



Although the African honey bee (above left) is slightly smaller than its European counterpart (right), the two belong to the same species, and only a highly skilled expert using sophisticated techniques can tell them apart. Africanized colonies are easily aroused, a trait that has given them a reputation as "killer bees." (Photos by E.S. Ross)

# The Africanized honey bee: ahead of schedule

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## *The bee's early arrival added urgency to efforts to devise effective controls*

**T**he accidental discovery in June 1985 of a wild colony of Africanized honey bees in Lost Hills, near Bakersfield, was unwelcome news for California apiculturists and growers. The bee's appearance in California was not a complete surprise, but it was not expected to arrive until sometime in the 1990s after gradual migration and spread from its present northernmost location in Honduras, Central America. The bee's early arrival was probably caused by the unintentional importation of a wild colony inside drilling equipment shipped from South America to the oil fields in Kern County, or from a truckload of imported cargo.

As additional colonies were found during the summer, California's Department of Food and Agriculture intensified its monitoring and eradication efforts, imposed a holding action on the movement of commercial hives, and ordered the de-

struction of any wild honey bee colonies found in the area. Agency officials and scientists are cautiously optimistic that their actions, combined with genetic dilution, will prevent the further spread and premature establishment of the Africanized bee in the continental United States. At the time this article was written, five commercial and three wild colonies of Africanized bees had been found and destroyed, but additional finds were expected. All finds to date are of mixed parentage, indicating that the common European bee in California is interbreeding with the introduced Africanized bee, and suggesting that genetic dilution is occurring.

### History

The honey bee, *Apis mellifera*, ranges from northern Europe to the southern tip of Africa, and eastward into western Asia.

Across this range, the races differ little in appearance or structure, but do differ significantly in behavior. Over the years, the relatively gentle European races were taken to other continents for use by beekeepers. The honey bees in both North and South America originated from European sources, with the Italian race, *Apis mellifera ligustica*, the most favored by commercial beekeepers.

A race of African bees, *Apis mellifera scutellata*, was introduced into Brazil in 1956 in an effort to breed a bee that would produce more honey in the tropics. European bees are adapted to temperate climates and do not perform well in tropical and subtropical climates, especially in the lowlands. As part of a breeding program to eliminate or minimize the African bee's undesirable characteristics while retaining its honey-producing traits, Brazilian researchers brought 47 queens from Afri-

ca to Rio Claro in the state of São Paulo, Brazil. The bees were introduced into colonies equipped with double queen excluders covering the entrances to prevent their escape. In 1957, a visiting beekeeper, not understanding the strict precautions against the escape of queens and drones, removed the queen excluders from 35 hives when he noticed an accumulation of pollen at the entrances. Before his action was discovered, 26 colonies had swarmed or absconded.

After several years, it became apparent that the strain of African bees was not being diluted by the established European bee population but that European colonies were becoming Africanized. The African bee apparently hybridized to a limited degree with European stock, leading to a strain that genetically is still almost identical to the original African bee but is referred to as the Africanized or "killer" bee. Various Brazilian attempts between 1963 and 1972 to dilute the Africanized bees by requeening the most aggressive colonies with Italian bees had only limited success.

Africanized bees quickly supplanted European stock, expanding their range 200 to 300 miles a year from the original epicenter in Brazil, and now have reached Honduras. Studies in Venezuela, Colombia, and Central America found the bee has retained virtually all of its African characteristics as it has spread.

The bees are expected to arrive in Texas around 1988-90 and to become established from Florida to California in areas with adequate nectar, pollen, and nest sites, and suitable winter conditions.

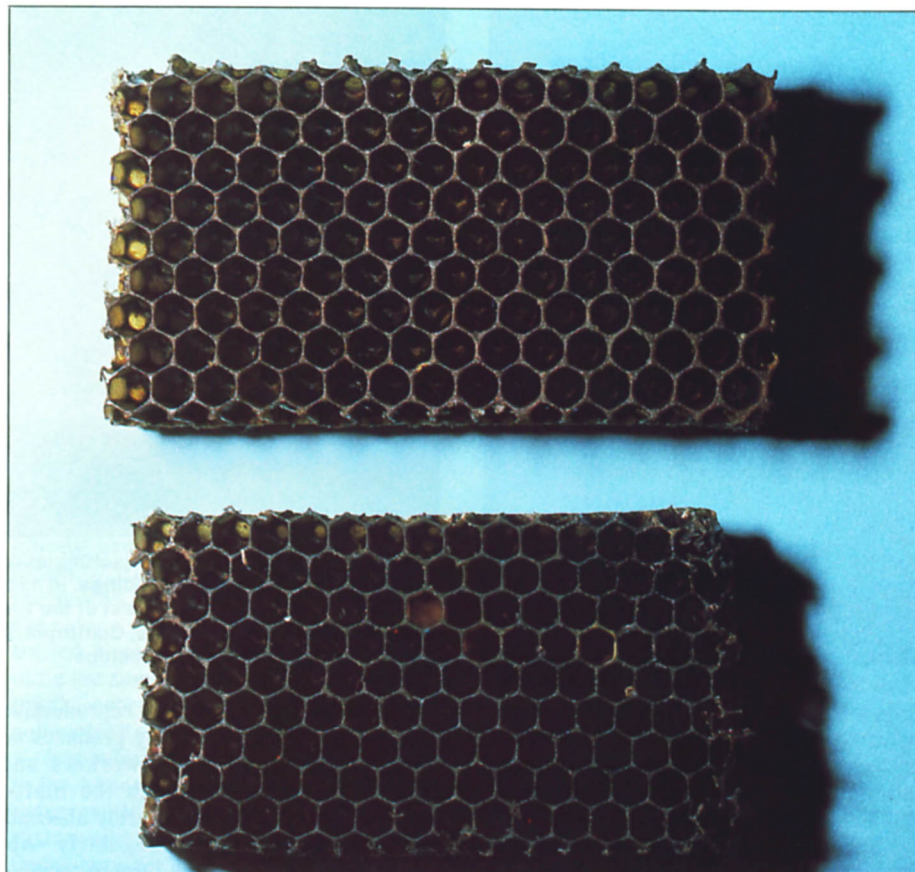
### Biology/natural history

No single structure distinguishes African or Africanized bees from European bees. Differences are a matter of degree and not of kind.

Africanized worker and queen bees on average are slightly smaller than workers and queens of the European races. Africanized worker cells in natural comb are also smaller in average diameter. Color is highly variable, but most Africanized workers have yellow abdominal bands.

Development time from egg to adult is shorter for Africanized than European workers (18 to 20 days versus 21 days). During the tropical dry season when floral sources are abundant and colonies begin a rapid population increase before swarming, Africanized workers live 12 to 18 days compared with 32 to 35 days for European worker bees.

Colony growth of Africanized bees is reported to be rapid, and the annual egg-laying rate is approximately double that of European bees. Individual colonies of



The combs distinguish the Africanized from the European bee; Africanized worker cells in natural comb (bottom) are smaller than the comb cells of European honey bees. Africanized bees develop faster and live shorter lives than European bees. Some apiculturists believe the Africanized bee is a better honey producer.

Africanized bees reportedly have a longer life expectancy than those of European bees, suggesting that they may be more successful at replacing queens than are European colonies.

Africanized bees nest in cavities found in the ground, in termite mounds, under buildings, in barrels, and in old cars. Sometimes they even construct combs in open exposed nests. They appear to prefer somewhat larger cavities for their nests than European bees do, even though they may only partially fill them with comb. European honey bees select smaller cavities that are large enough to store winter food reserves. Both races maintain similar brood nest temperatures.

Originally it was assumed that Africanized bees were unable to overwinter in cold climates, but recent studies in Argentina, as yet unpublished, indicate that they may be able to overwinter much farther north in the United States than was previously supposed.

Africanized bees are more excitable and active than European bees, flying in quicker and more erratic patterns and often flying directly into the hive entrance

rather than walking in as European bees do. When compared with European honey bees, African bees in Africa foraged at lower temperatures and light intensities, foraged in the rain, and foraged earlier and later during the day.

In some areas, Africanized bees reputedly produce more honey per colony than European bees, although there is conflicting information on the subject. Commercial honey production in northern Brazil dropped dramatically after many beekeepers were forced out of business by the bees' temperament, but efforts to improve beekeeping techniques have changed this.

The best known characteristic of Africanized bees is their extreme defensiveness, usually misinterpreted as aggressiveness. Colonies are extremely sensitive to disturbances, such as vibration, foreign odors, and movements, and the bees respond faster, in much greater numbers, and with more stinging than European bees. When disturbed, they follow and persistently sting animals and people hundreds of yards from their colony. Recovery time after disturbance is about 30





**Africanized bees show little discrimination in where they build their nests: in the ground, in termite mounds, under buildings, in exposed areas, even in old cars. Norman Gary, UC bee researcher, checks the nest of the first Africanized bee colony discovered in the United States, near Lost Hills, California, in June 1985. The well-established nest contained approximately 20 combs.**

minutes for Africanized bees compared with 3 minutes for European bees. Researchers concluded that Africanized bees are up to ten times more active in stinging than European bees.

Individual Africanized bee stings are no different from European stings. No significant chemical differences between venoms of Africanized and European bees are known. The difference in stinging episodes is due to the sheer number of stinging Africanized bees. A substantial number of cases have been reported in which animals and people have been severely or fatally stung because of the abundance and special behavioral characteristics of Africanized bees. It should be noted that some of these incidents, particularly those involving hypersensitive people, could have occurred even if European bees had been involved.

Honey bee colonies reproduce by swarming during periods of rich resources. During reproductive swarming, a significant portion of the workers and drones, along with the mated queen, leave the colony and establish a new colony elsewhere. Several afterswarms, each containing new virgin queens, may also issue from the same colony. In the tropics, Africanized honey bee colonies swarm three to four times annually. By comparison, in temperate North America, both wild and managed European bees swarm once or twice annually.

Owing to adverse conditions, disturbances, or rapid colony growth in inadequate space, Africanized bees frequently abscond and migrate to a new nest near better sources of nectar, pollen, and wa-

ter. Absconding differs from reproductive swarming in that the colony produces no new queens, and all the workers and drones leave the nest with the mated queen. European colonies rarely abscond; Africanized bees do so regularly. Absconding rates for honey bees in tropical Africa are 15 to 30 percent a year, but can be up to 100 percent in some areas.

In Brazil, wild Africanized bees are abundant. In one study, an average of 107 colonies per square kilometer were found in a savanna region. Wild European bees are practically nonexistent in the tropics. High densities of wild Africanized colonies produce large numbers of drones that may mate with virgin European queens from colonies in commercial apiaries.

There appears to be some degree of reproductive isolation between Africanized and European honey bees. Researchers have several possible explanations, including greater mating flight distances from the colonies by European queens than European drones. While this prevents inbreeding to drones from the same colony, it favors greater encounters with wild Africanized drones in areas where wild Africanized bees predominate. Slight differences between the two races in the time of day when drone flights occur may also contribute to reproductive isolation by increasing the probability that Africanized queens will encounter Africanized drones during their respective mating flights. Also, European colonies may produce fewer drones owing to the presence of invading Africanized drones and severe competition with Africanized colonies for limited nectar and pollen resources.

## Identification

There are two levels of identification of Africanized honey bees, one for detecting their presence, and the other for detecting varying degrees of hybridization between Africanized and European bees, once they coexist. Because African and European honey bees are two races of the same species, the differences between them and their hybrids are quantitative rather than qualitative. The problem of identification is complicated by the multiple matings of honey bee queens, which fertilize eggs with stored sperm from up to 17 drones. Thus, pure and hybrid bees frequently commingle within a single colony. Drones and workers also "drift" from one colony to another where hives are close together in commercial apiaries, creating sampling problems.

At present there are basically four identification methods to separate Africanized and European honey bees. These are (1) electrophoresis or isoelectric focusing of proteins in bee blood, a laboratory technique to detect inherited differences in enzymes within organisms, (2) evaluation of observable traits such as cell size, colony defensive response and bee weight, (3) gas chromatographic analysis to determine the kinds of hydrocarbons in the bees' cuticle, and (4) multivariate morphometric analysis, a statistical-computer analysis to distinguish races of bees based on measurements of many different body parts. For various reasons, none of these methods is fully satisfactory, but the morphometric method has been most frequently tested and used.

This identification method was developed at UC Berkeley, with some modifications by the U.S. Department of Agriculture (USDA), and then employed in the recent infestation in Kern County.

Other methods of identification are needed to improve the accuracy of evaluating the degrees of hybridization and to monitor the purity of breeding stock in the future.

### Control methods

Because Africanized and European honey bees are the same species, there is little possibility that selective control methods can be developed.

**Eradication.** Where Africanized honey bees are firmly established in the tropics, their very high reproductive rate, the long distance migration of swarms, their partial reproductive isolation, and their resilience to known control techniques have made attempts to eradicate them unsuccessful.

**Pesticides.** Frequent use of pesticides over extensive areas would not be acceptable because of the potentially severe ecological impact on nontarget organisms, the resilience of honey bee colonies (as opposed to the susceptibility of individual foragers away from the hive) to pesticides, the reproductive and migratory behavior of Africanized bees, and the political, legal, and economic problems associated with such a program. Aerial application would be ineffective, because Africanized bees nest in cavities that would not be hit by the sprays.

**Biological agents.** There are no known biological agents, such as pathogens or parasites, that would control or reduce populations of Africanized honey bees without also seriously damaging the economically important European bees.

**Trap and bait hives.** Aside from detecting and monitoring any early introductions preceding a large-scale migration, the use of bait hives to control Africanized bees appears impractical because of (1) the potential of swarms to move long distances despite available nest sites, migrating many miles through and beyond trap zones, perhaps within a few hours, (2) the numbers needed to cover thousands of square miles, and the logistics of distribution, even if they were effective, (3) the unknowns associated with the identification, synthesis, and controlled release of pheromones used to attract swarms, and (4) the expense of such a program.

**Release of European drones.** The massive release of European drones would be ineffective in diluting Africanized bee genes in an area. Honey bee drones are fed and maintained by worker bees within their respective colonies and

must return to their colonies after their mating flights. Individual European drones released in an area would die of starvation within several hours, because they would have no home colony to which to return.

European bee colonies managed for drone production would have to be distributed throughout a given area. However, because of the partial reproductive isolation caused by differences in drone mating flight times, this method would be most effective if a genetic line of European drones were to be bred to fly at times similar to Africanized drones.

**Genetic control.** Genetic manipulation appears to be a promising approach. Because Africanized and European bees are the same species, Africanized honey bees should be viewed as pest genes rather than a typical pest species. All bees in a colony are the progeny of the single queen. Through artificial insemination the queen's genetic makeup, and therefore the colony's genetic makeup, can be controlled. Beekeepers therefore can manipulate the stock in their colonies by replacing the queen yearly or when undesirable colony traits appear.

It should also be possible to work with in the Africanized bee gene pool to select more gentle strains of Africanized bees that would be easier to manage. New technology for quickly locating and destroying the old queen in each colony (necessary if bees are to accept a new queen) has recently been developed at UC Davis, making it economically feasible to find and replace queens in commercial beekeeping operations.

### Conclusions

Africanized bees are a potentially serious threat to the pollination of many agricultural crops. Nationwide, the total value of honey bee pollination to agriculture has been estimated at \$20 billion annually. In California, more than 600,000 commercially managed beehives pollinate 40 crops, valued at \$4 billion annually and including fruits, melons, berries, almonds, citrus, seed crops for vegetables, and forage crops such as alfalfa.

On a bee-by-bee basis, when foraging in the field, Africanized bees may pollinate as effectively as European bees. Their colonies, however, are not manageable as commercial pollination units under California conditions, with the vast acreages of crops interspersed with roads, livestock, and people, and especially the need to transport hives frequently by truck from area to area.

Even with continual diligence by commercial beekeepers to maintain strict genetic control of their European colonies, wild Africanized bees may occupy enough

hives to make apiaries unwelcome in fields and orchards because of the sting hazard. Assuming pure European stock can still be produced in California after Africanized bees become established, it is unknown whether European bees will be able to compete with a potentially high density of wild Africanized bees foraging on the limited pollen and nectar sources.

Also, Africanized bees could have a serious effect on the commercial beekeeping industry for queen and package bee production as well as honey production. California ranks eighth in the nation in honey production.

Another potential problem for U.S. beekeeping is the introduction, by incoming Africanized swarms from South America, of the mite *Varroa jacobsoni*, a parasite of honey bees. This destructive mite thrives in all climates and could spread throughout the United States and Canada.

The public would most likely encounter Africanized bees in the form of wild colonies and swarms in urban and suburban as well as rural areas. Increased incidences of stinging would probably occur but might be reduced significantly by the establishment of public awareness programs, as well as continuous, permanent programs by public agencies to control wild colonies.

Research priorities for the immediate future are to continue the development of more sophisticated identification methods and to initiate, as quickly as possible, a "crash" genetics research program on honey bees. European bee breeding stock must be protected as long as possible and selection of desirable traits from African bees must be a high priority.

The summer's outbreak brought a renewed sense of urgency to planning for the anticipated natural spread of the bees into California. To date, the Africanized bee has not been eradicated from any area in which it has become established. The Africanized bee has the potential to have a devastating impact on California's agricultural industry and to threaten public health and safety. All indications are that we can expect a long-term, if not permanent, battle to gain and maintain genetic control and to continue efforts to improve honey bee stock to fit the changing needs of agriculture.

Ironically, the Africanized bee breeding program that was envisioned in Brazil many years ago now must be conducted in California.

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