some, like the boll weevil, which toppled the cotton economy of the American South during the early 20th century, are notorious munchers of crops, stored grain, or timber.

Back in the buffalo days a striped leaf beetle lived out on the Great Plains, contentedly eating buffalo bur, having mastered the trick of digesting the natural toxins that these plants in the nightshade family manufacture to defend themselves. Then settlers replaced the native prairie with solid rows of potatoes—also in the

nightshade family—putting an obscure little critter on the road to big-time pesthood. By the late 1800s the problem had spread across the U.S. and was soon bound for Europe. We named it the Colorado potato beetle.

One of the first insects to come under broad attack from pesticides, the Colorado potato beetle was among the first to become resistant. Genetic variation, coupled with the insects' rapid rate of reproduction, kept yielding generations able to tolerate each new poison. The species is still thriving, costing farmers as much as \$250 an acre in the latest chemicals.

Did the agrochemical folks really think they could brew up an easy way to erase organisms that have been reinventing themselves for 300 million years? There are blister beetles whose touch can start your skin peeling and bombardier beetles that shoot boiling hot mixtures from glands near their anus to repel enemies.

These creatures are like little chemical factories crossed with organic microchips crossed with Swiss army knives, able to add to their basic armored body plan the latest survival tool needed. Some beetles proceed through four or five dissimilar forms using separate habitats as they grow to adulthood. They are really several

Desert magician, a darkling beetle conjures moisture where there appears to be none. Even in Africa's harsh Namib Desert, dew forms at daybreak. As condensation forms on its shiny exoskeleton, the beetle tilts forward, sending water down its body and into its mouth.

ONYMACRIS UNGUICULORIS



organisms in one, each subject to different natural selection pressures. This may boost the whole pace at which they evolve.

THE WORLD'S BIG WILDLIFE is under heavy siege, which makes being a nature lover seem more a burden than a joy at times. Yet as soon as I start poking around the plant stems in my backyard and turning over old boards or linger by the porch light on a mid-summer night, the natural realm suddenly seems crowded again, wilder and more varied than ever, teeming with opportunities—the way it used to feel when we were children.

"As a boy, Dan was always vanishing when we went for walks in the fields," said his father, Don Schmidt, leaning on a tractor near Schuyler, Nebraska. "I'd turn around, and he'd have disappeared on his knees in the grass."

Dan, a slim, mustached man who raises pigs on his own place and helps his father with corn and cattle next door, laughed and said, "Like most kids I was crazy about dinosaurs. Then I discovered there are even stranger creatures underfoot. I became an avid insect collector."

As time passed and responsibilities grew, Dan dropped his hobby. A few years ago, however, he read a newspaper article by Brett Ratcliffe, a professor at the University of Nebraska in nearby Lincoln. Ratcliffe, a leading scarab beetle researcher, was asking people to help keep an eye out for the American burying beetle, recently rediscovered in the state. Intrigued, Dan visited the university, and Ratcliffe guided him through the museum's collections, rattling off information with infectious enthusiasm. I know, because Ratcliffe later guided me, pulling out drawers that included the most beautiful life-forms I had ever laid eyes on: weevils that were turquoise and amethyst mosaics; scarabs like thumb-size ingots of gleaming gold; rhinoceros beetles whose huge horned heads reminded me of *Triceratops*.

"I got excited about collecting again," Dan recalled. "I thought, I'm not the only crazy guy around—people actually do this for a living." At Ratcliffe's suggestion Dan concentrated on certain subfamilies of rove beetles that can be extremely difficult to tell apart. To gain a clearer understanding of the rove beetle family tree, taxonomists need to scrutinize the larval stages, but there had been very little luck rearing the larvae from eggs. Working in his home

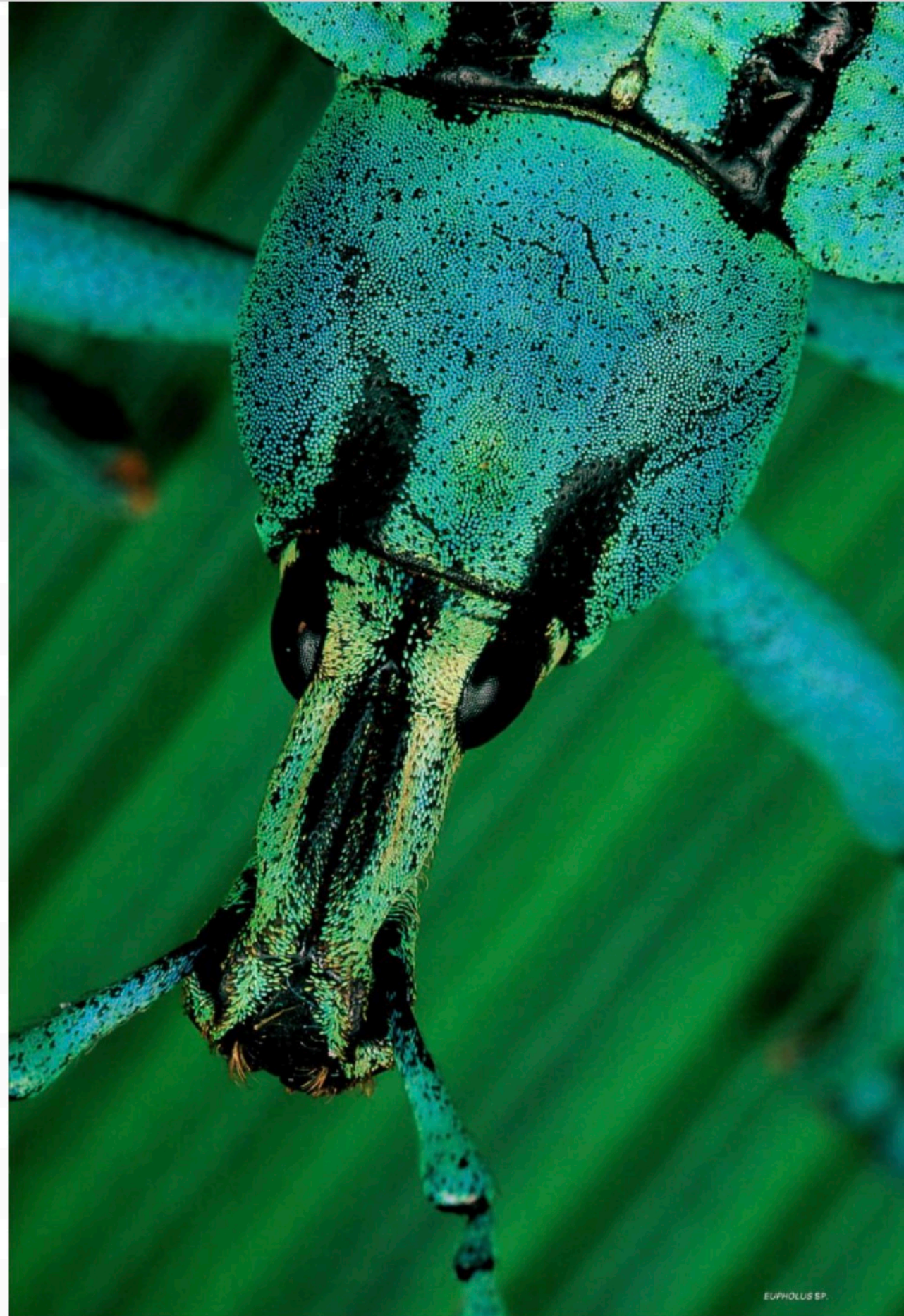
The streamlined shape and shimmering scales of a New Guinea weevil would please any collector. Naturalists Joseph Banks and Charles Darwin were both avid beetle collectors even as children. With untold numbers of species yet to be identified, new discoveries promise more wonders for decades to come.

laboratory—a closet warren of shelves and jars next to the furnace room, plus a corner table in the living room—Dan devised a way to keep the larvae of one species thriving. The key? American cheese, which grows the fungi that feed the nematodes that Dan found the larvae require as food.

"Check out these guys." Dan set out a shallow dish of soil with rove beetle larvae and added primitive little insects known as springtails. Though nimble jumpers, springtails are wingless, and as they hopped about plump and pale, the beetle larvae came racing through the openings between clots of soil. Leaping and twisting, they impaled their prey between pincer-jaws, shook them in the air, ripped them in pieces, and drained their vital juices. Staring through Dan's microscope, I was seeing cheetahs among antelope fawns, *Velociraptor* falling upon a herd of soft-bellied fellow reptiles.

"It's a fierce world down there," said my host, who has published three scientific papers and is preparing a fourth. Amateur naturalists have always made invaluable contributions to our knowledge about insects, especially beetles. Science sometimes seems intimidating, but, at heart, it is just about looking and asking questions. All you need is an advanced degree of curiosity. Read about Charles Darwin, an indifferent student but a fanatic beetle collector when young. Ask Dan, who corresponds with rove beetle specialists around the world.

The Schmidts invited me to dinner. It was the Fourth of July, and the table was crowded with relatives of all ages. By the time I left, night had fallen. I drove down the dirt lane past the corn rows with my car lights off, so I could see the show in the sky better. Skyrockets were bursting in the distance. Closer by, fireflies danced over low-lying fields dampened by recent rains. I thought they were more spectacular, for there were thousands of them: beetles becoming living explosions of light, ignited by their need to mate, to make more of themselves, to be alive. □




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