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Fall 2013

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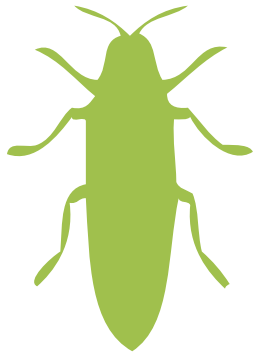
Earlier this year a team of Museum scientists ventured deep into Borneo's Gunung Mulu National Park. They went to learn more about insects, bats, mushrooms... and to gain insight into the effects of climate change on life on our planet. The results—like their experiences—are amazing

PHOTOS AND TEXT BY JOSHUA SEE





Descending some of the steepest terrain on Mulu's summit trail, mycologist Bryn Dentinger steadies himself with a knotted rope. The high-elevation section of trail has been carved through thick vegetation of shrubs, stunted trees, and carnivorous pitcher plants.



It is nighttime in the jungle as two faint torchlights move along a winding trail, their beams cutting in and out of the darkness. They sweep the forest floor in search of steady footholds, among wet clay and tangled vegetation. Despite the darkness, the forest is awake and booming with sounds. Loud cicadas nearly drown out the rest of the forest chorus, but a patient

ear hears more: frogs, barking deer, and the chattering of bats overhead. The press of the jungle is all around.

Overhead through the dense rainforest canopy, the sky is heavy with mist. To the east, peaks of the island's vast mountainous spine guard its interior. This is Gunung Mulu National Park, an internationally recognized biodiversity hotspot. Encompassing ancient tropical lowland forest and mountain wilderness, the park is nestled in the heart of Borneo—a vast Southeast Asian island sprawling along both sides of the equator. More than three times the size of Great Britain, Borneo is home to an astonishing 10 percent of all living species.

It is the final months of the rainy season, April and May, and a team of nine ROM biologists and collaborators are setting out to live and work here in Gunung Mulu. The expedition brings together a diverse group of scientists: mycologists, who study fungi, entomologists, who concentrate on insects, and mammalogists, who focus on mammals.

Ascending Mount Mulu, from near sea-level to a summit elevation of 2,377 metres, about the height of a 720-storey building, the team is here observing, studying, sampling, and collecting cicadas, moths, bats, rats, fungi, and more. While the specific questions driving team members' research vary widely, everyone ultimately shares an underlying common agenda: to learn about the diversification of life on earth.

Researchers look at where species discovered today fit on the evolutionary tree of life. Taxonomists, who classify living and extinct organisms, evolutionary biologists, and ecologists, these scientists are actively piecing together fundamental questions about biological evolution. With Borneo changing rapidly as rainforest is converted to timber and palm oil—and with a shifting global climate that leaves nothing, even this remote island, untouched—their work has taken on greater urgency. They know that by illuminating and specifying relationships among living things, we are all better able to make critical decisions about conservation and resource management.

Most visitors to Gunung Mulu stay in lodging at the park headquarters at the base of Mount Mulu. There, amenities are relatively

cozy, with satellite-linked internet and a café overlooking one of the park's cool rivers. But beyond the headquarters, the expedition must leave behind the comforts of electricity and fresh produce, staying instead in a series of three basic open-air shelters along the steep and narrow footpath to Mulu's summit. From Camp One next to a crashing river, to Camp Four just below the summit, the forest and the species that live there change drastically. For biologists, this elevational gradient translates to great sampling.

Each specialist team has its own focus. Veteran entomologists, curator Chris Darling and technician Brad Hubley primarily focus their efforts on geometrid moths and the cicadas of Mulu's forests. Tropical mammalogist and assistant curator Burton Lim along with graduate student Tom Horsley search out Mulu's famous bats and many of its small rodents. The mycology team, foraging under leaves and across the forest floor, finds strength in numbers: curator Jean-Marc Moncalvo and his eldest son, Mathieu, technician Simona Margaritescu, visual artist Hilary Hatzipetrakos, and Bryn Dentinger, a former post-doctoral fellow of Jean-Marc's and currently head of mycology at Kew Gardens in London, UK.

The collective experience of tropical biological exploration within the team is immense. Although the team's collaboration is strengthened by a common research agenda, it is also born out of practical necessity. Working, living, and trekking through tropical mountain wilderness are difficult endeavours, and sharing resources makes it all easier. With no roads in Mulu, the only way to reach the summit is by foot, along a sometimes treacherous, always wet, and usually steep mountain trail.

More than three times the size of Great Britain, Borneo is home to an astonishing 10 percent of all living species

Much of that trail was blazed in 1977 and 1978 during a Royal Geographic Society expedition, and it ascends 24 kilometres to the summit of Mount Mulu. The Society's ambitious expedition established critical baseline information on the area's biological diversity. As was the case in 1977 and 1978, the modern ROM expedition, with the integral support of local guides and porters, must carry everything along this trail on their backs: scientific equipment, liquid nitrogen, ethanol, hammocks, cameras, bags of rice, cartons of eggs, and more.

Living in the rainforest means a lot of things, and one of those is certainly water management. Humidity is constantly approaching 100 percent and a heavy downpour is never far away. At Camp Three, damp clothing hangs heavy on a rope criss-crossing the rafters, doing its best to dry in the thick mountain breeze. The only way to fully dry something is to wear it, body heat doing what unassisted evaporation cannot. Given this, it is not unusual for a team member to be seen putting on rather than taking off wet clothing.



The slopes of Mulu, steep and saturated, often channel rain into streams that then rapidly swell into rivers. This is what Chris, Brad, and a small group of Penan porters encounter when ascending towards Camp One in relentless rain: a surging river that other members of the team had crossed earlier in the day without so much as rolling their pants to the knees. In a few hours, the river has become deep and dangerous enough that the entomologists are forced to erect a makeshift overnight camp while the mountain drains itself.

Dark, heavy planks of ironwood form the frames and steps of Mulu's camp structures. Corrugated metal, green with moss and algae, amplifies the sound of the strong afternoon rains. Strung between upright posts and crossbeams, the expedition's hammocks offer a comfortable refuge after long days and evenings working in the forest. A local guide prepares meals that usually consist of rice, rehydrated mushrooms, cabbage and tinned chicken or beans. On the equator, the sun sets quickly and so evening meals are shared sitting cross-legged by candlelight.

The particular urgency of biological research in Borneo stems from the fact that in the 35 years since the Royal Geographic Society conducted its fieldwork, much has changed on the island. Although Mulu itself is a protected area, park boundaries and ecological realities do not necessarily respect one another. Outside of its mountainous interior, around 90 percent of Borneo has been deforested, legally and illegally, at increasingly rapid rates. When the surrounding forest is removed, the weather in Mulu can change, particularly with respect to rainfall—the very essence of rainforest. In addition to local factors, the reach of global climate change may also be marking Mulu.

But for now at least, Borneo offers unparalleled riches for all biologists. For mammalogists, the lure is intense. Some of the largest caves in the known world are here, where nightly millions of bats leave their dark roosts to feed on insects high above the forest canopy. By moonlight, through mist net collection and aluminum live traps, mammalogists Burton and Tom catch these winged mammals along with rats, squirrels, and shrews. Recent

research suggests that bat diversity in Southeast Asia may be underestimated by as much as 50 percent, while the geographical distribution of many small mammals remains poorly known.

Mammalogy curator Burton and graduate student Tom form the team that works in darkness, torchlights in hand. Together they hike toward the thin threads of a mist net strung between rain-forest trees. Burton's light outlines the forms of three bats caught in the netting. The first is a pygmy fruit bat, an important helper of trees in need of seed dispersal. Reaching up, Burton untangles the flying mammal, as if it were a puzzle to be solved. Each wing, hand, and foot is removed in just the right way, a mix of precision and confidence necessary when working with animals that readily



Top: By morning light, cicadas collected during the previous night are sorted, catalogued, and packed for transport down the mountain and on to Toronto.

Middle: Chris Darling displays a moth captured using high-powered light traps in the night-time forest.

Bottom: At high-elevation Camp 4, entomologist Brad Hubley labels and pins moths onto foam plates, for study later by the ROM's and other experts.



Partially removed from a mist net near Mulu's summit, a species of fruit-eating bat is examined by mammalogist Tom Horsley. For many species of rainforest trees, these bats are essential workers of seed dispersal and tree renewal.



defend by biting. The disentangled creature in Burton's hand is a glimpse into the usually secretive world of bats.

With Tom working on removing the second bat, Burton pushes through plants to reach the third, tangled high on the opposite side of the net. It's another fruit bat, but clearly of a different species than the first. On its face, folded projections of skin curve upwards and back towards the bat's large ears, working to direct echolocation to where it is needed.

They untangle the bats carefully; each will offer a valuable glimpse into a secretive world

Back in his lab at the ROM, Burton will use his findings to help answer questions of evolutionary diversification. He stands among a small crowd of modern scientists who have discovered an entirely new species of mammal.

For entomologists, the setting is equally bountiful. From the treetops male cicadas scream their dusk chorus hoping to attract mates. Their sounds are produced through specialized vibrating plates, stretched over a resonance chamber. Using high-output mercury vapour lights, white sheets, and trap boxes, Chris and Brad coerce these cicadas and geometrid moths to participate

in novel research; as our climate warms, species are predicted to ascend mountains. The ROM entomologists and international collaborators are testing whether or not these movements are already taking place in Borneo.

Despite the need for meticulous analysis and identification of insect specimens in the lab, sometimes novel discovery loudly shouts its arrival from the field. And on this trip there's one such find: a particular cicada, alive and well but an unwilling host to caterpillar larvae. The ROM's entomology veterans immediately know they have something unique. Despite targeted cicada sampling in the 1970s Royal Geographic Society expedition, parasitic caterpillars weren't found and have never been reported for Borneo. And they may never be found again.

For mycologists, Borneo also teems with scientific discovery. Camp Four sits just a few hours' scramble from the cloud-laden summit. For three days the ROM's mycologists eat and sleep in the surrounding high-elevation forest while combing it for mushrooms. Peering into the screens of each other's cameras, they marvel at what has so far been found in the expedition.

Mycologists might say that if poetry lives in the natural sciences it might very well be found in fungi. Beautiful, delicate, delicious and sexy may not be words that spring to mind when most of us consider fungi and mushrooms. But, spend some time mushroom hunting with mycologists and quickly you will understand. The strange appeal of this largely hidden world is hard to ignore once you know what to look for.

The mushroom is the fruit of the fungus, its reproductive organ. Most of the fungus, however, lies out of sight, yet close beneath our

feet or above our heads. What we don't normally see are the immense networks of fungal mycelium, thin strands that connect plants in the forest to each other. The largest organism on earth, in Oregon, is thought to be a fungus, its mycelium covering nearly 10 square kilometres. In the tropics, fungi diversity is off the charts, with an estimated seven species per every species of plant, perhaps of mostly unknown species.

Borneo may be a creative engine of global fungal diversity. Collecting and classifying fungi from Mulu, Jean-Marc and his team of mycologists hope to learn whether fungal groups originating in Southeast Asia have spread their genes around the globe.

Upon descending back to park headquarters, visitors can depart Mulu by air from the small airport at the mountain's base. From this aerial vantage, Mulu's wilderness gives way to a vast expanse of palm oil plantations and deforested land. Virtually unbroken all the way to the coast, the deforestation is a grim reminder of how vital this research expedition and its findings are.

The mycologists came to learn whether Borneo is a global generator of "fungal biodiversity"

Back in Toronto the mycologists count 410 unique fungal specimens brought back from the forests of Borneo. Some 20 percent of the collection, they estimate, will contain species entirely new to science.

The mammologists have added at least four new species of bats to those known to live in Mulu, while charting the extended elevational range of others. Park managers and strategists will use this information to make critical decisions about the forest's future.

For the insect team, the cicada and geometrid moth samples have been carefully organized and shipped to entomology colleagues in The Netherlands and the United Kingdom for specialized identification. Once completed, these new records will be compared to the original Royal Geographic Society's findings to see what has changed in nearly four decades within Mulu. The parasitic caterpillars found living on the cicada will be more difficult to identify and will present more questions than answers.



There is still much for us to learn about our world, even though the nature of discovery is perhaps less dramatic than in the early days of frontier scientific expeditions. Still, for now, this island remains a frontier. After a lifetime of exploration, biologists treasure the fact that Borneo still teems with new discoveries, lying in wait for their return. Fortunately fieldwork is a way of life for them. For without knowing what lives where on this planet, we can't be sure of what we stand to lose—let alone take steps to stop the losses. o

Top: The day's fungi collection is arrayed on the floorboards of Camp 3. Next, the fungi will be sampled for DNA, catalogued, and dried.

Bottom: Hillary Hatzipetrakos and mycologist Jean-Marc Moncalvo carefully search for and extract mushrooms from the forest floor.

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Follow our Borneo adventures at rom.on.ca/nature
Learn more about the challenges facing the conservation, diversity and survival of life on earth in the **Life in Crisis: Schad Gallery of Biodiversity**.