*Article and photographs by Mark Moffett*

# These plants scratch, claw and strangle their way to the top

*Tropical climbers will do almost anything to reach the canopy and life-giving light; some even start at the top and grow down*

Research assistants climb the cylindrical jungle gym that is a mature strangler fig tree in Costa Rica.

Host tree around which the strangler grew has long since died and decomposed, leaving only its shape.

Upon first entering the rain forest in Borneo, I was surprised that the palms I'd seen overrunning the trees had long, inch-wide stems instead of stout trunks. These rose in messy spirals, held to tree trunks by straplike extensions that tore my arms and legs with spines as nasty as sharks' teeth. Walking off the beaten path, I blundered into a maze of coils that resembled the barricade of barbed wire around a prison. Bloodied, I sank knee-deep into mud. Above, I could see how the palms' stems looped out of view into the canopy, spines racheting against tree limbs along the way. Eventually, I pulled one aside and made my escape.

Picking at my rice beneath a dripping lean-to later that day, I learned from the forest guards that these climbing plants were rattan palms, valued for furniture. Rattans use their spines primarily to claw their way into the canopy and secondarily to keep biologists and other large vertebrates at bay. Perhaps my scars from this encounter diminished any esthetic appreciation I could have been nurturing for climbing plants.

Years afterward, while downing beef stew in the more refined atmosphere of the cafeteria on Panama's Barro Colorado Island, part of the Smithsonian Tropical Research Institute, I voiced my opinion of climbers in front of several resident biologists. This raised the hackles of botanist Darlyne Murawski, who proposed to set me straight. In the course of rambles on the island, Darlyne introduced me to climbers at every turn.

This six-square-mile island harbors 175 species of climbers. What surprised me most was their visual diversity. Though their species are fewer, climbers belong to twice as many families of flowering plants as do epiphytes (plants that usually root in trees instead of the ground, such as bromeliads and some orchids). Darlyne pointed out species new to me: climbing ferns, climbing bamboos, climbing gymnosperms (relatives of the conifers). For their assault on the canopy mountain they come equipped with whips, claws, hooks, glues, Velcro-like bristles, pitchforks, suckers, corkscrews–seemingly in every combination. Structure varies as well. Many of the bigger climbers were plaited like rope.

My favorites were flat ones that looked like ribbons. In South America I had come across such "monkey ladders," a foot wide by a half-inch thick, with elegant, undulating surfaces. Where a loop of one hung near the ground, Darlyne and I could not resist taking turns sitting in it and kicking our feet to swing like children.

Both delicate and robust climbers abounded. One specimen, a member of the pea family with a cylindrical bole two feet in diameter, was Jack's beanstalk come true. Initially shooting to the heavens like a tree trunk, it subdivided again and again to create a viny cosmos, swathing 64 canopy trees spread across an acre with leaflets so fine it was hard to believe they belonged to such a large organism. This plant, the research subject of Francis (Jack) Putz at the University of Florida, may be the most enormous climber ever studied.

These titans sprout more foliage than any single tree. Jack calculates that a climber three inches in diameter may have as many leaves as a tree with a trunk two feet across. The difference is that the climber, freed from supporting its own weight, can direct more of its resources into dominating the canopy.

With their ground connections, climbers can withstand conditions that would be too dry for many epiphytes. But transporting water and nutrients over long distances requires special anatomy. The vascular channels of most plants are undetectable with the naked eye, but in climbers they are wide enough to be seen as pores when the plant is cut. Large quantities of liquid pass through with ease. In temperate climates such wide vessels would be detrimental; freezing can introduce air into them, and air–by blocking nutrient and water flow–can be as deadly as nitrogen bubbles in the capillaries of a careless diver. This may explain the scarcity, except for some ivy species, of long-lived woody climbers, called lianas, in the temperate zones. Short-lived herbaceous climbers, called vines, are common in the understories of both temperate and tropical regions.

Almost any part of a plant can be modified into a contrivance for scaling the heights. "Darwin wrote a book on this subject," Darlyne reminded me, clinching the issue of the importance of climbing plants. Some species use tendrils–projections evolved from leaves or branches. Tendrils sprout at intervals along the stem and curl around anything they touch. Moreover, tendrils of some plants explore preferentially in the direction of nearby objects, apparently sensing them from afar.

Other climbers, called twiners, wind their entire length around a support plant; the tip revolves as it grows. Still others use modified roots or twigs to adhere to the trunk or grip cracks in the bark. Finally, those known as scramblers simply grapple their way upward through foliage without clinging tightly to any part of it.

Vine tendril reaches out and touches nearby stem (top). Two days later (above) tendril has a firm grip.

Each strategy is ideal for particular circumstances. Tendrils work best with slim supports. Twiners, perfect for supports of moderate diameter, fall into a heap if they attempt too wide a limb. At the other extreme, adhering roots succeed with trunks too bulky to be held any other way but fail with slim vegetation.

Lianas start life indistinguishable from seedling trees. These young grew everywhere Darlyne and I looked. Wherever *Doliocarpus* juveniles were exposed to sunbeams in small canopy gaps, the young climbers were transformed, thrusting upward and acquiring a long terminal shoot. "Unless a young vine finds something to lasso, it eventually collapses under its own weight," Darlyne said. Fallen individuals continue to send up shoots, one after another, in search of that crucial first toehold toward the canopy.

"Tendril-bearers and scramblers need frequent stepping-stones to continue skyward," Darlyne said. Twigs and branches of other plants are stepping-stones. Most climbers cannot bridge a space of more than one to five feet between these support rungs. The first steps upward



Thick, ropelike stems of an adult liana girdle a tree trunk. Smaller climbers compete for space.

can be difficult in the relatively open understory of an undisturbed forest. By contrast, any place with a thick understory (a riverine or hurricane-prone forest or a major treefall gap) provides support every step of the way. Such "jungles" are enveloped in a riot of vines at ground level.

Pristine tropical forests may be as laden with climbers as any of these heavily disturbed places: their greenery is just not visible from the ground, having grown over the top of the canopy. In New World rain forest (where most research is based), about half the canopy trees have lianas. These either reached the canopy long ago, during periods of forest disturbance, or ascended tree boles or other lianas. When a liana arrives at a tree's summit, it extends toward the heavens before falling back to the canopy surface. Continuing in this clumsy fashion, it grows horizontally across the crown. In many cases the plant expands over swaths of canopy by repeated dividing.

Eventually the liana comes to the crown edge. To bridge a gap between trees, a terminal shoot arches up, then leans over to the next crown. This is accomplished through trial and error, so that shoots may sprout at different angles before one succeeds. The initial connection is hard to maintain. Crowns often throw off tendrils while swaying in the wind; gaps wider than a couple of yards cannot be bridged at all. While trying to cross an abyss, all or part of a liana may plummet over the edge of the crown. The plant can still succeed in an assault on the adjacent tree, but now it does it the hard way: starting from below, it finds and climbs a suitable trunk.

Growing slowly in girth, lianas may outlive many of the trees that support them. They are built to survive smashing and twisting, and they seem potentially immortal. Yet forest upheavals leave permanent marks on lianas. Climbers spiraling in empty air, odd shifts in direction or distortions of form–all suggest the ghosts of trees past. A liana draped partway to earth between crowns, for example, tells us that a tree bearing it aloft once stood at the intermediate spot.

Climbers drive some of this history themselves. Lianas are a burden to trees, spreading over and shading them. They slow growth and even snap the saplings they use as stepping stones. Trees improve their chances of surviving if they can grow faster than the climbers on them. Jack Putz has found that trees with large leaves, shedding bark and swaying trunks often dislodge pesky climbers. And fewer climbers may be able to bridge trees that sway out of sync, he notes. Perhaps the varied architectures of tropical trees result in different rocking patterns. It is Jack's conjecture that the tactics of lianas may promote local tree diversity.

Drooping languidly over trees, lianas appear to have little of the vigor needed to reach the canopy. Some early observers had assumed that lianas were carried up like hitchhikers on a growing tree. "Absolutely not," Darlyne insisted. Because plants lengthen only at their tips, any points along a trunk forever remain the same distance apart; growth there occurs only in girth. A liana has to do all the climbing by itself.

Not all vinelike plants start at the bottom and work up. Cristián Samper, an ecologist, researches a group of such plants called hemiepiphytes (plants that are epiphytes for part of their lives) in Colombia's La Planada Reserve. La Planada lies in the greatest expanse of cloud forest on Earth, a vast breeding ground for new plant species. In disturbed forest around the living quarters in the reserve, epiphytes that anywhere else would be hidden in treetops adorn branches at eye level with garlands of flowers. In deep forest, plants form herbaceous coats a yard thick on trunks and hang like draperies from branches.

We stopped to look at the roots of a clusia, the

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Botanist Darlyne Murawski untangles monkey ladder vine in Panama's Soberania National Park. More than 175 climbing species grow on nearby Barro Colorado Island, part of Smithsonian tropical research station.

hemiepiphyte Cristián was studying. A half-inch or so wide, the roots stretched straight from the canopy to the ground. They felt as taut as strings on a supersized banjo. I plucked one and watched it oscillate in waves up to the canopy, where I spied, at last, its big rubbery leaves.

By definition, a hemiepiphyte switches survival strategy over its lifetime. Living first as a canopy epiphyte, a juvenile clusia may grow just two leaves a year. In a few years it will have accumulated sufficient reserves to abruptly grow a root to earth. No longer impeded by the canopy's unpredictable water supply, the plant can now reach a huge size by sending down more roots. Eventually it may dominate much of the crown space of the host.

Clusia seeds sprout so swiftly that you can virtually watch the seedling unfold, Cristián told me. "They are not choosy about where they germinate. But for some reason a seedling requires a branch surface to root properly. A dead branch on the ground will do. Maybe the plant will grow a little faster in bright canopy light, but the point is, unless it's on a branch, it will die."

To survive long, a clusia must germinate not only in the safety of the canopy but about halfway out along an intermediate-sized branch. "That's different from figs, some of which are also hemiepiphytes," Cristián continued. "Figs survive most often at the crotch of a branch."

The most fantastic hemiepiphyte strategy, used by some clusias and many figs, is that of the stranglers. Starting as an epiphyte, a strangler extends its roots down the trunk of the support tree, plastered against the bark. Whereas the roots of other plants remain simple conduits to the earth, in the extreme forms of stranglers the roots coalesce until they form a cramped basket around the tree trunk. Then, as the tree attempts to grow, they crush it to death.

This description is too colorful for some biologists, who downplay such notions of tree strangulation. They insist trees die by the overshadowing of dense hemiepiphyte foliage or by losing the competition with the roots of the fig for nutrients and water. I find it odd that this vegetable version of Tennyson's "nature, red in tooth and claw" has been watered down. Undoubtedly, the roots of a strangler fig impede expansion of the tree. Inside their viselike grip, the trunk bulges from each opening in its woody cage. Such expansion is absolutely necessary for the tree's survival. In the trunk, new vessels must periodically replace dying ones. If rings of vessels cannot be added by increasing trunk girth, nutrients and water cease to flow as surely as blood flow stops when a tourniquet is applied to a human limb. Jack Putz agrees with me. "That's why strangler figs seldom kill palms," he says. "Palms don't need to grow in diameter to replenish their vessels."

There's no dispute about what happens after a strangler kills its host. The tree corpse, cradled aloft in the



arms of its slayer, rots and falls away, making compost for its replacement. And replacement it is: what was once an innocuous canopy plant now stands on its own as a tree, albeit a curious one. Its trunk persists as a woody cylinder, hollow down the middle where its predecessor once stood (pp. 110-11). Continuing to grow to an enormous height, the trunk retains countless nooks and crannies, left over from the fusion of scores of roots. These form wondrous hideaways for epiphytes and canopy creatures.

Another class of hemiepiphytes turns the life history of the species discussed thus far on its head. Unlike primary hemiepiphytes such as clusias that begin life as epiphytes perched in trees, these start at ground level as vines and often work their way up to becoming epiphytes, severing their connection with the ground. We call them secondary hemiepiphytes. They are the most remarkable, however, for the way they move across the forest floor and, later, the canopy, looking and acting much like snakes in search of a place to bask.

These plants belong to groups within the arum family that we regard as mundane: houseplants such as philodendrons and monsteras imported from the American tropics. But Thomas S. Ray of the University of Delaware discovered how unmundane they are while a Harvard graduate student working in Costa Rica (SMITHSONIAN, March 1979). As their stem grows in one direction, putting out both leaves and roots on each new segment, the trailing section dies. The living stem appears to "move" through the forest. No part of the vine actually moves, but to an observer the effect is the same.

The plant is unusual not only for how it moves but for the direction in which it moves. Unlike seedlings of almost every other plant, those of the monstera head not for the light but for the nearest dark object. This usually leads them to a tree trunk. Once there, they shift to the conventional strategy of growth toward light, and so they climb.

Once it has found its place in the sun, a monstera's foliage changes radically. In the dark understory the heart-shaped leaves are a couple of inches wide and lie flat against the bark. Where the sun shines on the plant, the leaves grow to "monstrous" size: as long as six feet, with deep lobes. Eventually the vine's terrestrial roots become superfluous, and its stem dies at the base of the tree. What was once a terrestrial seedling has become an epiphyte. Such plants enjoy unusually flexible lives. Most epiphytes die if they fall from a tree. If a whole monstera takes the plunge, it simply heads for a nearby trunk and starts up again.

These "green snakes" have often baffled me. On the one hand, epiphytes live at the brink of death from dehydration or lack of nutrients, the price they pay, it appears, for not being rooted to bountiful Mother Earth. On the other, we find secondary hemiepiphytes that cast off their earthly connections at the earliest convenience as so much excess baggage. But it is becoming increasingly clear that secondary hemiepiphytes are more flexible than they have usually been made out to be: at times of water stress, they have the option (unlike epi-

Climbing tactics vary. From the left: this scrambler species uses spikes for traction; philodendrons rely on lateral roots; a cat-claw vine forms three-pronged hooks to gain a toehold in the bark of a host tree.

phytes) of dropping new roots to the ground. Indeed, because such roots, being small and plastered to tree bark, are next to impossible to trace to the ground, it may be that many secondary hemiepiphytes have them most of the time. Such plants would behave more like vagabond lianas than epiphytes.

The rain forest tapestry changes constantly. As humans we are oblivious to the movement of plants. One thing I've learned is that there is art in plant motion. We may appreciate the grace of animals as individuals (the whir of a hummingbird, the leap of a monkey, the scramble of a beetle), but viewed in reference to the forest, animals move as simple projectiles–dots in a greater framework of vegetation.

Plant dynamics are another matter. Rooted in place, plants give us a dance of interwoven forms that begins just at the limit of our perception of time and proceeds across human generations. There are a few curiosities–sensitive plants or carnivorous forms capable of swift but simple action–but these contribute little to the canopy superstructure. Straining hard, we barely make out the rotation of a climber's terminal shoot, its speed hardly matching the crawl of a clock's minute hand. But accelerate time a hundredfold, so that about two hours pass in an interval we experience as one minute. Then most animals will progress in jerky blurs, scarcely identifiable; even lethargic snails will sprint. Plants now inspire our awe. The climbing shoot that we had watched before now spirals, like the yardlong feeler of some monster in a horror film. All around us these shoots rise pugnaciously, groping like blind predators would for their quarry. On other plants, tendrils encircle trellises in graceful arcs, like monkeys coiling prehensile tails; clusia roots glide slowly downward.

Now we speed up time once more by a hundredfold. About one week will pass during the single minute of our observations. Animals shimmer in the air, barely registering on our senses; one night's sleep takes a couple of our seconds. Plants have gone wild. Leaves pop open; most flowers unfold and die as a mere flash of color. Climbers move in a combative frenzy, tendrils and twining shoots spinning in a blur; plant tips seem to flow doggedly upward, often piling one atop another in a life-or-death race to the light.

Now, again, another temporal acceleration. About two years pass during our minute. Sapling vines and trees appear as crowds of writhing vermin that continuously die and decay, but for a lucky few. Branches of the mature trees overhead thrust outward. Lagging close behind, epiphytes burst forth. Monsteras slither among them uncannily like green serpents, transforming light into motion with absolute silence. In a minute we may be able to detect the ever-tightening grip of a strangler around its victim.

In our next time jump, the strangler grows its clasping tentacles like, well, like nothing that exists in our time frame, but our minds conjure a horrific meshwork of contracting muscle. Trees ramify tumultuously, seizing canopy space in an exuberant dance. All around us during our minute of observations (that is, in two centuries of actual time), collapsing trees tear holes in the canopy that pioneer trees swiftly invade. This dance we can now see is ecology in action.

Any further jumps in our perception of time and everything but the geological vista will be blurred. Unable to distinguish even the most enduring organisms, we will have left behind the realm of individuals and entered the domain of biological evolution.

On an unusually bright day in Colombia's La Planada cloud forest reserve, ecologist Cristián Samper checks growing root of a clusia, a hemiepiphyte. Like an epiphyte, it germinated on high, 120 feet up a tree. Eventually, it will be grounded by massive roots like those of the mature clusia that frame Samper (below, center). Some climbing plants begin life on the ground, then sever their roots when they reach the canopy.