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The Science of Big, Weird Flowers

Some of the best things in botany come in large packages

By SUSAN MILIUS

Right up there with the world's largest collection of airsickness bags (Niek Vermeulen's 2,112 specimens in the Netherlands) and the world's most decorated woman (Canadian "strip artiste" Krystyne Kolorful, with 95 percent of her skin tatooed), the 1998 *Guinness Book of World Records* awards the honor of the world's largest bloom to *Rafflesia arnoldii* of Southeast Asia.

A single one of the meat-red flowers can stretch 3 feet across and weigh 36 pounds, according to the arbiter of superlatives. In 1818, the plant flabbergasted the Western explorers who first found it, and today it can still knock the syntax out of the lucky few who see it in bloom.

This *Rafflesia* and a few other floral giants offer an old-fashioned thrill to a world jaded by the miracles of modern botany. Perfect emerald golf courses now grow in deserts, and markets carry strawberries year-round, but only one botanic garden has ever managed to coax any of the 13 or so *Rafflesia* species into bloom. Even the handful of world experts on *Rafflesia* are still debating basic questions, such as whether blooms can pollinate themselves.

The fascination that big flowers hold was demonstrated this summer, when 76,000 people converged on Huntington Botanical Gardens in San Marino, Calif., to admire the 11th *Amorphophallus titanum,* or corpse flower, ever to bloom in the United States. A tropical relative of jack-in-the-pulpit, the foul-smelling bloom cluster rose to 5 feet, 9 1/2 inches in height before wilting.

These giants are attracting scientific attention as well. The number of *Amorphophallus* plants in captivity is growing, allowing researchers to study pollination and seed production. Scientists at the Sabah Parks, headquartered in Kota Kinabalu, Malaysia, are systematically exploring the elusive *Rafflesia's* natural history, and they have just succeeded in making seeds germinate. U.S. geneticists are sequencing its DNA in an effort to resolve debates about how to classify it.

One mystery looks as if it will persist, however: Why do these things get so big?

"To tell you the truth, had I been alone, and had there been no witnesses, I should, I think, have been fearful of mentioning the dimensions of this flower," wrote Joseph Arnold, the first Westerner to view any *Rafflesia* species. He was traveling as a naturalist on an expedition that Sir Stamford Raffles, the founder of Singapore, and his wife led into the heart of Sumatra 181 years ago.

Finding the giant blossom immortalized the trip, but Arnold's great moment of discovery involved little more than recognizing the obvious. He had strayed from the main party, he wrote, when one of the Malay men working for the expedition rushed up to him very excited. The man led him several hundred yards into the jungle to a plant "which was truly astonishing." Arnold's first reaction to the world's largest flower was to pick it. He needed to borrow the Malay man's big parang blade to do so, however.

In turn, malaria picked off Arnold only days later, but before he died, he managed to describe the plant in his letters. The expedition members estimated that a single bloom weighed 15 pounds. Arnold reported finding large piles of dung nearby and speculated that such big flowers are pollinated by elephants.

Less theatrical souls suggested flies, instead, but the question of pollinators for the 13 or so *Rafflesia* species did not get rigorous attention until studies in the early 1980s by John H. Beaman of the Royal Botanic Gardens, Kew, in Richmond, England, and his colleagues.

Rafflesia species grow wild in Thailand, Malaysia, Indonesia, and the Philippines. The same

basic flower structure underlies their large blossoms, the smallest of which is about the size of a teapot. However, they differ in habitat preference and details such as spot pattern. None has chlorophyll, and all grow as parasites on vines of the genus *Tetrastigma,* which is in the grape family.

A *Rafflesia* bud erupts from the host vine as a dark lump and slowly swells for some 9 months before opening. "It really looks like a brown cabbage," Beaman says. Despite the long buildup, flowers last less than a week. "They are prettiest for the first day or two," he says. After that, brown blemishes develop, and the flesh darkens and finally collapses.

Scouring forests in Borneo, Beaman and his colleagues located a male flower of *Rafflesia pricei* in bloom and created a picture window on its private life. Beaman cut a circle out of the side of the flower, which was about 1 foot in diameter, and fitted the opening with a glass UV filter from a camera. He then lay down on the forest floor to watch through the window, covering himself with a black cloth to minimize any human influence on the pollinators.

Hefty carrion flies buzzed into the stinking bloom to explore. Beaman noticed that rows of hairs lined grooves on the broad pedestal arising in the flower's center. Guided by the hairs, flies crawled up the grooves and bumped against an overhang, where perfectly positioned anthers delivered a dollop of gooey pollen onto each fly's back.

Botanists had debated where this pollen would go when flies bumbled into female flowers, and Beaman's team was able to solve that question, too. He observed that the pedestal in the center of a female flower contains a collar of stigmatic tissue that receives pollen. When flies clambered up the pedestal grooves and bumped against the collar, the goo on their backs rubbed off on this ring.

The *R. pricei* flowers stink "like a dead animal," though not as intensely as some other *Rafflesia* species do, says Beaman. To pick up the smell, "I had to stick my nose into it," he remembers.

The smell is just false advertising. The flower offers nothing edible to the flies, nor does it provide a good place to lay eggs since there's no food available for hatching larvae. The flies "are victims of the *Rafflesia,*" Beaman says. "It's absolutely pollination by deception."

Only when the flower is fresh does it maintain the carcass odor. Once the bloom starts decaying for real, the carrion flies stop visiting, Beaman reports. Fruit flies land on the fading blossom but are too tiny to pollinate it.

As the rest of the bloom decays, a fleshy brown bloblike fruit develops, taking about a year to mature. As late as the 1980s, researchers still argued over what creatures disperse the seeds. Suggestions again ranged from ants to elephants.

The chance to solve the puzzle came in 1991, when Jamili Nais of the Sabah Parks and mammologist Louise H. Emmons of the Smithsonian Institution in Washington, D.C., found a half-eaten fruit of *Rafflesia keithii* on Borneo. It looked like a dark soccer ball cut in half, Nais says. The whitish green flesh inside has an oily texture and holds 270,000 seeds. Yes, he's tasted the flesh, and it tastes the way it looks—"like a rotting coconut."

To try to see what was eating the fruit, Nais spent 4 hours hiding in a blind about 20 feet up in a tree. No luck. When Emmons took her turn, however, she spotted potential dispersing agents that were less than elephantine: the plantain squirrel and a tree shrew.

Emmons and Nais speculate that the tiny seeds catch in the rodents' teeth and claws. Then, if the animal nibbles or scrapes one of the right vines, the seeds rub off onto susceptible tissue.

Nais has devoted the past decade to studying the park's *Rafflesia* species for his dissertation at the University of Aberdeen in Scotland. Thanks to his efforts and tips from other Sabah residents, Nais has located more than 80 patches of the three local *Rafflesias.*

To date, he's monitored more than 1,000 flower buds, checking them every 10 days or so.

Some 60 to 90 percent die before opening, he reports. Animals and people trample some, and egg-laying wasps puncture others, but he finds that "most just shrivel and die without any apparent cause."

Male blooms outnumber the females about 6 to 1, Nais reports. The flowers that do open can be far from other flowers, and they don't show much synchronicity in blooming. Nais has become increasingly amazed that pollination occurs at all. "It seems almost impossible," he says.

Even in the best of circumstances, no *Rafflesia* species reproduces prodigiously, and spreading human settlements threaten the habitat for lowland species. In Sabah, only half of the patches Nais monitors are protected.

"I used to be very gloomy about saving *Rafflesia,*" Nais says. Even preserving the plant in botanic gardens didn't seem like a promising option, since only the Bogor Botanical Garden in Indonesia has succeeded in growing a *Rafflesia*—and its last bloom opened in 1929. Now, however, Nais reports that vines inoculated with seeds have sprouted five buds of *R. keithii.* He estimates that the largest bud could bloom in 5 months.

The Rafflesian past has been as puzzling as its present, according to Claude W. dePamphilis of Pennsylvania State University in State College. The species are such stripped-down parasites—literally just flowers attached to strands that infiltrate a host and steal nutrients—that botanists studying evolution don't have a lot to go on. DePamphilis hopes that DNA analysis will clarify *Rafflesia*'s relationship to other plants.

As part of an effort to place parasitic species in the family tree of flowering plants, dePamphilis' team has sequenced two mitochondrial genes from 161 plant species, including 2 of *Rafflesia.* The researchers also included a wide range of plants—from water lilies and magnolias, long considered to be of ancient lineages, to newer creatures like tobacco and peas. Parasitism has arisen at least 11 times in the history of flowering plants, dePamphilis reports.

He says that the picture that's taking shape fits "surprisingly well" with the family tree emerging from another big evolutionary analysis, the collaboration called "Deep Green" (SN: 8/7/99, p. 85).

For their analysis, dePamphilis and Penn State colleague Todd J. Barkman visited Nais in Borneo to collect *Rafflesia* tissue samples. Because they were working with such difficult-to-obtain specimens, the researchers lugged some 80 pounds of equipment into the jungle, including a coffee grinder for pulverizing tissue, and did DNA isolations on the spot.

So far, they've found that the parasitic genus *Cytinus,* traditionally classified in the same family as *Rafflesia,* belongs much higher in the branches of the evolutionary tree, near the hibiscus order. As for the genus *Rafflesia* itself, "we're zeroing in" on its exact branch, dePamphilis says.

Seeing wild *Rafflesia* plants thrilled dePamphilis. "The buds are as big as a basketball—it's otherworldly," he says. However, he's never caught a bloom during its brief prime. "The bud we were watching didn't open until the day our plane was in the air," he says.

Not all botanical giants are so hard to see. *A. titanum* will display its huge blooms in captivity. Discovered on Sumatra by 19th-century explorers, it's not a parasite like *Rafflesia.* The jack-in-the-pulpit relative caused a sensation when a 10-year-old plant at Kew bloomed in 1887. The first bloom in the United States, at the New York Botanical Gardens in 1937, drew thousands of spectators. Paramount Studios sent a camera crew.

"This is the kind of plant that will get people excited about plants," says Huntington curator Kathy Musial. Whether its flower is large or really small depends on how strictly you define *flower,* she explains. Technically, a single *A. titanum* flower stretches less than a sliver of an inch across. The fabulous bloom, as tall as a person, consists of a column of several hundred of the tiny female flowers arrayed below thousands of tiny male flowers.

"It smells like a dead animal," Musial reports, but for many spectators, that was just part of the fun.

The odor might also be a factor in the size of such monsters as *A. titanum, Rafflesias,* and the pelican flower, *Aristolochia gigantea,* whose pipe-shaped flowers can reach more than a foot long.

"Most of the very big flowers all are pollinated by some form of deceit," notes Peter G. Kevan, a pollination researcher at the University of Guelph in Ontario. They mimic the smell of rotting flesh and attract insects normally drawn to carrion. However, "there are always dead things lying around," Kevan points out, so "the flowers have to compete with real food." Considering, too, the long distances that often separate blooms, these flowers have to grow big enough to attract the attention of huge numbers of visitors.

Plants in temperate zones also rely on foul smells, but their blooms remain small. Pawpaws attract flies and beetles with an odor that Kevan describes as "mawkish," and skunk cabbage flowers emit five odors, including fungal and fecal mimics, in rotation. Really big flowers may require the abundant water and sauna steaminess of the tropics, Kevan suggests.

When asked why plant giants get so big, Josef Bogner of the Munich Botanical Gardens retorts, "You could just as well ask why the other species are so small. . . . In nature, you have everything—big and small."

Bogner has collected many of the world's 170 *Amorphophallus* species in the wild, and he's most excited about the smallest. *Amorphophallus pusillus,* which sends up a spike not even 3 inches high, is part of the vast wealth of species that Western botanists are discovering now that Vietnam has become more accessible.

Size doesn't matter much to Thomas B. Croat of the Missouri Botanical Garden in St. Louis. Of course, he's heard about Huntington Botanical Gardens' big bloom and the attendant furor. "Can you imagine people lining up to smell something bad?" he chuckles.

He points out that people have known about that species for more than 100 years, whereas he sees the biggest dramas in botany today in the staggering volume of species that don't have names yet. The flora of South America, Southeast Asia, and other barely explored parts of the world are yielding riches literally faster than scientists can describe them.

Croat has already named 350 new plant species from such areas, and the backlog of collected material currently waiting to be classified is overwhelming, he says. Just that morning, he told SCIENCE NEWS, he, Bogner, and some of their colleagues discovered that a plant flourishing in their greenhouse represents a new species of *Amorphophallus.*

There are more important things in botany, according to Croat, than getting into *Guinness.* □