

Out of Africa: A Tale of Gorillas, Heart Disease... and a Swamp Plant

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Captive western lowland gorillas (*Gorilla gorilla gorilla*) are susceptible to a heart condition known as fibrosing cardiomyopathy. Although the cause of the disease is unknown, the captive gorillas' diet may be a contributing factor. *Aframomum melegueta*, an herbaceous perennial plant that gorillas in the wild consume with gusto, contains substances with powerful anti-inflammatory properties that may protect gorillas' health.

Sitting in a restaurant eating a
quiet meal,
I'm often struck by how much
human beings resemble
gorillas.
In these moments in restaurants,
When I see a gorilla in every
chair,
And the chairs are humps of
earth
And the booths are lush booths
of vegetation,
I think of kinship across three
million years...
And the deep-browed gaze of the
silverback
Stripping wild celery, stopping to
look up,
And looking carefully around.

Howard Nelson, *Gorilla Blessing*
(Falling Tree Press, 1993)

In the words of poet Howard Nelson may lie a clue to a medical mystery: Gorillas are dying, and not just in Africa. For captive gorillas in the United States, Europe, and elsewhere, the answer may lie in the connections among a disease, a diet, and a plant.

The disease

Western lowland gorillas (*Gorilla gorilla gorilla*) in zoos and animal parks are susceptible to an unexplained heart condition known as fibrosing cardiomyopathy, in which healthy heart muscle turns into fibrous bands unable to pump blood. No one has kept track of exactly how many captive western lowland gorillas have succumbed, but scientists are hot on the trail. Veterinarians Tom Meehan of the Brookfield Zoo in Chicago and Linda Lowenstine of the University

of California–Davis say that 41 percent of deaths of captive western lowland gorillas—and 70 percent of deaths of the males older than 30—are the result of heart disease, primarily fibrosing cardiomyopathy.

The toll in 2006 alone includes at least four gorillas: Mopie and Kuja at the National Zoo in Washington, DC; Pogo at the San Francisco Zoo; and Tumai at the Memphis Zoo. In previous years, there were others: Akbar at the Toledo Zoo (2005), Sam at the Knoxville Zoo (2000), and Michael at the Gorilla Foundation in California (2000), to name but a few of the stricken gorillas.

Scientists are searching for ways of treating fibrosing cardiomyopathy by developing better health monitoring techniques and more sophisticated medical interventions. "It might be a bacterial or



Holli, a 17-year-old female western lowland gorilla (Gorilla gorilla gorilla), lives with 21 other gorillas in the Bronx Zoo's Congo Gorilla Forest, a 6.5-acre (2.6-hectare) rainforest environment that closely resembles the western lowland gorillas' native West Africa. The Bronx Zoo's gorilla captive breeding program, the largest in the United States, produced four babies last year, bringing the total number of gorilla births at the zoo since 1972 to 57.

viral infection of the heart that's responsible," Meehan says. "It could be a response to the stress of being in captivity, in which harmful substances called catecholamines are released, or something in gorillas' diets in captivity that wild gorillas either eat or don't eat."

What has scientists stumped, says Lowenstine, "is that it doesn't appear to be related to coronary artery disease or cholesterol levels. It may be related to a process like inflammation, in which levels of inflammatory markers like C-reactive protein are elevated." Levels of C-reactive protein (CRP) rise in the presence of acute inflammation, which can stem from rheumatoid arthritis, cancer, pneumonia, or other diseases. Studies in humans and other animals demonstrate a clear link between high

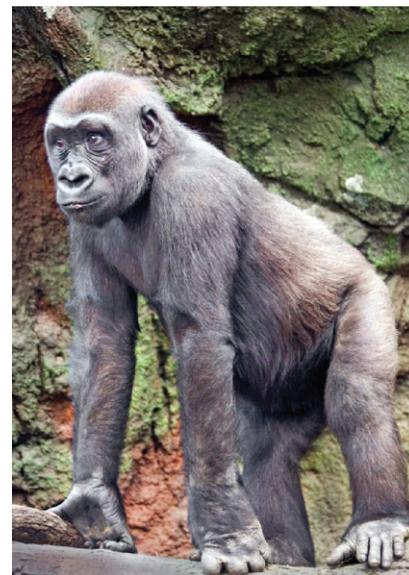
levels of CRP, which is produced by the liver, and cardiomyopathy and other heart diseases.

Autopsies performed on gorillas who have died of fibrosing cardiomyopathy show evidence of myocarditis, an inflammation of the heart muscle that leads to heart failure. "We've checked CRP levels in certain gorillas and they've come back elevated," says Meehan, "but no large study of CRP has been done yet in the captive gorilla population."

"As far as anyone knows," says primatologist Joe Erwin, director of the Foundation for Comparative and Conservation Biology in Needmore, Pennsylvania, wild gorillas aren't prone to heart disease, including fibrosing cardiomyopathy, "although more study of the wild population is needed." But wild gorillas, endangered in their native Africa, are under siege from other threats: habitat loss, the bushmeat trade, and the Ebola virus. From 2001 to 2005, more than 5000 western lowland gorillas in Africa died from Ebola, according to Magdalena Bermejo, a primatologist at the University of Barcelona.

"As a result, western lowland gorillas in zoos are even more important to the future of the species," says Dan Wharton, a primatologist at the Wildlife Conservation Society (WCS), headquartered at the Bronx Zoo in New York. Wharton is coordinator of the Species Survival Plan (SSP) for the western lowland gorilla; the SSP is a zoo and aquarium population management program for selected species, usually those threatened or endangered in the wild. According to the United Nations Environment Programme's Great Apes Survival Project, western lowland gorillas and other gorilla species—eastern lowland gorillas, mountain gorillas, Cross River gorillas, and Bwindi gorillas—may be extinct by 2050. "You have to wonder," Wharton muses, "will our children even know what a gorilla is?"

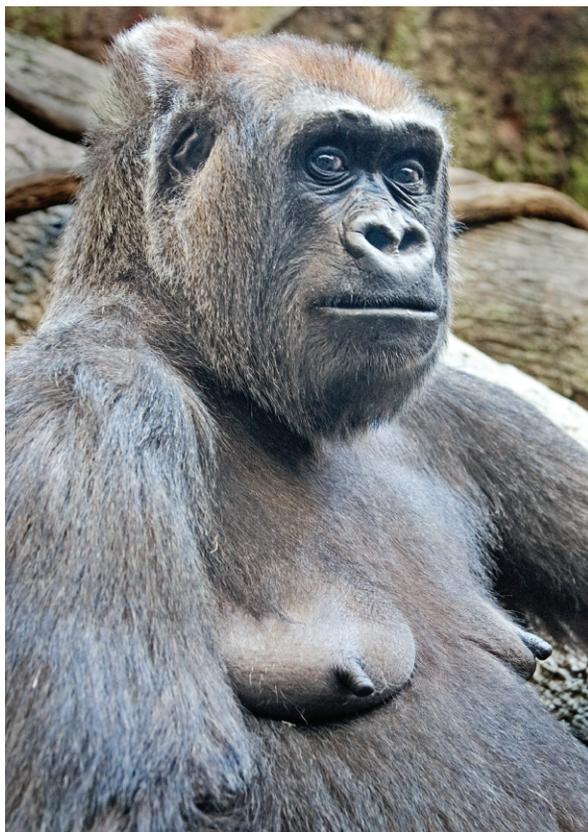
If it's up to the Bronx Zoo, they will. The zoo is home to 22 western lowland gorillas, 16 females and 6 males, in a habitat called Congo Gorilla Forest. Zuri, a 23-year-old silverback gorilla, leads one of two gorilla troupes. Sharing the ropy vines in his enclosure is Holli, a 17-year-



Western lowland gorilla Shana, a four-year-old male, was born in the Bronx Zoo's Congo Gorilla Forest. Shana and other gorillas in zoos in North America are cared for under the Species Survival Plan (SSP) for gorillas, a program to manage the population of captive western lowland gorillas. SSPs for threatened and endangered species were initiated by the American Zoo and Aquarium Association in 1982. Most of the more than 370 gorillas currently living in North American zoos were born in 55 SSP-participating zoos.

old female. The "kids" scamper among them: Zohari, a male born in 2005; Zola, his older brother, born in 2002; and Sufi, their older sister, born in 2001. Imani, an adult female gorilla born in 1994, is also part of the troupe.

Zookeeper Kathy D'Andrea says the zoo has created the closest thing to an African rainforest outside of Africa. "The gorillas in what we call the 'Great Gorilla Forest' have several acres to roam around in." Close your eyes, and you might think you're in the Congo. A chorus of calls from red-chested cuckoos, tambourine doves, and blue monkeys echoes among waterfalls. Tropical plants from trees 15 meters tall to diminutive orchids drape over a visitor pathway, creating a lacy curtain. "You almost forget where you are," says D'Andrea.



Female western lowland gorilla Julia, 26 years old, is a member of one of two troupes of gorillas in the Bronx Zoo's Congo Gorilla Forest. Julia is part of Zuri's group. Zuri is a silverback western lowland gorilla who has sired seven offspring at the Bronx Zoo. One of Zuri's and Julia's offspring, Johari, was born at the Bronx Zoo in 2005.

Not for long, though. A film on the plight of wild western lowland gorillas reveals the stark reality of life in the real Congo. "These are the last of Africa's wild gorillas," states the film's narrator, WCS biologist Michael Fay. Gazing out from the Great Gorilla Forest, Holli's brown eyes meet a visitor's.

"The captive population of gorillas soon might be all there is," echoes veterinarian Hayley Murphy of Zoo New England in Boston. She and human cardiologist Ilana Kutinsky of the Michigan Heart Group in Troy, Michigan, have started a National Gorilla Cardiac Database to track cases of fibrosing cardiomyopathy in captive western lowland gorillas. "Regional coordinators are keeping tabs on the US population," says Murphy, "and comparing echocardiograms from healthy and sick gorillas so we can identify the onset of the disease." The

western lowland gorilla SSP also recommends that echocardiograms, the only reliable way of diagnosing fibrosing cardiomyopathy, be performed on captive gorillas. Omaha's Henry Doorly Zoo is among the first zoos to initiate regular echocardiogram screenings of its gorillas, says veterinarian Lee Simmons, the zoo's director.

Early detection is important, according to Neal Kay, a cardiologist at the University of Alabama at Birmingham, who implanted an advanced pacemaker in a gorilla with the condition. Babec, a 26-year-old male western lowland gorilla at the Birmingham Zoo, received "cardiac resynchronization therapy," or CRT. The procedure corrected the breakdown in the heart's electrical circuitry that comes with fibrosing cardiomyopathy and restored the organ's ability to pump properly. "Babec is doing great," says Marie

Rush, a veterinarian at the zoo. "But he's the only gorilla we've been able to save." The critical question, says Kay, "is why are these gorillas developing the disease in the first place?"

The ultimate answer to captive gorillas' heart problems may be quietly growing in West Africa's vine-choked swamps: a member of the ginger family, *Aframomum melegueta*, better known as "grains of paradise." This plant, which wild western lowland gorillas preferentially eat, contains a powerful anti-inflammatory compound. As scientists learn more about the inflammatory process that underlies heart disease, the lack of *Aframomum* and other African plants in captive gorillas' diets has emerged as a chief suspect in their poor health.

The diet

"Undoubtedly, the highest desire of every zoological garden and park is to own and exhibit a real, live gorilla of a size sufficiently large to compel both admiration and awe," wrote William Hornaday in the January 1915 edition of the *Zoological Society Bulletin*, published by the New York Zoological Society. "The human mind loves to contemplate, with a suitable intervention of bars, the apes that stand nearest to man."

The New York Zoological Society, now the Bronx Zoo, got the nation's first gorilla out of Africa in 1912. But all was not well: The gorilla refused to eat any of the foods it was offered. As described by Hornaday, the gorilla was extremely unhealthy when it arrived at the zoo, from food refusal: "Its food preferences and aversions were at once the rage and the despair of its keepers. Of the score of good things [mostly meat] offered that gorilla, and of which it should have eaten, it partook of not one."

Maybe because gorillas are in fact herbivores, says Wharton.

Fables about gorillas' carnivorous nature eventually turned out to be just that: stories made up by imaginative early explorers hacking their way through African jungles, expecting to meet up with a "man-eating" gorilla along every narrow, dark path. "We came to a part of the forest where the underwood became so dense that we could scarcely make our

way through it,” wrote R. M. Ballantyne in his 1862 novel *The Gorilla Hunters*. “Here we began to have a clearer conception of the creature we were in pursuit of, for it had torn down great branches and snapped them in two as one would snap a walking-cane.”

That fictional gorilla likely would have been peacefully nibbling on the branches’ leaves, says gorilla nutritionist Ellen Dierenfeld of the St. Louis Zoo. No wonder the nameless 1912 New York Zoological Society gorilla wasn’t interested in raw eggs with milk, or dinner brought in hot from New York City’s Rockingstone Restaurant. The meal always contained a cooked-meat dish—hardly typical fare for a lowland gorilla from the swampy forests of West Africa. In 1912, zoos didn’t have the benefit of scientific studies of western lowland gorillas’ diets, say Dierenfeld and primatologist Melissa Remis of Purdue University. It wasn’t until recently that zoos began to realize that their gorilla meals left something to be desired...by the gorillas.

According to scientist Don Cousins, who took the first hard look at the diets of captive gorillas in 1976, western lowland gorillas once were fed everything from milk and eggs in Albuquerque, to condensed milk and raw horse meat in Dallas, cooked meat and boiled eggs in Los Angeles, and sweet potatoes in Tampa. Cousins sounded a warning: Stop feeding gorillas “human food.” Today, the diets of captive gorillas at zoos like the Bronx Zoo, Brookfield Zoo, and Smithsonian National Zoological Park are closer to those of wild gorillas, but gorillas still are not fed plants from their native Africa. Some facilities, however, are looking into the possibility of feeding gorillas African plants like *Aframomum*, and one is already doing it.

According to a 1997 survey Dierenfeld conducted, gorillas’ diets varied considerably from zoo to zoo, with more than 115 food items on the menu. Twenty different vegetables were offered on a regular basis in the survey’s 37 zoos. Then there were 23 fruits, including apples, bananas, oranges, raisins, and tomatoes. “But cultivated fruits are usually lower in fiber and higher in moisture and simple sugars than native fruits eaten by gorillas



Biochemists at Rutgers University have found a powerful anti-inflammatory compound in the seeds of the African wetland plant Aframomum melegueta, or grains of paradise. The compound, named “006,” has been licensed by Rutgers to Phytomedics, a New Jersey pharmaceutical company, for possible drug development. Phytomedics in turn licensed cosmetics rights to Avon Products, which will release an 006-containing skin-care line this spring.

in the wild,” says Dierenfeld. Twenty-five types of greenery, or “browse,” were on the list, as well as 18 kinds of cereals or grains. Meat, eggs, milk, and yogurt were given to gorillas in several zoos: 21 zoos fed yogurt; 19 zoos, eggs; 18, milk; and 6, meat.

Aframomum, however, makes up 80 to 90 percent of the diets of wild western lowland gorillas, studies show. A symbiotic relationship has evolved, scientists believe, between western lowland gorillas and the seeds of the fruit they eat, which pass unharmed through the gorillas’ gastrointestinal tracts. The seeds then take root wherever they’re dropped, proving beneficial to both plant and gorilla.

The plant: Grains of paradise

Western lowland gorillas in Africa don’t have far to look for *A. melegueta*. An herbaceous perennial plant, it is among the most common plants in the swampy lowlands there. Palmlike, it forms dense

tangles and grows up to 1.5 meters high. Its trumpet-shaped, purple flowers develop into pods filled with small, reddish-brown seeds. The common name for the plant, grains of paradise, comes from its seeds and dates back to the Middle Ages, when the plant was a highly valued commodity.

It still is vital to gorillas, who not only eat the plant but use it to make the nests, or beds, where they sleep each night. The great apes are the sole nonhuman primates to construct nests, and gorillas are the only ones who make their nests on the ground. Colin Groves, of the Australian National University, and J. Sabater Pi, of Parque Zoológico in Barcelona, were “struck by gorillas’ elaborate nests: their ubiquity, the regularity of their construction, and the skill required to make them,” they wrote in the March 1985 issue of the journal *Man*. The most common type of bed made by western lowland gorillas, the scientists found, is in

patches of *Aframomum*. The researchers witnessed western lowland gorillas making nighttime nests from *Aframomum* 366 times.

In food by day and in beds by night, gorillas are virtually steeped in *Aframomum*. What, scientists have begun to wonder, is so attractive about the plant? “*Aframomum* contains a potent antibacterial, antiviral, antifungal, and anti-inflammatory ‘natural drug,’” says primatologist Michael Huffman of Japan’s Kyoto University. “The plant may be as much a source of preventive medicine for gorillas as it is of food.”

Gorillas, it turns out, may eat *Aframomum* for its cardioprotective abilities. It has long been a favorite of native West African healers, who use its seeds to treat illnesses from coughs to toothaches to measles. The first record of its use on other continents appears in 1633, in a book called *Gerard’s Herbal* (officially known as *The Herbal, or General History of Plants*), by John Gerard. (From ancient Greek times to the 17th century or later, botany was an adjunct of medicine and pharmacy. Plants were studied for their curative powers, and the knowledge was contained in books known as herbals.) According to *Gerard’s Herbal*, grains of paradise could “comfort and warm the weak and cold, and rid the body of infection.”

Those applications may soon be expanded, believes biochemist Ilya Raskin of Rutgers University’s Biotech Center in New Brunswick, New Jersey. A substance Raskin calls “006,” made from the seeds of *A. melegueta*, may prove to be one of the most powerful anti-inflammatory substances ever discovered. Raskin’s work builds on earlier research by Nigerian scientists at the University of Lagos College of Medicine, which showed that the plant had an anti-inflammatory effect. The compound works in much the same way as the



Phytomedics scientist Neb Ilic holds a vial of 006, which shines like a rare topaz under laboratory lighting. This may be the most powerful anti-inflammatory compound yet discovered. Western lowland gorillas in the wild preferentially eat Aframomum, which makes up 80 to 90 percent of their diet and may be protecting them against heart disease and other illnesses.

well-known drugs Vioxx, Celebrex, and Bextra but, it is hoped, without their side effects. Rutgers has licensed rights to 006 to Phytomedics, Inc., a pharmaceutical company in Jamesburg, New Jersey.

Raskin and scientist Neb Ilic of Phytomedics have, as if by alchemical magic, changed *Aframomum* seeds into a bronze liquid that, when spread on an aching joint or a small cut, makes the inflammation disappear. As a result of that discovery, Phytomedics licensed Avon Products, Inc., to manufacture skin-care products that contain *Aframomum*, says Tolo Fridlender, president of Phytomedics. Robert Kalafsky, executive director of skincare at Avon Global

Research and Development Center, says, “*Aframomum* provides strong anti-inflammatory activity and is in our 2007 Solutions Hydra-Radiance line.” Avon will release the products this spring. Ahead may be a broader anti-inflammatory application.

Raskin first became interested in *Aframomum* as part of an international bioexploration effort to search for plants with medicinal properties. “*Aframomum* contains compounds called gingerols, which are chemically similar to other anti-inflammatory compounds,” he says. “That chemical similarity is what initially drew attention to the plant, then was confirmed in the lab.”

Scientists have “extraordinarily powerful tools now to explore biodiversity,” says Joshua Rosenthal, deputy director of the Division of International Training and Research at the National Institutes of Health’s Fogarty International Center. “New pharmaceuticals and other innovations are waiting to be discovered and developed using genomics, chemical biology, informatics, phylogenetics, and spatial analysis.”

With those tools, Raskin and Ilic found that extracts from plants in the ginger family, like *A. melegueta*, modulate biochemical pathways activated in inflammation. Ginger extracts inhibit pro-inflammatory gene expression, including genes encoding cytokines—proteins secreted at the sites of inflammation—and three inflammation-causing enzymes, cyclooxygenases 1 and 2 (COX-1, COX-2) and a lipooxygenase (5-LOX). Ginger’s ability to inhibit both COX and LOX enzymes might explain why even high doses of ginger extracts don’t produce the side effects often seen in drugs that act only on COX-1 and COX-2. Vioxx, Celebrex, and Bextra, for example, are COX-only inhibitors.

“With *Aframomum*’s anti-inflammatory properties and its long history of use as a spice in foods, and therefore safety record,” says Raskin, “it’s likely to be very valuable in the treatment of inflammatory diseases.” Those diseases range from heart disease to cancer to arthritis.

Aframomum isn’t easy to come by, however. It grows in just one place: the

Visit these Web sites for more information:

Global Institute for Bioexploration, Rutgers University: <http://gibex.rutgers.edu>

Species Survival Plan Program: www.aza.org/conscience/conscienceSSPFact

Bronx Zoo’s Congo Gorilla Forest: www.congorillaforest.com

Primates at the National Zoo: <http://nationalzoo.si.edu/Animals/Primates>

swampy lowlands of West Africa's Grain Coast. Stretching from Sherbro Island in Sierra Leone to Cape Palmas in Liberia, this rain-drenched, humid land is named for its abundant grains of paradise. Outside Africa, *Aframomum* is usually available only as a hard-to-find spice. For their experiments, Raskin and colleagues purchase seeds at commercial rates from African marketplaces. The markets get their seeds from farmers who cultivate the plants. "If a successful medicine is made from this plant," says Raskin, "the supply of plants will come from West Africa. *Aframomum* would also help small farmers there, who could expand their culti-

vation of the plants and sell the seeds, giving farmers a value-added crop."

The demand for *Aframomum* in West Africa is high. When a visitor arrives at someone's home, the host offers a bowl of *Aframomum* seeds. Have West Africans mimicked habits they long ago observed in wild gorillas? "Gorillas and humans have something important to teach each other about what constitutes a healthy diet," Dierenfeld believes.

Raskin and colleagues are investigating the connection between native African plants and heart disease, in people and in gorillas. Why captive western lowland gorillas develop cardiomyopathy remains

unknown—at least for now. The solution, for all primates, may lie in Africa's "heart of darkness," the jungle—and for captive gorillas, perhaps, in the food served in their equivalent of a restaurant.

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