Colony Defense by the Africanized Honey Bee in Venezuela

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Introduction

In recent years, the media has carried a number of stories and interviews dealing with the Africanized honey bee, or "Killer Bee," including conflicting reports on the value of this bee type for honey production and pollination, the level of its colony defense, especially stinging, and the introduction of this bee to the United States and its probable spread within our borders.

The term Africanized bee refers to the hybrid population of honey bees (*Apis mellifera L.*) which currently exists in South America. This population of bees is the result of mating between offspring of twenty-six *A. m. scutella* queens which were imported from South Africa to Brazil in 1957 and the various European varieties that had been imported to South America over the years. This importation from Africa was originally made to improve the quality of honey production by honey bees in Brazil through the introduction of a genotype adapted to a tropical environment. The imported bees also introduced a genotype that was much more defensive than the temperately-adapted European varieties already in use in Brazil.

The rapid spread of these Africanized bees throughout South and Central America does pose a threat to the beekeeping industry, related agriculture, and the general public in the United States because of the undesirable behavioral characteristics they express. The Honey-Bee Breeding, Genetics and Physiology Laboratory, Baton Rouge, Louisiana, was directed to carry out research to reduce the effects of this bee on the U.S. beekeeping industry. The results of a part of this research involving defensive behavior are presented here, as well as a discussion of the impact of such behavior on the beekeeper and the general public.

Behavior Model

Honey bee defensive behavior is a complex sequence of actions by a group of honey bees. In order to study such a complex behavior it is first necessary to divide the behavioral sequence into its component parts. We have constructed a model (Collins et al. 1980) as shown in Figure 1 to identify units of defensive behavior which would be subject to genetic analysis and manipulation by selective breeding. This figure shows the basic four-step sequence of stimulus and response that we have proposed. These responses are variable, both in quality and quantity. The stimuli involved in eliciting this behavior at each step may be the same or different aspects of the bee's environment.

The first step in the sequence is alerting. A stimulus from the environment is perceived by a worker honey bee who then responds in one of three ways: she becomes alert, she recruits other bees, or she withdraws. An alerted worker has a characteristic posture with her body raised, the abdomen cocked upward, wings extended and sometimes fanning. In this position the mandibles are held open and the antennae are waved. Occasionally the sting may be protracted. This posture is nondirectional and reflects a level of excitation that is receptive to a second stimulus from the environment.

A recruiting bee opens her sting chamber with her sting protracted and runs into the colony. The protracted sting position allows for the release of alarm pheromone which communicates to other bees in the colony. These other bees in turn become alert.

The third possible response, withdrawal or fleeing, may be seen during hive manipulations. Bees not in a

This range of responsiveness could be a very positive aspect of the Africanized population, because variation is the raw material with which a geneticist can work in selecting a more manageable bee. The fact that there is a lot of variation present in the Africanized population is a good sign that genetic selection on Africanized bees could produce stock that is within the limits of acceptability.

Production of desirable types

We began a genetic selection program using only Africanized honey bees, believing that it would be possible to alter their defensive behavior. This belief was based on the variation we saw expressed in the population and on estimates of heritability, a genetic parameter indicating the probability of success of a program of genetic selection. The heritability (h^2) values that were calculated for 6 of the measures of defensive behavior (Collins et al. 1984) were sufficiently high to predict reasonable success in a selection program for less defensive bees.

After two generations of selection for more and less defensive bees, two lines were produced that were significantly different in their levels of response to the standardized test (Collins, in preparation). However, it was clear that we were more successful in selection for increased defensiveness, and that selection in the opposite direction was much slower. This result only enhanced the viewpoint we were developing, that it would be wiser to prevent Africanization of managed populations of European-type honey bees in the U.S. than to alter these bees after Africanization.

Impact in South and Central America

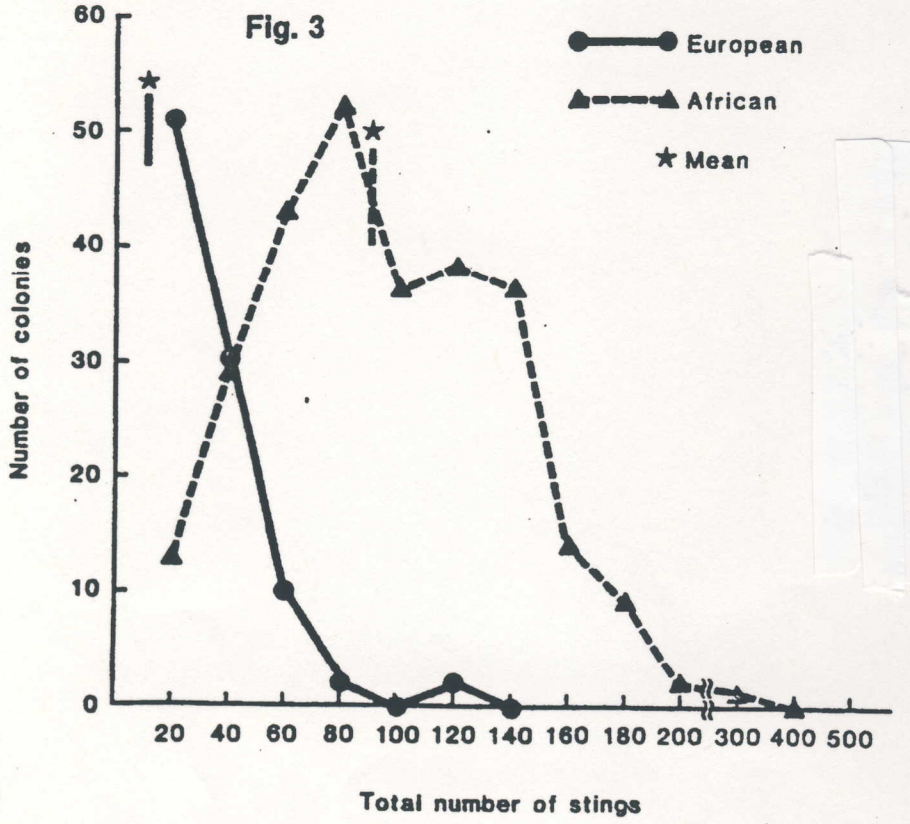
The impact of this bee on beekeeping in South and Central America has been due in part to its excessive colony defense. Certainly the sensationalism in the press is a direct result of this stinging behavior. The importance of other behavioral differences should not be overlooked and are discussed in other sections of the Symposium.

Following the Africanization of an area, generally about one-half to two-thirds of the resident beekeepers give up beekeeping or are forced to abandon the business, especially the small farmers who kept a few colonies to supplement their income. Colonies which once could be kept near home and livestock have the potential to become lethal, so apiary sites must be more isolated and are harder to find. The probability of man-bee interactions is higher and even problems created by wild colonies may be blamed on the beekeeper. Maintaining good relations with neighbors is more difficult and may include the additional expense of replacement of livestock that has been killed by stinging.

In addition to the danger inherent in keeping excessively defensive honey bees, the expenses of running a beekeeping business are greater. Much more equipment is necessary to protect the beekeeper while working with the bees. Prior to Africanization, a veil, street clothes, and a small smoker were sufficient for working colonies. Now it is necessary to wear a veil, some sort of protective suit, usually of heavy cotton, gloves, sometimes rubber gloves, boots and ties, and straps or tape to seal any openings. Also heavy smoking throughout the time colonies are being worked is necessary, so that two or three people are required to complete the work one used to do. More stinging occurs, even with the additional protection. In general, the work is considerably more unpleasant and many beekeepers are unable or unwilling to make the changes necessary to cope.

Another drawback is that the time required to carry out routine management procedures is increased significantly due to the necessity for more careful preparation before the work and more manipulation to prevent problems with angry bees after handling. More time is required for travel to remote apiary sites. And more time and energy must be devoted to public relations.

For many beekeepers this has meant the end of their beekeeping career. Some have been forced out of business by their neighbors burning or destroying equipment. Some do not want to work with this bee anymore because of extreme defensiveness or the necessity for wearing such heavy clothing while working.



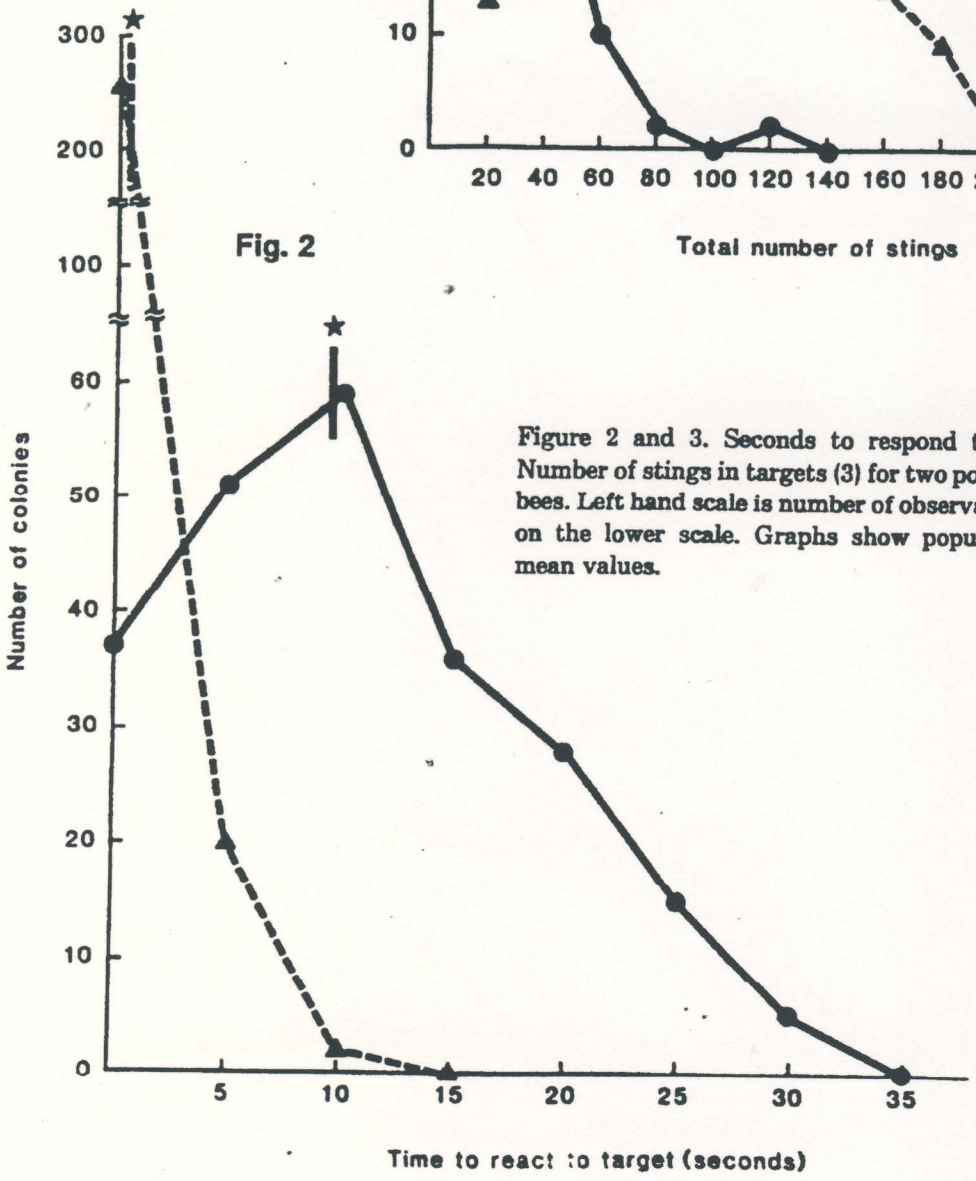


Figure 2 and 3. Seconds to respond to targets (2) and Number of stings in targets (3) for two populations of honey bees. Left hand scale is number of observations at each level on the lower scale. Graphs show population ranges and mean values.

population of European bees that existed in Venezuela, probably *Apis mellifera mellifera*, to produce a hybrid that is extremely aggressive. This particular cross of any bee type to *Apis mellifera mellifera*, is one that frequently produces defensive bees (Brother Adam, pers. comm.).

One approach that has been taken by a few beekeepers in Venezuela to improve their managed stock is to produce specific hybrids and evaluate them for their colony defense and honey production. That is, they are rearing queens of known European genotypes, allowing them to mate freely in an area of Africanization and then evaluating these F1 hybrid colonies for their temperament. Table 2 presents the results from the standardized test of an array of colonies in such a program. We had 12 European colonies (European queens mated to European drones, 6 Italian and 6 Caucasian), 6 Africanized colonies (wild caught swarms, headed by Africanized queens mated to Africanized drones), and 12 of the F1 hybrids (6 Italian queens free mated in an Africanized area). It is clear that the hybrids are intermediate to the two parental types (European and Africanized) for all the characters. They tend to respond to alarm pheromone almost as slowly as the Europeans do, however their response to the moving target was more like the fast-responding Africanized parent. The number of bees responding was intermediate and so was the number of stings. However 2-3 times the average stinging of European colonies is still more than many beekeepers or neighbors of beekeepers would tolerate.

	Time to respond to: (seconds)		Number of bees:				
	alarm pheromone	moving target	pre	30s	60s	90s	No. of stings
European	10.2	5.6	19.5	33.1	44.5	64.6	30.9
Hybrids	8.6	2.2	44.5	49.4	66.5	117.2	76.4
Africanized	3.6	0.8	73.7	89.4	115.5	256.6	143.2

Table 2. Results from a standardized test of colony defense using European (6 Italian, 6 Caucasian), Africanized (6), and Hybrid (6 Italian x Africanized, 6 Carniolan x Africanized) colonies.

However, it was clearly evident that the Africanized population was extremely variable (Figures 2 & 3). Colonies that were Africanized could be as nonresponsive or gentle as many of the Europeans, but there were also Africanized colonies that were very extreme in their defensiveness. When dealing with Africanized honey bees, these extreme colonies are of major concern.

Standardized Colony Evaluation

Once we had divided the sequence of honey bee defensive behavior into more manageable units, it was necessary to devise a standard measurement procedure in order to compare defensive behavior between different type of bees (Collins and Kubasek 1982). This standardized test involves presentation of a series of stimuli to a colony and the measurement of that colony's response in several ways. The stimuli presented are: 1. A chemical stimulus consisting of a mixture of alarm pheromones associated with the honey bee sting (Blum et al. 1978) that are diluted 1 to 99 (volume to volume) in paraffin oil; 2. A physical stimulus which is provided by the impact of a glass sphere (18.5 g, 2.3 cm in diameter) propelled at the colony directly above the entrance. This physical stimulus provides further arousal to the bees being tested; 3. A visual stimulus (as well as a tactical stimulus) provided by two dark suede-leather squares (5 x 5 cm) that are moved in front of the colony by a mechanical apparatus. These targets are swung vertically through 20 cm, 120 times per minute, providing a dark color, a jerkily moving object, a distinctive leather odor, and a slightly rough texture, all of which are prime stimuli for eliciting stinging (Free 1961).

Our data include counts of the number of bees responding taken from two series of 4 photographs, one of the area around the entrance and one of the airspace in front of the colony, the time at which bees respond to the initial chemical stimulus by emerging from the entrance in alerted posture, the time at which bees respond to the presented target, and the number of stings which remain embedded in the leather targets.

Evaluation of Several Bee types

Using this standardized test of defensive behavior we tested two honey bee types: 150 European colonies headed by queens of U.S. commercial stocks in Louisiana and 147 Africanized colonies headed by queens that had mated freely in an Africanized area of Venezuela (Collins et al. 1982). Table 1 shows the results from this comparison. For all measures of defensive behavior the Africanized bees were significantly more responsive. They responded about 3 times as fast as the Europeans to alarm pheromone and about 27 times as fast to the targets. The number of bees issuing from the colony in response to the disturbance provided by this test was also greater in the Africanized bees, about twice as many bees at each stage of the test. Finally the number of stings averaged 8-10 times more in the Africanized population.

	Time to respond to: (seconds)		Number of bees:				
	alarm pheromone	moving target	pre	30s	60s	90s	No. of stings
European	13.1 ±0.5 **	9.2 ±0.5 **	44.2 ±3.5 **	61.1 ±4.9 **	66.6 ±4.0 **	84.3 ±4.4 **	10.4 ±0.9 **
Africanized	5.4 ±0.3	0.3 ±0.1	70.6 ±7.0	121.6 ±6.8	141.7 ±7.8	172.8 ±9.8	85.7 ±2.6

Table 1. Results from a standardized test of colony defense using 150 European colonies (U.S. commercial stocks) and 147 Africanized colonies (free-mated in Venezuela). ** Paired means are significantly different at $P < 0.01$.

Comparison of results from a similar type of study in Brazil with our results in Venezuela indicates that the Africanized bee as it exists in northern South America is more defensive than its counterpart in southern and central South America. A possible explanation for this is that the Africanized bee crossed with a wild

physiological condition that allows them to engage in defensive behavior will show this response, i.e., younger nurse bees.

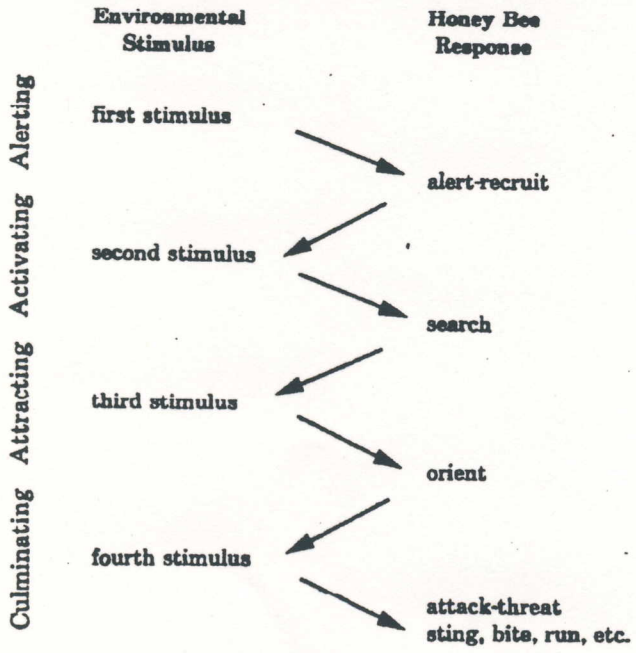


Fig. 1 Honey-bee defensive behavior

The second step of defensive behavior is activating, during which a bee will seek the source of the disturbance. Initially the searching behavior will take place randomly in the area close to the alerted bee. However, in the absence of an appropriate third stimulus this search may continue throughout the colony and beyond the confines of the colony.

During the search phase of defensive behavior, if an appropriate environmental stimulus (third stimulus) is encountered, the alerted bee will orient to that stimulus. Often the same disturbance simultaneously activates and attracts, and the sequence of the behavior is so rapid that the components may not be distinguished by the observer.

Once the alerted bee has searched and oriented to a disturbing situation, the continuation of this disturbance will provide an appropriate fourth stimulus that will elicit attack. Attack can encompass various responses by a worker bee. In threat behavior, the bee rapidly flies around the fourth stimulus. This flying is accompanied by a high-pitched buzz that is markedly different from that of a foraging bee. This buzzing threat in itself may be sufficient to deter an intruder from disturbing the colony further. With a first stimulus that is close to a bee and on the same surface, threat behavior may involve running or walking toward the stimulus making body thrusts toward this stimulus with antennae and prothoracic legs waving. Of course, stinging and biting are the most obvious attack behaviors associated with honey bees. In addition the bee may pull hair, or burrow into hair, clothes, fur, or orifices of an intruder. The stinging and possibly the biting, can also release pheromones that serve as the first stimulus to alert other bees, or possibly as a stimulus for orientation of searching bees. Finally, for some bees, running is a defensive option when the integrity of their nest has been severely disturbed. Such bees may run away from combs that have been manipulated or leave the colony entirely.