The Defensive Behavior of The Africanized Bee

(Third of a Series)

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WHAT ACTUALLY happens when an Africanized bee defends her colony? What events trigger a defensive response? What factors, if any, can change or at least control the defensive behavior of the Africanized bee?

These questions are important ones as the United States faces the eventuality of the presence of the Africanized bee within its boundaries. Queens from South Africa were introduced into Brazil in the late 1950's to improve honey production with a more tropically adapted bee. The honey bee resulting from the interbreeding of the established European and imported African types, which is referred to as the Africanized bee, has spread through much of South and Central America, as far north as Guatemala. Predictions by O. R. Taylor (1977) are that the bee will make its way into the United States by approximately 1990. Already, isolated cases of the bee's presence in this country have been confirmed and the colonies have been destroyed.

A look into the honey bee's defensive behavior starts with a model based on careful observation and much experimental data. This four-step sequence of defensive action begins after the bee has been disturbed in some way.

The first step is alerting. An alerted worker bee raises her body with abdomen cocked upward, with wings extended and sometimes fanning. Mandibles are held open and antennae waved. Sometimes the sting is extended. Sting protrusion releases alarm pheromone, which evaporates and hangs in the air like perfume. The smell in turn stimulates other bees in the colony to defend. There is a general increase in movement on the combs, unoriented in direction.

The second step is activating. An alerted bee begins to seek the source of disturbance. If the bothersome stimulus continues the bees will engage in active searching behavior, moving throughout the colony and eventually outside the colony.

The third step is attracting, when bees engaged in random searching encounter something they can sense — for example, a skunk appearing at the entrance to the hive, their movements become oriented to the source of stimulation.

The fourth step is attack. Once they are oriented to the disturbance, they can attack. An attack can be stinging, displaying a threat, such as flying vigorously around the eyes and face, making a high-pitched buzzing sound; burrowing into hair, fur, clothes, and ears; biting; or pulling hair. Some bees flee at this point instead of attacking.

While it is well known that Africanized bees are more defensive than their European counterparts, we needed to actually measure their defensive behavior. We developed a field test to do this, and conducted experiments on European bees in Baton Rouge, Louisiana, USA, and on Africanized bees in colonies in Maturin, Monagas, Venezuela. The Louisiana colonies were made up of bees from various United States honey-bee stocks and their supersedures. The Venezuelan colonies had once contained European bees, but were chosen because they had been allowed to breed freely for at least the past year with the feral Africanized bees that had been in the area for at least two years.

An important consideration in evaluating colony defensive behavior is the temperature and relative humidity at the time of testing. The conditions during measurement in Louisiana (temperature 77 to 96°F; relative humidity 61 to 97 percent) were very similar to those in Venezuela (78 to 95°F; relative humidity 61 to 92 percent).

All the hive entrances were made uniform (5.5 by 0.5 in) and any additional openings were screened shut. Each colony was tested twice in a standard 90-second test sequence. Observations of defensive behavior were quantified in three ways. First, the number of bees at the colony entrance was counted from photographs taken at 30-second intervals during the test. A stationary camera was set up to take pictures of the front of the colony. Second, two time-measurements were made: the length of time until bees began to emerge after alarm pheromone was sprayed above the entrance, and the length of time it took for the first bee to orient to and land on a suede leather target. Third, to measure the number of stings, a dark-colored square of suede was attacked to a mechanism that moved it up and down in front of the colony. Suede was chosen as the target because the stings would stay imbedded in it, to be counted later.

At the beginning of each test, the front of the hive was sprayed with alarm pheromone. This alerted the colony and the bees carried out the first two steps of the defense sequence.

The bees were allowed to respond to this stimulus for 30 seconds, and then a second stimulus was presented. From a standard distance, the colony was hit with a large marble from a slingshot. This second stimulus tended to increase the level of response from the bees. They responded without disturbance for 30 seconds, and then the moving target of suede was put at the entrance.

The bees responded to and stung the

A

B

C

D

Figure 1. The sequence of steps in the defense test: a. photographing the number of bees responding, b. spraying alarm pheromone to begin the test, c. delivering the physical disturbance, d. and presenting the suede targets for attack. Photos by A., Bolten for USDA-ARS.

target for 30 seconds, the target was removed and placed in a container to prevent further stinging and the last picture was taken. The targets were brought to the laboratory and the stings counted later.

After several of these experiments, we noticed that so many Africanized bees became airborne when the target was presented that the one picture taken of the bees in front of the hive wasn't giving an accurate estimate of the number of defenders. In later tests, a second camera was set up to the side of the colony, to get pictures of the airborne bees.

After the experiments, the colonies were smoked, to calm the bees, and disrupt the defensive sequence.

After observations and statistics were compiled, the results were clear: the Africanized bees responded more quickly to both the pheromone and the targets (Collins, et al. 1982). Usually, the responses of the Africanized bees to the target were immediate, they harassed the experimenters continually, and they occasionally stung the targets before they were placed at the entrances. This is in contrast to the European colonies in which many bees continued to forage and did not respond at all.

The Africanized colonies had significantly more bees at the entrance at all times than the European colonies. However, the numbers reported for the Africanized bees at the entrance were often underestimates of the numbers of bees responding because, immediately after the pheromone spraying, many of these bees became airborne. In contrast, the European bees usually remained near the entrance until the targets provided a stimulus for orientation and attack.

The total number of stings recorded from the Africanized colonies averaged 8.2 times greater than the number of European bee stings. However, the total number of stings produced by the Africanized bees was probably another underestimate, especially for the most responsive colonies, because the targets were completely covered by the bees within a few seconds of being presented. Since the bees remained on the targets, biting and stinging, other bees could not reach the surface with their stings. If the target had been a human, for example, there would have been thousands of stings counted, not hundreds.

Other facts discovered about European and Africanized bees' colony defense:

— A greater proportion of Africanized bees participated in colony defense, compared with European bees.

— Africanized bees had a greater tendency to come out of the colony and fly around it. There were many more bees in the air harassing the experimenters during tests of these colonies than during tests of the European colonies.

— Africanized bees at the entrance frequently attacked other bees — a behavior not exhibited by the European bees.

— Africanized bees stayed alerted for a longer period of time. While the European bees responded quickly to the smoking and soon after calmed down, the Africanized bees stayed alerted for a long time. In some tests, it took seven days for the bees to return to a pretest level of behavior. Other experiments with Africanized bees have shown that if the disturbance is continual, the bees will readily abscond.

— There was more variation in behavior among the Africanized bees than among the European bees. Some colonies were extremely attack-oriented and others were no more defensive than the European colonies in Baton Rouge. The most likely explanation for this variance is the different levels of hybridization in the Africanized bees. In other words, those Africanized colonies not giving a vigorous response to the testing probably had a higher percentage of European genes.

Measurement of defensive behavior is made more complex because the behavior is influenced by many factors, some of them known through observation and other experiments. For example:

— The more honey in the hive, the less defensive the response, and vice versa. With only a small amount of stored honey, there is a scramble to defend the waning store of honey. When the moving target was presented, those bees that had been in a hive with more empty comb responded twice as fast as bees from the units with less empty comb (Collins & Rinderer 1985). There were also twice as many stings in the targets attacked by these bees.

— Bees stimulated in hot humid weather are more defensive.

— If the colony has recently been threatened or bothered, such as by a lizard crawling near the entrance, the bees will be more defensive to a threat of attack.

— The higher the concentration of the alarm pheromone sprayed at the hive entrance, or emitted by the bees in the hive, the stronger the response. Assays of alarm pheromone production in both bee types show higher levels of ten of the alarm pheromone chemicals in Africanized samples (Collins, et al. 1986).

The implications of this excessive colony defense for the beekeeper are multiple. The problem is not that the bee cannot be managed, people are successfully using Africanized bees for honey production. However, probably a greater number have chosen not to continue in beekeeping because of the problems, or were "discouraged" by their neighbors.

Certainly managing defensive bees is more costly and time consuming. It is necessary to wear protective clothing, including a veil, gloves, and beesuit, carefully strapped or taped to cover any possible holes. These outfits are expensive, and require time to put on properly. Also, the work is much clumsier with gloves, and certainly hotter.

More effort is necessary to smoke the colony while working, since the bees become so aroused when disturbed. It is necessary to have at least two people working the colony at any time: one person doing the management op-

Figure 2. Photographs of the entrances of two average colonies during the test. Left — a European colony. Right — an Africanized colony. This does not adequately show the numbers of bees in the air defending the colony. Photos by USDA-ARS and A. Bolten.

eration and one person smoking. Some South African beekeepers also have a third person watching the activities, looking out for any building response in the colony. As with handling European bees, a beekeeper can learn which colonies are the hardest to handle, and save them until last. Working them first causes greater disruption of the other colonies in the apiary.

After the work is finished, additional time must be spent to protect neighbors. Driving the truck around the apiary to keep the bees from following it to areas with people and livestock, is one technique. This requires time. A part of the defensive behavior is persistence in following intruders.

As part of our research on defensive behavior, we asked if a breeding program could change these undesirable defensive traits. Using a complex statistical analysis, we calculated heritability — a number between zero and one that measures what proportion of a certain characteristic is controlled by genes, and how much the behavior could be changed by a selective breeding program. The heritability values for aspects of defensive behavior were high enough to encourage us to attempt a selection program (Collins, et al. 1984).

To do this, we measured defensive behavior using the standard test on a group of Africanized colonies. We tested 80 Africanized colonies with the field test and found the 10 most defensive colonies and the 10 gentlest colonies. We reared the queens and drones in those lines, and then mated them within the same line. This was repeated for three generations, with the 10 most defensive from the defensive line and the 10 most passive in the gentle line.

We were able to produce lines that were significant different in behavior with successive generations. In other words, in the defensive line, each successive generation was more defensive than their parents, and in the gentle line, each successive generation was calmer than their parents. In fact, one Africanized colony from the gentle line was so gentle that you could almost work the colony without gloves. However on the whole, we were much more successful in producing a more defensive bee than a gentler one. For some aspects of defense, the gentle line was not different from the base population.

A simple conclusion to the experiment is that if a breeding program is begun with just Africanized beees, it will be difficult to make them as gentle as European bees. Africanized bees must be crossed with Europeans to produce gentler lines. Or conversely, this study emphasizes how important it is to maintain reproductively isolated populations — to keep the European bees as separate as possible from the Africanized bees.

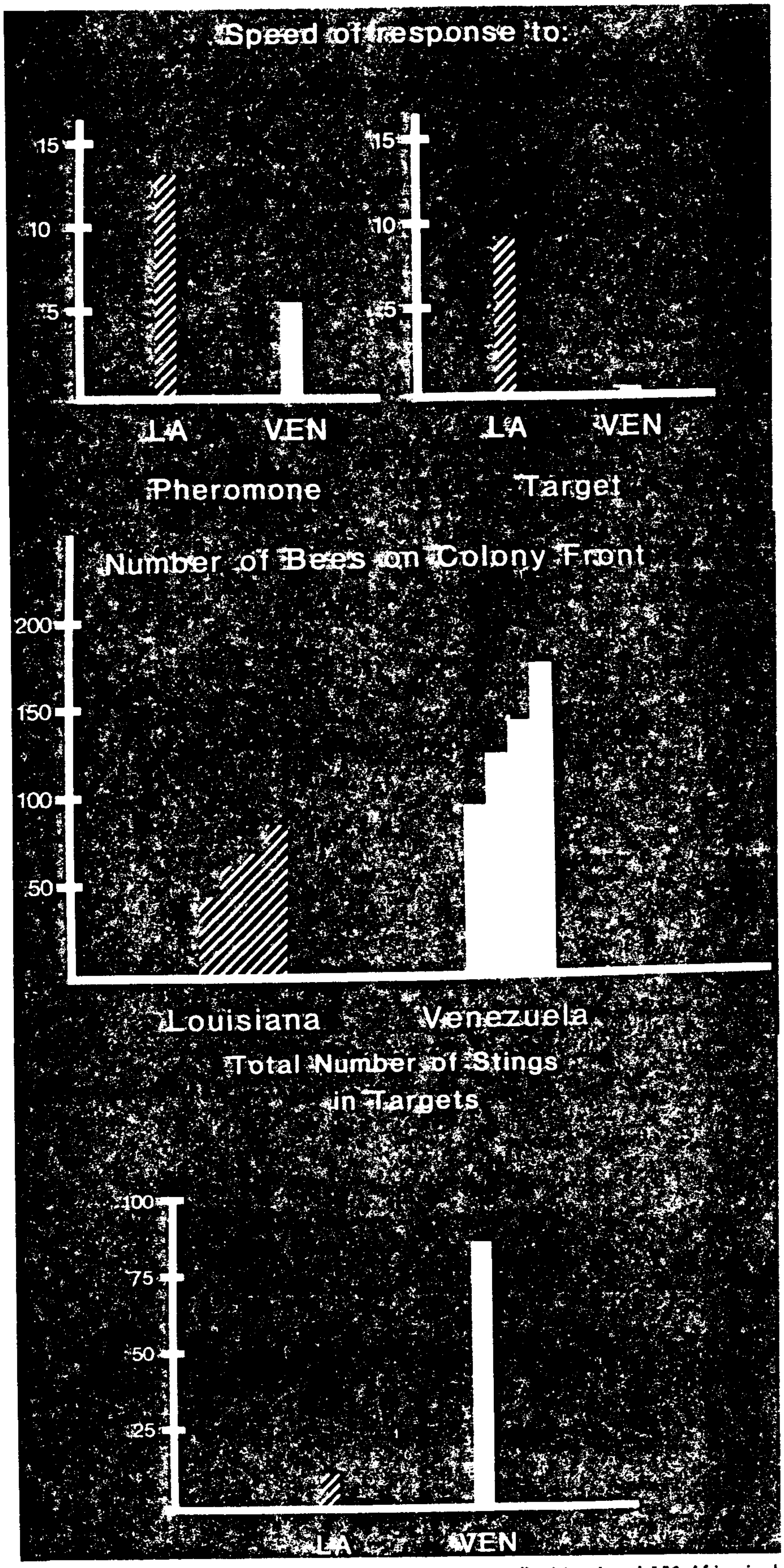

Figure 3. Results of the defense test on 150 European (Louisiana) and 150 Africanized colonies (Venezuela) for averages of time to respond to alarm pheromone or a moving target, number of bees responding and number of stings. The differences between the two bee types are clearly seen.

Since the first step in the defense sequence involves communication with alarm pheromone, we have looked at this pheromone as a possible difference between the bee types and, perhaps, a way to control colony defense levels. We have found that Africanized bees respond more vigorously to lower concentrations of alarm pheromone than do their European counterparts, and that they have a greater production level of 10 of the 13 active pheromone components.

Another experiment in England by Al-Sa'ad, Free and Howse (1985) is utilizing pheromone to try to reduce defensive behavior. They put alarm pheromone in the colony, on the premise that an animal habituates to an odor if it is present constantly, and thus reduced their response to a marked target. However, attempts to replicate this with Africanized bees and their response to the standard test do not look too promising.

The impact of the Africanized bee on the United States beekeeping industry and agriculture will be considerable. Personal and public response to the possibility of severe stinging and death would cause many beekeepers to give up beekeeping or reduce their colony holdings. The resulting reduction in honey production, and the loss of the major insect pollinator of many crops would constitute a major expense for American agriculture.

Our preliminary response to these and other experiments done by us and others is that European stocks of bees should be protected. Use and maintenance of manageable stocks can be a strong tool for the beekeeper to convince his neighbors that he is not the cause of problems with wild colonies and swarms of Africanized bees, but that he is, in fact, the major line of defense against them. By monitoring his own colonies and destroying wild ones, he may have a significant impact on reducing the effects of Africanization.

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REFERENCES CITED

Al-Sa'ad, B. N., Free, J. B. and Howse, P. E. Adaptation of worker honey bees to their alarm pheromones. Physiol. Entomol. 10: 1-14.

Collins, A. M. and Rinderer, T. E. 1985. Effect of empty comb on defensive behavior of honey bees. Jour. Chem. Ecol. 11: 333-338.

Collins, A. M., Rinderer, T. E., Harbo, J. R., and Bolten, A. B. 1982. Colony defense by Africanized and European honey bees. Science 218: 72-74.

Collins, A. M., Rinderer, T. E., Harbo, J. R., and Brown, M. A. 1984. Heritabilities and correlations for several characters of the honey bee. **Apis mellifera.** J. Heredity 75: 135-140.

Collins, A. M., Rinderer, T. E., Harbo, J. R., and Tucker, K. W. 1986. Alarm pheromone production by two honeybee types. In press.

Taylor, O. R. Jr. 1977. The past and possible future spread of Africanized honeybees in the Americas. Bee World 58: 19-30.

Figure 4. Africanized bees defending colonies in Venezuela. Even with protective gear, the beekeeper is being stung, especially in the hands. Photos by G. Killion and M. Ellis.

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