

Flight Characteristics of Foraging Africanized and European Honey Bees (Hymenoptera: Apidae)

ROBERT G. DANKA, RICHARD L. HELLMICH II, ANITA M. COLLINS,
THOMAS E. RINDERER, AND VERNON L. WRIGHT¹

Honey-Bee Breeding, Genetics and Physiology Laboratory, USDA-ARS,
Baton Rouge, Louisiana 70820

Purchased by the
United States
Dept. of Agriculture
for official use.

Ann. Entomol. Soc. Am. 83(4): 855-859 (1990)

ABSTRACT Interfloral movement and visitation parameters were quantified for individual Africanized and European honey bees (*Apis mellifera* L.) foraging in a field of sesame. The two bee types showed nearly identical movement and visitation characteristics for most of the parameters measured. Africanized bees spent slightly less time per flower visit ($\bar{x} \pm SD$; 10 ± 4 s versus 12 ± 6 s) and tended to travel at a slightly faster rate (210 ± 150 cm/min versus 180 ± 120 cm/min). The frequencies of visits for various resources differed; Africanized bees collected only pollen on 51% of visits and only nectar on 22% of visits, whereas for European bees, these types of visits each constituted about 38% of the total visits. Both bee types showed a strong tendency to move straight ahead on interfloral moves. The minor differences found in foraging flight characteristics at the level of individual foragers are likely to be insignificant in the context of using Africanized bees as commercial crop pollinators.

KEY WORDS Insecta, Africanized honey bees, *Apis mellifera*, pollination

ANECDOTAL REPORTS abound regarding differences in flight characteristics of Africanized and European honey bees, *Apis mellifera* L. For example, the flight of Africanized foragers is said to be "quicker and more nervous" (Michener 1972, 1975) and "quicker and more erratic" (Winston et al. 1983); similarly, parental African bees also "dart more rapidly" (Smith 1958), tend to "zigzag" (Ruttner 1976), and are "more rapid" (Fletcher 1978) while foraging. Documented quantification of flight patterns would be a useful component in an evaluation of these bees as potential U.S. agroecosystem pollinators. Pollinator movement is a fundamental component of pollen dispersal among plants (Levin & Kerster 1974); relatively quick and erratic flight patterns thus could be expected to enhance efficiency of pollen movement in a crop. With the general goal of evaluating Africanized bees as pollinators, we examined the differences in flight patterns of Africanized and European bees.

Materials and Methods

Movement and visitation rates and resource collection trends were quantified by making direct comparisons of the two bee types while they foraged simultaneously in an agricultural setting. Observations were made 7-17 March 1985 in a 24-ha field of sesame (*Sesamum indicum*) near Acarigua, Venezuela ($10^{\circ}45'N$, $69^{\circ}08'W$). Row spacing in the field was 50 cm, but foliage of plants in adjacent

rows grew as close as 10 cm. A grid of marker flags aided in monitoring bee movements. Honey bees actively visited the plot; sesame is a good source of nectar and pollen for bees (McGregor 1976).

Two colonies each of Africanized and European honey bees were moved to the field to supply foragers for observations, which were made within 80 m of the hives. A feral Africanized population also was present in the area. The European bees used were colored a relatively uniform light yellow and were readily distinguishable in the field from darker, striped Africanized bees. When possible, foragers were captured after observation for later verification of bee type by morphometric analysis (Daly & Balling 1978). Correct classification was found for each of the 44 European and 35 Africanized field-identified foragers that were captured. These bees are deposited as vouchers at the USDA-ARS Honey-Bee Breeding, Genetics and Physiology Laboratory.

Observations consisted of choosing a forager working in the field and watching her for a minimum of three consecutive flower visits. Each series of three visits allowed calculation of the angle between consecutive interfloral moves. Bees were followed until they were lost from view or for a maximum of 3 min. Observations usually were alternated between the two bee types. Forager movements and flower positions were recorded on audio tape in the field. A total of 1,167 flower visits by 118 Africanized foragers and 1,007 flower visits by 101 European foragers was monitored.

Positions of visited flowers were mapped after transcription of audio data. Also transcribed were

¹ Department of Experimental Statistics, Louisiana State University, Baton Rouge, Louisiana 70803.

Table 1. Means (\pm SD) of visitation and movement parameters of Africanized and European honey bees foraging in sesame. Data summarize portions of foraging bouts of 118 Africanized foragers and 101 European foragers monitored near Acarigua, Venezuela, in March 1985

Parameter	Bee type		Prob <i>t</i>
	Africanized	European	
Flowers visited while observed	10 \pm 5	10 \pm 4	NS
Duration of flower visit (s)	10 \pm 4	12 \pm 6	0.005
Duration of interfloral move (s)	5 \pm 2	5 \pm 2	NS
Cm/interfloral move	50 \pm 30	50 \pm 30	NS
Flowers visited/min	5 \pm 1	5 \pm 3	NS
Cm traveled/min ^a	210 \pm 150	180 \pm 120	0.100 ^b
Wandering index ^c	42 \pm 23	40 \pm 22	0.522 ^b
Percentage of visits for:			
Nectar	22	38	0.065 ^d
Nectar and pollen	21	19	0.320 ^d
Pollen	51	37	0.031 ^d
Unsuccessful	6	6	NS

^a Includes both flower visits and interfloral moves.

^b Probability levels for these parameters are based on rank-transformed data.

^c Described in text.

^d χ^2 probabilities; 1-df tests are on counts of first resource collected by the 219 bees observed.

the duration of each visit to a flower, the resources collected, the duration of flight to the next flower, and the distance to the next flower. It was possible to discriminate which resource was being collected on any visit because nectar collectors crawl completely into the corolla, whereas pollen collectors remain on the corolla lip. The resource category was termed unsuccessful if no resources were collected (usually because a bee had difficulty grasping a flower in the wind). Movement information yielded the parameters of flowers visited per minute and centimeters traveled per minute for each bee in all bee type and resource combinations. In addition, a "wandering index" (the quotient of the two movement parameters for each bee; numerically, centimeters traveled per flower visited) was calculated to determine if bees tended to visit relatively few flowers locally or relatively more flowers over greater distances; more wandering is desirable for extensive pollen dispersal. Also noted were forager interactions, which occurred as a second bee landed on a flower already being visited by another bee.

Differences between bee types were evaluated with *t* tests for most parameters. Individual flower visits were treated as samples and used to produce mean values for each forager, from which means for each bee type were calculated. For each interfloral move, the resource category assigned was that of the resource collected during the flower visit immediately preceding the flight. Because centimeters traveled per minute and wandering index were not distributed normally, these parameters were transformed by ranking before analyses were done.

The proportions of flower visits during which only nectar, only pollen, or nectar and pollen were collected were compared by χ^2 analysis (Siegel 1956). Only first visits were analyzed to avoid problems of dependence among observations within

bees; the pattern of resource collection on first visits was very similar to that of all visits.

The change in movement direction within each three-flower-visit sequence for each bee yielded an angle; these angles contributed to a mean angle and an angular deviation (Zar 1974) of movement for each bee type. The likelihood that the samples of angles of the two bee types were of similar distribution was tested by Watson's two-sample *U*² test (Zar 1974). Differences in distributions of interfloral movement rates of the bee types within each resource category were evaluated with Kolmogorov-Smirnov tests (Siegel 1956).

Results

Africanized bees spent slightly less time per flower visit and tended to travel at a slightly faster rate (Table 1). The remainder of movement and visitation parameters were very similar or identical for the two bee types. These are general results pooled over all resource categories; only minor differences likewise were found within each resource category.

The proportions of visits for various resources differed between the bee types (overall $\chi^2_{2,df} = 9.07$; $P = 0.011$; $n = 219$) (Table 1). Africanized bees collected only pollen more than twice as frequently as they collected only nectar, and European bees made these types of visits with similar frequencies. Percentages of visits for both nectar and pollen and unsuccessful visits were similar for the bee types.

Changes in direction were distributed similarly for the bee types ($U^2_{756, 863} = 0.003$, $P > 0.50$) (Fig. 1). The mean angles were closely distributed near 0°; i.e., straight ahead movement ($a_A = 356^\circ$; $a_E = 358^\circ$); this is typical for many bee species on various plants (Waddington & Heinrich 1981). Angular deviations also were similar ($s_A = 72^\circ$; $s_E = 74^\circ$). Both bee types crossed rows on 34% of their moves.

The distributions of interfloral movement rates

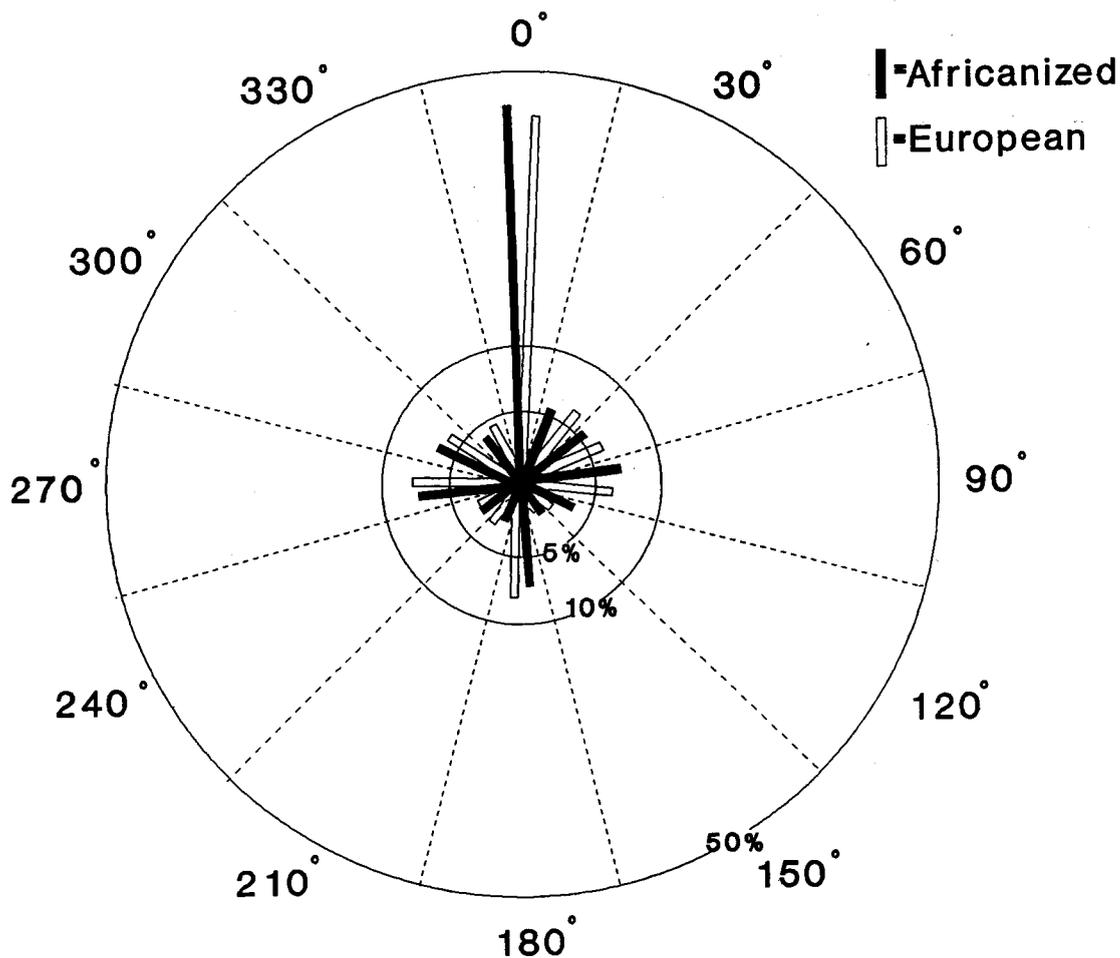


Fig. 1. Distributions of departure angles for interfloral flights by Africanized and European honey bees foraging in a field of sesame. Percentages are of 756 Africanized flights and 863 European flights.

for each resource category showed that slower movement was much more frequent than faster movement (Fig. 2). Differences in movement rate patterns between the bee types appeared to follow differences in resource collection trends. For nectar-only visits, there were more faster working European bees ($P < 0.01$) (European median, 100 cm/min; Africanized median, 60 cm/min). Conversely, more Africanized bees moved faster during pollen-only bouts ($P < 0.01$) (Africanized median, 100 cm/min; European median, 60 cm/min) and when visits were unsuccessful ($P < 0.01$) (Africanized median, 40 cm/min; European median, 20 cm/min).

Interactions between foragers at flowers were noted 28 times. Africanized bees interrupted other bees in 25 of these cases; they were disrupted 10 times but only twice by European bees. Invariably both the interfering bee and the interrupted bee left the flower after contact. In a few extreme cases, Africanized bees were notably more aggressive in their actions; they bit and pulled European foragers

out of the blossoms in which the Europeans had been working. Such aggression was exhibited only very rarely by Africanized bees foraging together with various *Meliponini* on artificial nectar sources (Roubik 1980) and with polybiine wasps on flowers (Roubik 1981).

Discussion

The minor differences found in foraging flight characteristics are probably insignificant in the overall context of using Africanized bees as commercial crop pollinators. There is no known reason to expect that the minor differences in flight patterns of Africanized and European bees as measured on sesame would differ substantially on other crops (e.g., tree crops, nonrow forage crops, or crops yielding better or poorer resource rewards). Although Africanized foragers sometimes did appear to be slightly more darting (and sensitive to disturbance) on interfloral flights than European bees were (personal observation), this heightened activ-

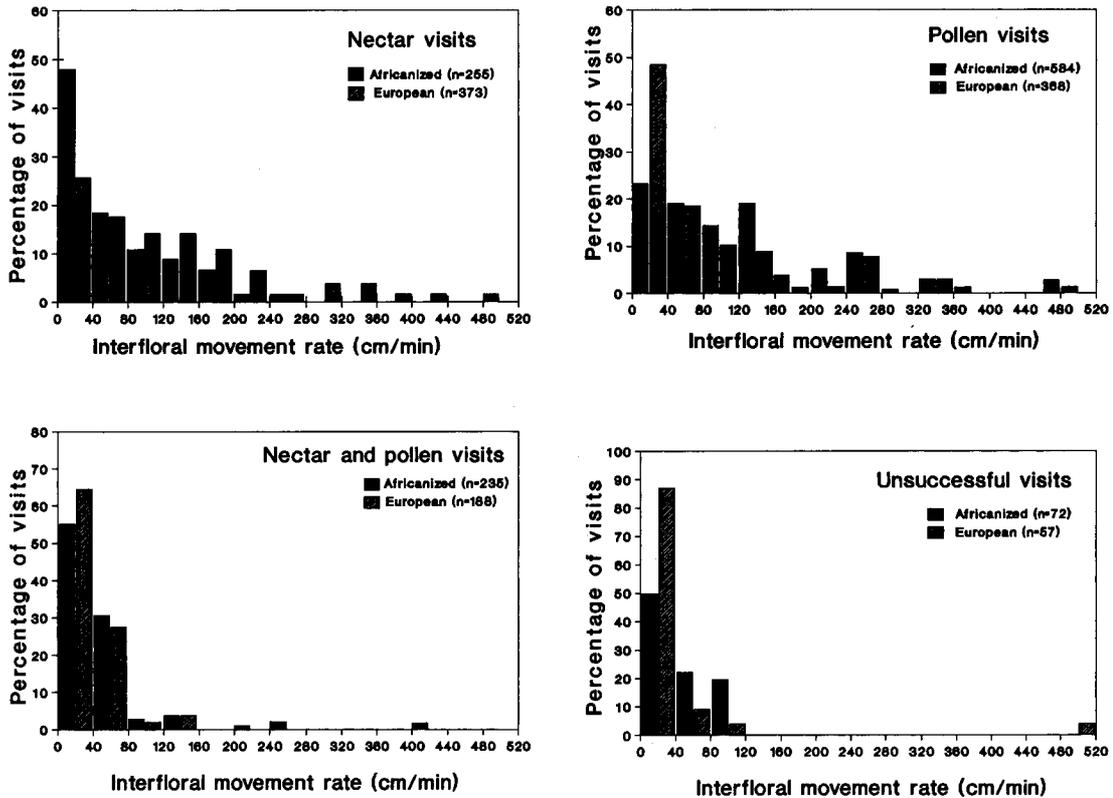


Fig. 2. Distributions of interfloral movement rates of Africanized and European honey bees foraging in sesame. Resource classification of each flight is based on the resource collected during the preceding flower visit.

ity generally was not manifested in the parameters used to quantify pollination-related behavior (Table 1); such activity might be better described by other flight measures.

Perhaps the most significant aspect of Africanized bee foraging behavior with regard to crop pollination is the high proportion of visits made for pollen. Pollen-collecting bees are usually better pollinators because they often are well dusted with pollen after active contact with anthers (Free 1970). Thus the propensity of Africanized colonies to devote more foraging effort to collecting pollen (as noted in this and in previous studies [Danka et al. 1987b, Pesante et al. 1987]) offers a potentially valuable trait to incorporate into breeding schemes focussed on creating effective pollinators. Given the absence of large differences in foraging flight characteristics, however, the most important aspect of using Africanized bees commercially for crop pollination is likely to be a variety of disagreeable responses to pollination management, most significant of which are population losses and stinging (Danka et al. 1987a).

Acknowledgment

Excellent technical assistance was provided by Roberto Colmenares, Alcides Escalona, Sandra Kleinpeter, J.

Anthony Stelzer, and Daniel Winfrey. Deborah Boykin and Steven Buco gave extensive statistical advice. This work was completed in cooperation with the Louisiana State Agricultural Experiment Station and the Universidad Centro Occidental 'Lisandro Alvarado,' Barquisimeto, Venezuela.

References Cited

- Daly, H. V. & S. S. Balling. 1978. Identification of Africanized honeybees in the Western Hemisphere by discriminant analysis. *J. Kans. Entomol. Soc.* 51: 857-869.
- Danka, R. G., T. E. Rinderer, A. M. Collins & R. L. Hellmich II. 1987a. Responses of Africanized honey bees (Hymenoptera: Apidae) to pollination-management stress. *J. Econ. Entomol.* 80: 621-624.
- Danka, R. G., R. L. Hellmich II, T. E. Rinderer & A. M. Collins. 1987b. Diet-selection ecology of tropically and temperately adapted honey bees. *Anim. Behav.* 35: 1858-1863.
- Fletcher, D. J. C. 1978. The African bee, *Apis mellifera adansonii*, in Africa. *Annu. Rev. Entomol.* 23: 151-171.
- Free, J. B. 1970. *Insect pollination of crops*. Academic, London.
- Levin, D. A. & H. W. Kerster. 1974. Gene flow in seed plants. *Evol. Biol.* 7: 139-220.
- McGregor, S. E. 1976. *Insect pollination of cultivated crop plants*. USDA Handbook 496.

- Michener, C. D. 1972.** The final report of the committee on the African honey bee. National Technical Information Service, Springfield, Va.
- 1975.** The Brazilian bee problem. *Annu. Rev. Entomol.* 20: 399-416.
- Pesante, D. G., T. E. Rinderer & A. M. Collins. 1987.** Differential pollen collection by Africanized and European honeybees in Venezuela. *J. Apic. Res.* 26: 24-29.
- Roubik, D. W. 1980.** Foraging behavior of competing Africanized honeybees and stingless bees. *Ecology* 61: 836-845.
- 1981.** Comparative foraging behavior of *Apis mellifera* and *Trigona corvina* (Hymenoptera: Apidae) on *Baltimora mora* (Compositae). *Rev. Biol. Trop.* 29: 177-183.
- Ruttner, F. 1976.** Honeybees of the tropics: their variety and characteristics of importance for apiculture, pp. 41-46. *In* E. Crane [ed.], *Apiculture in tropical climates*. International Bee Research Association, London.
- Siegel, S. 1956.** *Nonparametric statistics for the behavioral sciences*. McGraw-Hill, New York.
- Smith, F. G. 1958.** The honeybees of the tropics. *Indian Bee J.* 20: 108-112 (cited in Fletcher 1978).
- Waddington, K. D. & B. Heinrich. 1981.** Patterns of movement and floral choice by foraging bees, pp. 215-230. *In* A. C. Kamil & T. D. Sargent [eds.], *Foraging behavior: ecological, ethological and physiological approaches*. Garland, New York.
- Winston, M. L., O. R. Taylor & G. W. Otis. 1983.** Some differences between temperate European and tropical African and South American honeybees. *Bee World* 64: 12-21.
- Zar, J. H. 1974.** *Biostatistical analysis*. Prentice-Hall, Englewood Cliffs, N.J.

Received for publication 12 June 1989; accepted 11 January 1990.