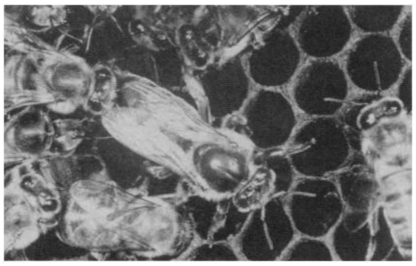
How African Are "Killer" Bees?

The long-awaited "Africanized killer bees" finally arrived in the United States last month, 33 years after their African ancestors were accidentally released in Rio Claro, Brazil. But even as the first swarm crossed the U.S. border near Weslaco, Texas, researchers argued about how African the invaders really are. The question isn't merely theoretical: the more African traits—such as irritability, increased swarming, and low honey production—they carry, the greater the threat they pose to the $150-million U.S. honey industry and to the vital role that domestic bees play in pollinating agricultural crops.

Researchers at the U.S. Department of Agriculture (USDA) contend that as the migrants made their long journey north, they interbred with domesticated European bees, diluting many of their original traits. The evidence: physically the bees look like a blend of African and European types, say the USDA researchers.

Not so, argues a band of academic scientists that has been looking at the bees' genetic makeup. "These are *African* bees," says University of Florida entomologist H. Glenn Hall. "They have arrived at the border largely undiluted. Therefore we are going to have to cope with their traits."

Last year, Hall, along with Deborah Roan Smith of the University of Michigan and Orley Taylor of the University of Kansas, inflicted a painful sting on the genetic-dilution argument. Hall and Smith had independently analyzed the mitochondrial DNA from wild bee swarms collected in Brazil, Mexico, and Venezuela. They both found that more than 97% of the bees carried African-type mitochondrial DNA. Since an animal's mitochondria—and the small DNA genome they contain—are inherited entirely from its mother, "the only way that could happen is with a continuous [African] maternal lineage," says Hall.



African queen. *Her DNA shows little sign of hybridization with European bees.*

Their finding suggested that, although African drones were clearly breeding with European queens and "Africanizing" the colonies of Latin American beekeepers, the northward migration was being carried on solely by wild swarms led by African queens.

Even though their maternal lineage was nearly pure African, the possibility remained that the bees had picked up non-African genes from the countless generations of local European drones that would have bred with the African queens since 1957. Such genes would be contained in the bees' nuclear DNA, which is inherited equally from both parents. When Hall analyzed the nuclear DNA from wild swarms, he found no European genes in bees taken from Venezuela, and in swarms taken from Mexico, near the leading edge of the northward migration, roughly 15% of the bees carried European markers. "These feral African maternal lineages have hybridized only slightly with the European bees," he concludes. That suggests that, although African queens might indeed mate with European drones, the hybrid offspring are less likely to survive. The hybrids could be placed at a disadvantage by maladaptive genes from the European bees, which are not suited to the tropics and survive only with a beekeeper's care.

Thomas Rinderer, director of the USDA Honeybee Laboratory in Baton Rouge, Louisiana, disputes Hall's conclusions but not his data. "The data demonstrate that the bees are hybrids," he says, but he goes on to fault Hall for looking at only three genetic markers when he tested for genetic mixing. Rinderer says that's not enough information to accurately determine the degree of hybridization, a value he places at 50% for bees collected in Mexico.

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Saturn Mission Backed, Europeans Relieved

Last August, Caltech astronomer Andrew Ingersoll sent an urgent letter to his fellow planetary scientists: The next planned mission to the outer solar system is in serious budgetary trouble. In order to preserve big-ticket items like the space station, Ingersoll wrote, Congress may cancel the CRAF/Cassini mission—a pair of spacecraft one of which should be launched in 1995 to investigate an asteroid and the other a year later to study Saturn. Write your member of Congress, Ingersoll urged.

Congress apparently got the message. Last week, it approved $145 million for the mission—just $3 million short of NASA's request. And that was a huge relief to the European Space Agency (ESA). The Europeans are responsible for a key part of the Saturn investigation, a $260-million probe that will descend to the surface of Saturn's largest moon, Titan. ESA is already heavily committed to the project, and just a week before Congress approved NASA's budget the agency chose six instruments that will fly on the probe.

Called the Huygens probe after the Dutch astronomer Christian Huygens who was the first to interpret Saturn's rings correctly, it will parachute slowly through Titan's atmosphere. The instruments chosen last month to fly on Huygens will measure the temperature and pressure of the atmosphere, its turbulence, winds, and electricity; analyze the chemical composition of Titan's atmosphere during the descent; sample and analyze aerosols in the atmosphere; make spectral measurements in several wavelengths and take pictures of the clouds and the ground; measure the characteristics of the winds on Titan with very high accuracy; and report back on the state of Titan's surface—liquid, semi-liquid, or solid—at the point of touchdown.

Though the probe is not designed to survive a hard impact, if it lands on an ocean of liquid methane and ethane it should survive for a few minutes before sinking, says Daniel Gautier, director of research at the French national center for scientific research (CNRS) and one of three scientists who will be coordinating the probe's work. "In 3 minutes we can measure many things and send the data back," he says.

The probe will be sent to Titan from an orbiter that is being developed by NASA. The orbiter will carry a battery of instruments to study Saturn and its system of moons and rings. If the spacecraft is launched on time, it will reach the giant planet in 2002.

Though astronomers are relieved that Congress has come through with the funds for next year, they are still nervous about future years. One worry: Last year, Congress capped total spending on CRAF/Cassini at $1.6 billion, so if there are cost overruns on the hardware, the science could get squeezed.

■ JEREMY CHERFAS

Rinderer bases his number on morphometrics, the measurement of 25 physical features known to differ between African and European bees, such as wing length, leg length, and the angles between some veins in the wings. These traits are genetically determined, he says, and so serve as independent genetic markers. And the bees he has analyzed look like a 50-50 mix of European and African traits.

But even the person who developed the morphometric system, entomologist Howell Daly of the University of California at Berkeley, is skeptical about Rinderer's use of the technique. "I'm not so sure we can interpret what we see morphometrically as evidence of hybridization," Daly told *Science*. One problem: morphometric characteristics are not determined purely by genetics. Environmental influences such as climate and diet can change a bee's proportions. And even when morphometric changes do reflect genetic changes, hybridization between strains may not be the reason, Daly says. It may be that the bee that founded a given population was itself a genetic variant. Or it could be that the variant genetic traits have been selected for because of some adaptive value, he adds.

Both camps do agree on one thing: that the bees' tendency to hybridize will change when they reach the temperate United States. But exactly how readily they will hybridize and how fast and far they will spread their traits through the U.S. bee population is uncertain. Taylor predicts that they will form a "hybrid zone" in which hybrid offspring will be favored over pure African bees because of the adaptive value of European traits in temperate climates. Hall agrees that increased hybridization is likely, but he points out that there may be biological mechanisms unrelated to climate that will diminish the survival of hybrids. Funding to address such questions has been unavailable, Hall says, perhaps due to the USDA's conviction that the bees have been hybridizing all along. ■ MARCIA BARINAGA

Materials Tips from Sea Urchins

The spines of a sea urchin are marvels of molecular engineering. Each tough, fracture-resistant spear is actually a single crystal of calcite—normally a very brittle material but somehow strengthened and toughened by the urchin. Materials scientists would love to learn how the creatures do it, in hopes of picking up ideas for strengthening other single crystals, such as the brittle silicon blocks that form the bases for integrated circuits.

Now researchers from the Weizmann Institute of Science in Rehovot, Israel, and Brookhaven National Laboratory in Upton, New York, believe they have uncovered an important clue to the spines' toughness. On page 664, they report that the key may be how the distribution of protein molecules throughout the calcite spines modifies the microstructure of the crystal.

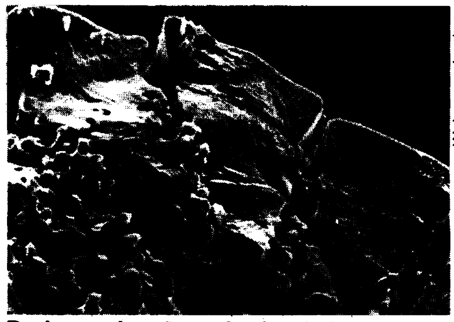
Scientists have long known that an urchin incorporates protein into the calcite crystals that compose its spines and, in 1988, Amir Berman, Lia Addadi, and Stephen Weiner of the Weizmann Institute showed that this protein affects how the spines fracture. They compared inorganic calcite (a chalk-like mineral consisting of calcium carbonate crystallized in hexagonal form) with crystals of calcite grown in the presence of proteins extracted from urchin skeletons (basically the same proteins as from the spines). The synthetic crystals fractured much as sea urchin spines do—they were much more difficult to crack than pure calcite crystals and, instead of cleaving neatly along flat planes as inorganic calcite does, they broke into irregularly shaped pieces like broken glass.

At the same time, the Weizmann researchers found the first hint of how the proteins change the fracturing behavior of the calcite. They discovered that as a crystal is being grown from a protein-bearing solution, the proteins are incorporated into the crystal on planes that lie at an angle to the cleavage planes (the planes along which cracks form). The proteins, which make up about 0.02% of the crystal by weight, apparently act like the fibers that materials scientists put into ceramic composites to prevent cracking, Weiner says. "The trick is not to prevent a crack from forming, but to stop its propagation," he adds. But although the synthetic crystals made with proteins from the sea urchins were stronger than pure calcite, they weren't as tough as the real thing. Something was missing.

Now Berman, Addadi, and Weiner, working with Leslie Leiserowitz at Weizmann and Åke Kvick and Mitch Nelson at Brookhaven, think they know what the missing piece of the puzzle is. At the National Synchrotron Light Source at Brookhaven, they performed x-ray diffraction studies of pure calcite crystals, synthetic calcite crystals made with proteins from sea urchin skeletons, and natural sea urchin spines. The powerful synchrotron radiation allowed them to detect very small variations in the crystalline textures of the various samples and revealed a telling difference.

No crystal is perfect in the purest sense of the word, Weiner notes, and the single crystals the researchers studied were actually mosaics of tiny near-perfect crystalline regions so closely aligned with one another that their x-ray diffraction patterns look like those of single crystals. But the high resolving power of the synchrotron radiation revealed variations in the arrangement of the individual regions, or domains, in the samples.

The pure crystals consisted of domains that were an average of about 500 nanometers across and that were misaligned by no more than about 0.004°. The synthetic crystals were very similar to the pure calcite crystals in the size of the domains, but the range of misalignments was about 0.03°. The domains in the sea urchin spines were smaller—only about 150 nanometers across—and were offset from one another by as much as 0.15°.



Weizmann Institute

Broken spine. *Irregular break distinguishes urchin's spine from natural calcite crystal.*

With this data, the Weizmann group is beginning to piece together exactly how the proteins are toughening the calcite spines. They suggest that the proteins are located along the boundaries of the individual domains, where they act to inhibit the spread of cracks in at least two ways. First, as their previous work indicated, the protein molecules are oblique to the cleavage planes and seem to act as barriers to any fractures along these planes. And second, because the domains in the spines are smaller and less perfectly aligned, a nascent crack will run into the boundary of a domain more quickly and will be less likely to jump to the next domain. The pure calcite crystals, with larger, almost perfectly aligned domains, are very brittle, and the synthetic crystals, with larger but less well aligned domains, are tougher than the pure crystals but more brittle than the spines. If this proves to be a general principle, the researchers say, the sea urchin may have pointed the way to making stronger crystals. Now the challenge will be to replicate the process in the laboratory.

■ ROBERT POOL