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Responses of Africanized Honey Bees (Hymenoptera: Apidae) to Pollination-management Stress

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ABSTRACT Fifteen Africanized (AHB) and 15 European (EHB) honey bee, *Apis mellifera* L., colonies were moved to six different crop sites during a 2-mo test in Venezuela. Several problems with AHB suggested that these bees may be difficult to use commercially for pollination. Debilitating reductions of adult populations occurred more frequently among AHB colonies ($n = 12$) than among EHB colonies ($n = 5$). In 6 of 11 tests of defensive response, targets were stung more by AHB colonies than by EHB colonies; no differences were found in the five other stinging comparisons. Also during defense tests, AHB colonies typically had more bees that contributed to nest defense by buzzing intruders. Inspections of AHB colonies were more difficult because bees often ran off combs and festooned. Weight gain (nectar and honey storage) was greater by EHB colonies than by AHB colonies at two of the six sites; gains were similar at the other four sites. Frequencies of queen losses were similar among the two groups of bees. Swarming was never initiated during the test.

KEY WORDS Africanized honey bees, crop pollination, *Apis mellifera*, beekeeping management

THE GREATEST ECONOMIC impact of Africanized honey bees (*Apis mellifera scutellata* Lepeletier hybridized with European honey bee subspecies) in the United States is expected to be related to agricultural pollination (Michener 1972, McDowell 1984). In the United States, the annual value of crops that require or are benefited by bee pollination approaches $20 billion (Levin 1983). Much crop pollination is provided by honey bees managed by commercial beekeepers. Concern has developed because these services may eventually have to come from beekeepers operating with Africanized bees.

Undesirable characteristics that may detract from use of Africanized bees for pollination include excessive stinging (Collins et al. 1982), absconding (Winston et al. 1979), killing of queens during transportation (Wiese 1972), swarming (Otis 1980), and difficulties in colony inspection (Michener 1972). In addition, the rigors of commercial pollination practices may exacerbate these objectionable traits. When used commercially to pollinate crops, colonies frequently are stressed by movement to crop sites, manipulation, exposure to pesticides, and the poor nectar and pollen rewards of some crop species.

Examining the effects of pollination-management stress on Africanized bees is essential in assessing the potential impact of these bees on agricultural pollination in the United States. In this study, we sought to evaluate problems related to such stress by comparing Africanized bees with the type of bees presently used for pollination in North America (European bees; a mixture of several European subspecies of *Apis mellifera* L.).

Materials and Methods

Testing occurred from 6 February to 12 April 1984 in the states of Lara and Portugesa, Venezuela. An apiary was established with 15 colonies of each bee type. Africanized colonies were started from local feral swarms; European colonies were headed by queens of commercial United States stocks. Most colonies were started at least 1 yr before the start of the test and were of typical field size for Venezuela. One week before the start of the test, Africanized colonies had an average of 9.6 combs covered with worker bees and 6.1 combs with brood of all ages. European colonies had 10.0 and 7.2 combs of bees and brood, respectively. Each colony was maintained in one standard Langstroth hive body (24 cm depth) and one honey-storage chamber (17 cm depth). Colonies were provided with additional storage space when necessary.

The colonies were evaluated during a 4-d pretest period, then moved to six different sites during the 2-mo experiment; moves and sites are described in Table 1. The colonies were moved at night with hive entrances screened and queens left uncaged; Wiese (1972) suggested caging queens to prevent losses.

A standardized defense test (Collins & Kubasek 1982) was administered to each colony on the day before the experiment began, on the day after each

Table 1. Dates and locations of sites, resource availabilities, and weather conditions during the pollination management study in Venezuela, 1984

Site no.	Starting date	Days at site	Town nearest to site	Latitude, longitude	Forage resources	Weather conditions[a]
Pretest	6 Feb.	5	Sarare	9°48′N, 69°08′W	Tropical dry forest	24–34°C, 38–82% RH
1	11 Feb.	13	Espinital	9°28′N, 69°10′W	Commercial sesame field (1 ha, full bloom)	25–34°C, 39–93% RH
2	24 Feb.	8	Araure	9°37′N, 69°14′W	Commercial mango and citrus orchard (38 ha, 10% bloom)	22–34°C, 33–92% RH
3	3 Mar.	13	Choro	9°29′N, 69°17′W	Commercial sesame field (22 ha, 20% bloom)	23–35°C, 29–84% RH
4	16 Mar.	11	La Miel	9°46′N, 69°12′W	Commercial mango orchard (11 ha, 20% bloom)	24–36°C, 32–84% RH
5	27 Mar.	3	Sarare	9°47′N, 69°08′W	Tropical dry forest	24–37°C, 33–90% RH
6	30 Mar.	14	Sarare	9°48′N, 69°08′W	Tropical dry forest; scattered mangos and citrus	23–37°C, 30–92% RH

[a] Temperature and humidity data collected at El Torrellero (9°46′N, 69°08′W). There was no rainfall during the experiment.

move, and 4 and 7 d after move 1 and move 6. During the defense test, pheromonal, physical, and visual stimuli (each for 30-s intervals) were presented sequentially to the colony. Colony defensive responses were summarized by the number of stings in two suede target patches after 30 s of exposure, the number of bees that crawled onto the hive front and remained there, and the number of bees that flew in front of the hive. Numbers of responding bees were determined by examining sets of photographs (one of the hive front and one of the airspace in front of the hive) taken at the start of the test and 30 s after the presentation of each stimulus (i.e., at 0, 30, 60, and 90 s into the test).

Nectar storage was estimated by weighing the colonies at the beginning and end of the stay at each site. Before weighing, each colony was inspected thoroughly to determine the presence and egg-laying status of the queen, signs of population loss, swarming, diseases or pests, and poor handling characteristics (i.e., excessive running, festooning, or stinging).

Adult mortality in five randomly chosen colonies of each bee type was monitored with Todd dead bee traps (Atkins et al. 1970). Trap contents were collected on each day before and after a move and usually at 3-d intervals between moves. Mortality was converted to the rate of dead bees per colony per day for each location. Bees and debris were examined for evidence of pathogens, pests, and ectoparasites. Colonies monitored for mortality were not included in defense tests, with the exception of being tested (without traps) on 6 and 11 February.

Two-tailed *t* tests, modified for unequal variances when necessary (Snedecor & Cochran 1980), were used in evaluating defensive responses, honey storage trends, and mortality rates of the two bee types. Binomial tests (Siegel 1956) were used to compare bee-type responses for numbers of colonies that had population losses and numbers of colonies that presented difficulties during each inspection. Trends of either bee type responding consistently with more bees on hive fronts or more flying bees were evaluated with sign tests (Siegel 1956) for each series of pictures during the defense tests.

Results and Discussion

More Africanized colonies than European colonies were debilitated by population losses ($n_A = 12$, $n_E = 5$; $P < 0.001$). During the first move, three of the Africanized colonies lost all but about two frames of bees (all queens remained) and had little flight activity for 2 wk. The populations of these colonies never returned to initial levels during the remaining 8 wk of the study. Thus, the colonies were unacceptable as pollination units, given recommendations of at least four frames of brood and bees for pollination services (e.g., Jaycox 1981). Nine other Africanized colonies and five European colonies had obviously reduced populations at some time during the test and probably were unacceptable as pollinating units for at least some portion of the study. The comparatively high rate of population losses among Africanized colonies was perhaps the biggest problem found with these bees during this study.

Differences in defensive responses of the two bee types were less than has been found when colonies were not managed for pollination (Collins et al. 1982). In 6 of the 11 defense tests performed, target patches were stung significantly more by Africanized bees than by European bees (Fig. 1); no significant differences were found in the other tests. Compared with the pretest baseline, stinging after movement was often increased in European bees and decreased in Africanized bees; these trends presumably were due to differential effects of stress (including resultant population losses). Africanized colonies moved less frequently would probably exhibit more stinging. Overall, targets received 33% more stings from Africanized colonies. Although these are far lower than the 5- to 8-fold differences found in previous work (Collins et al. 1982), sufficient stinging problems could be expected in a labor-intensive agricultural setting to warrant concern.

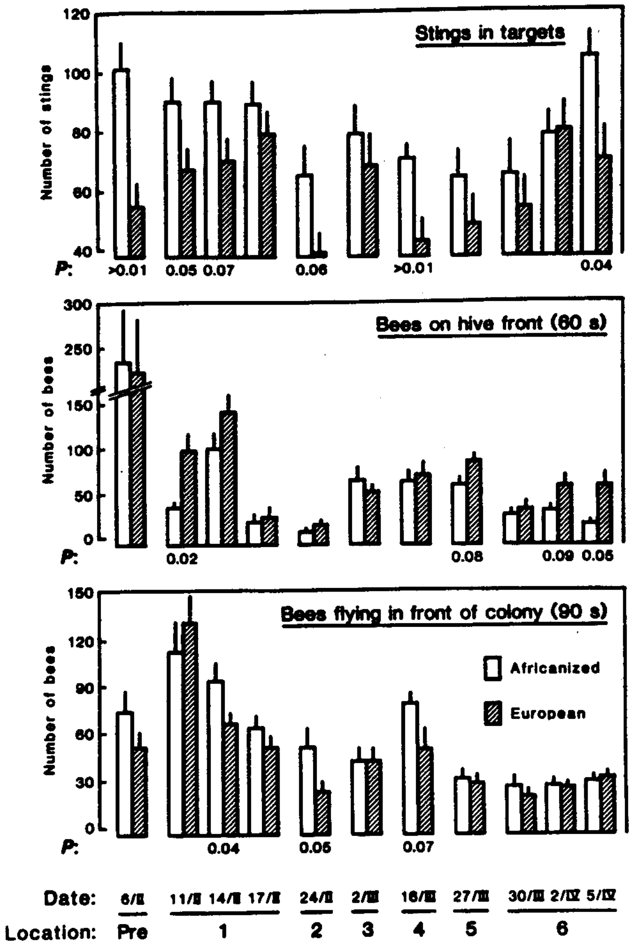

Fig. 1. Component responses of defense tests. Tests were administered on the 1st d at each new site and also on the 4th and 7th d after move 1 and move 6. Stings are number delivered to two suede patches (5 by 5 cm) in 30 s. Numbers of bees crawling on the hive front at 60 s and numbers of bees flying in front of the hive at 90 s are each one example from measurements taken 0, 30, 60, and 90 s into the tests. Error bars are 1 SEM.

Although the differences in numbers of bees responding to the defense test stimuli were usually small ($P \leq 0.05$ in only 5 of 88 comparisons), several trends appeared in these data. Bees crawling on the fronts of European hives typically outnumbered bees on the fronts of Africanized hives at 60 and 90 s into the defense tests ($P \leq 0.033$) (Fig. 1). In contrast, bees flying in front of Africanized hives typically outnumbered bees flying in front of European hives at 60 and 90 s ($P \leq 0.055$). No differences were found for either crawling or flying bees at 0 and 30 s. Nest defense consisting of many bees flying near a disturbance seems to be employed more frequently by Africanized colonies; such harassment may cause problems for nonbeekeeping agricultural personnel.

Running, festooning, and stinging bees caused problems more during inspections of Africanized colonies than European colonies during five of the seven inspections (Table 2). Summed over all inspections, >4-fold as many of these problems were encountered among the Africanized group. A large amount of smoke was needed to minimize stinging by Africanized colonies, and this contributed appreciably to bees festooning and running in the hives.

Requeening was required eight times among the Africanized colonies and seven times in the European group. This result differs from Wiese's (1972) observation of relatively high Africanized queen mortality associated with colony transportation. Locating Africanized queens during colony inspections was often difficult and time consuming. Swarming initiation was never observed during the study.

European colonies had significantly greater weight gains than Africanized colonies at two of the six sites (Table 2). At the four sites that yielded surplus nectar, European colonies gained an av-

Table 2. Colony weight changes, adult mortality ($\bar{x}$ ± SEM), and inspection difficulties (totals) for each experimental location

Site no.	Bee type	Colony wt change (kg) (n = 15)	P	Dead adult bees/colony/day[a] (n = 5)	P	Difficulties during colony inspections[b] (n = 15)	P
Pretest	Africanized	Not measured		4 ± 1	0.095	6	<0.001
	European	Not measured		18 ± 7		0	
1	Africanized	1.4 ± 1.2	0.012	10 ± 3	0.169	7	0.002
	European	5.3 ± 0.8		41 ± 18		2	
2	Africanized	−1.0 ± 0.2	0.791	11 ± 3	0.329	7	<0.001
	European	−0.9 ± 0.3		24 ± 11		1	
3	Africanized	0.4 ± 0.6	0.166	15 ± 5	0.363	8	<0.001
	European	1.7 ± 0.6		21 ± 5		1	
4	Africanized	3.2 ± 1.1	0.165	8 ± 2	0.252	3	0.323
	European	5.1 ± 0.8		35 ± 20		2	
5	Africanized	−0.2 ± 0.3	0.824	19 ± 4	0.049	0	0.117
	European	−0.3 ± 0.3		72 ± 29		2	
6	Africanized	1.3 ± 0.6	<0.001	6 ± 2	0.054	7	<0.001
	European	4.5 ± 0.5		17 ± 4		1	

Probability levels following each pair of means are based on t tests (or binomial tests for inspection difficulties).
[a] Bee mortality per colony was assessed with Todd dead bee hive entrance traps.
[b] Inspections difficulties arose because of excessive numbers of running, festooning, or stinging bees.

erage of 4.2 kg while Africanized colonies gained an average of 1.6 kg. Weight losses were similar for the bee types at the two sites that lacked nectar flows. Greater nectar storage by European bees is typical when nectar is abundant (Pesante 1985, Rinderer et al. 1985); thus, surplus honey from target crops that produce much nectar may be less from Africanized colonies.

European colonies had significantly higher rates of adult bee mortality than Africanized colonies at two locations and had numerically higher rates at each site (including the pretest period) (Table 2). These mortality trends may be atypical because three of the Africanized colonies with dead bee traps lost such large portions of their populations that mortality counts were relatively low. Dead pupae were found fairly frequently in traps on these three colonies but were not included in mortality data. During the inspections, four Africanized colonies and six European colonies were noted to have larvae dead with what appeared to be European foulbrood. No other problems with pathogens, pests, or ectoparasites were apparent.

Generally, the simulated pollination program resulted in smaller bee-type differences than expected for most potential problem areas. Still, the tendencies of Africanized colonies to suffer large population losses, to defend the nest excessively, to be difficult to inspect, and to store honey poorly make managing these bees for commercial pollination an unattractive prospect. Also, it is likely that most pollination situations would be less harsh than the rigorous management conditions we developed. Under less stressful conditions, Africanized bees would probably present even greater handling difficulties.

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