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DIFFERENTIAL POLLEN COLLECTION BY AFRICANIZED AND EUROPEAN HONEYBEES IN VENEZUELA

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Summary

A study of pollen collection by Africanized and European honeybees was conducted in Venezuela. Among the Africanized honeybees a larger proportion of the foraging force foraged for pollen, thus collecting significantly larger quantities of pollen. The larger pollen supply would provide the protein necessary to support increased brood production, thereby increasing the opportunities for Africanized honeybee colonies to cast multiple swarms.

Introduction

Africanized honeybees, descendants of the African honeybee *Apis mellifera scutellata* (formerly, *A. m. adansoni*; Ruttner, 1976) have dispersed and established populations throughout South and much of Central America. In the process they have displaced the European honeybee, chiefly *A. m. ligustica*. Such success is attributed in part to the capacity of the Africanized honeybee to cast multiple swarms (Winston, 1978; Otis, 1980).

Pollen is the main source of protein and lipid for honeybees, and is essential for brood rearing (Dietz, 1975). If Africanized honeybees produce more brood and have higher swarming rates than European honeybees, they should also be found to collect more pollen.

We compared pollen collection in Africanized and European honeybees. Specific questions asked were (1) do Africanized and European honeybees differ in numbers of pollen forages? and (2) do individual pollen forages of each geographical type* or form collect similar amounts of pollen?

Materials and Methods

The experiments were conducted 6 km southwest of Sarare, Venezuela. The floral resources available to the experimental honeybees were those of a deciduous, lowland, wet/dry forest, surrounded by patches of secondary successional grassland.

Two apiaries, one Africanized (AF) and the other European (EU), each with 20 colonies, were located 50 m from each other. Two different management strategies were employed in the study to provide an Africanized apiary with 10 equalized and 10 non-equalized colonies and a European apiary with 10 equalized and 10 non-equalized colonies. In one strategy 10 of 20 colonies of a geographical type were randomly chosen and equalized once a month throughout the experimental period. This involved lifting each frame in the colony and estimating, to the nearest sixteenth part of the frame, the amount of capped brood and adult bees present. The mean population size for equalized colonies of each geographical type was calculated and the population of each colony adjusted to the corresponding mean value by adding or removing frames of brood and bees. Corrections for the smaller size of the Africanized honeybee were incorporated into the estimates, yielding colonies with similar

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*Africanized honeybees are descendants of *Apis mellifera scutellata* imported from Africa and their hybrids with the various subspecies previously imported into Brazil. The European honeybees used in this study were from North America. The ancestry of such honeybees includes representatives of several subspecies. Neither of the honeybees constitutes a subspecies or a race, so their population will be designated 'geographical type' or 'form'. to indicate that the bees show major characteristics typical of adaptation to temperate or tropical regions.

populations of Africanized or European honeybees. The non-equalized colonies of each geographical type were left to expand their nests at their natural rate. This procedure allowed for the effective comparison of pollen collection between and within geographical types under conditions of similar and dissimilar colony populations.

On each day of the experiment, 30 foragers were collected from each of five Africanized and five European colonies per apiary and their pollen loads examined. Sampling order for colonies within a geographical type was random. Remaining colonies were sampled on successive days.

From 06.45 to 06.50 (h.min) the entrances of the colonies were closed with entrance blocks, and foraging bees that were back by 07.00–07.05 were collected using hollow cylinders provided with a top and with a plastic bag attached to the bottom. Once in the cylinder, honeybees would fly towards the sun and into the collecting bag. When approximately 30 honeybees per colony had been collected, the bags were removed from the cylinder and placed in a cooler with ice to reduce their metabolic activity and hence movement and possible loss of the pollen load.

At the laboratory, 30 foragers were chosen at random. Foragers were sorted according to whether they collected pollen, pollen and nectar or pollen and water or were not carrying anything. Nectar and water loads were distinguished using a hand-held refractometer; readings higher than 5% solids were considered to indicate nectar. Pollen was removed from the corbicula with tweezers, pooled for the colony and dried in an oven for 72 h at 60°C. Its weight was then recorded to the nearest mg using an electronic balance.

The same collecting procedure was repeated each day for four days until all 40 colonies were tested. Each four-day test constituted a trial. Each trial was repeated once a week during the last three weeks of each month. The study lasted from 7 March 1983 through 31 January 1984. Data were averaged over months to compare rainy (April-September) *vs* dry season (October-March). A total of 618 samples per geographical type (30 bees per sample) were included in the statistical analysis. The variables used to test the null hypothesis between geographical types were (1) total numbers of pollen foragers and (2) mean mass of pollen per pollen forager.

Analysis of variance procedures (ANOVA) were performed on the data in a completely randomized design with a 2 × 2 × 2 factorial treatment arrangement of geographical type, management strategy and season.

Results

Management strategy (Eq)

As significant differences in numbers of pollen foragers from equalized *vs* non-equalized colonies for geographical type and seasons were not observed during the study (Table 1, Table 3), it was concluded that differences in population size did not affect pollen foraging.

TABLE 1. ANOVA procedure for numbers of sampled honeybees foraging for pollen at Sarare, Venezuela, by geographical type, Geo-type (Africanized or European); management strategy, Eq (equalized or non-equalized colonies); and season (dry or rainy).

Source	*df*	*F*	*P*
Season	1	7·11	0·0090*
Eq	1	0·05	0·8262
Season × Eq	1	1·33	0·2514
Geo-type	1	133·13	0·0001*
Season × Geo-type	1	6·02	0·0159*
Eq × Geo-type	1	0·67	0·4159
Season × Eq × Geo-type	1	0·50	0·4830
Error	98		

* Significant at the 5% level.

Pollen foragers

Among Africanized honeybees twice as many foragers returned to the colony with pollen (for AF, $\bar{x} \pm SE = 15{\cdot}17 \pm 2{\cdot}26$; for EU, $\bar{x} = 7{\cdot}95 \pm 0{\cdot}09$). A significant interaction ($P<0{\cdot}0159$) occurred between season and geographical type (Table 1) because numbers of Africanized pollen foragers were significantly greater for the dry season, whereas for European honeybees seasonal differences were non-significant (Table 2).

Pollen foragers fell into three general categories: (1) pollen foragers that collected pollen only, (2) pollen foragers that also collected nectar and (3) pollen foragers that also collected water. The largest fraction of the pollen foragers foraged for pollen only (Fig. 1). Significant geographical type differences were detected ($P<0{\cdot}0001$) as a result of samples of Africanized honeybees having higher numbers of foragers that collected pollen only (for AF, $\bar{x} = 10{\cdot}05 \pm 0{\cdot}33$; for EU, $\bar{x} = 4{\cdot}99 \pm 0{\cdot}33$). Significant seasonal differences ($P<0{\cdot}0001$) were detected as a result of samples of both types of honeybee colonies containing larger numbers of foragers returning with pollen only in the rainy season ($\bar{x} = 10{\cdot}01 \pm 0{\cdot}27$) and reduced numbers in the dry season ($\bar{x} = 5{\cdot}03 \pm 0{\cdot}38$).

TABLE 2. Mean numbers of sampled foragers of Africaned (AF) and European (EU) honeybees foraging for pollen at Sarare, Venezuela, for the rainy season (April-September) and the dry season (October-March).
Means followed by the same letter are not significantly different.

Geographical type	*Season*	
	Dry	*Rainy*
AF	16·77 ± 0·72*a*	13·57 ± 0·51*b*
EU	8·01 ± 0·72*c*	7·88 ± 0·51*c*

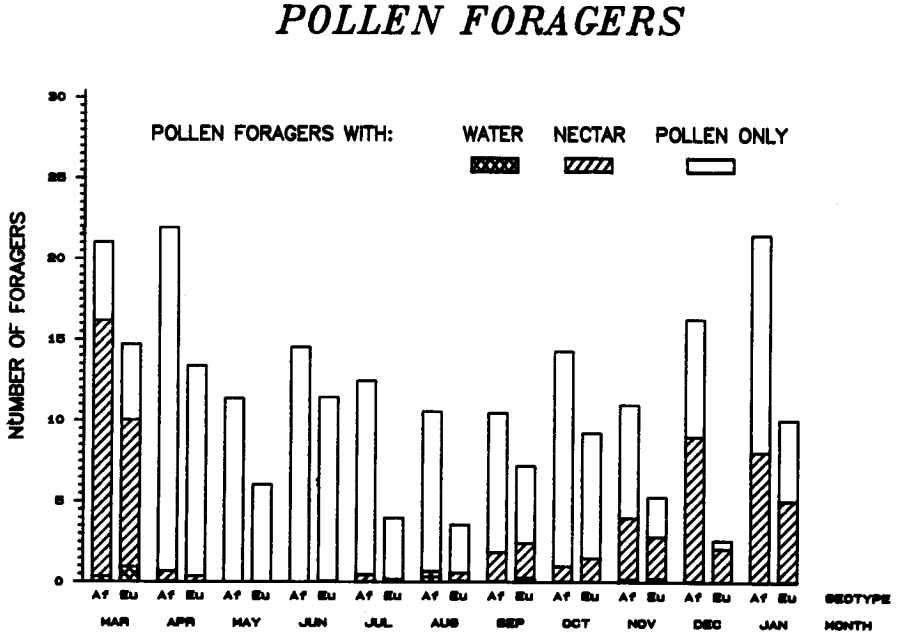

FIG. 1. Mean monthly numbers (out of sample of 30) of Africanized (AF) and European (EU) honeybees foraging for pollen only, for pollen and nectar and for pollen and water at Sarare, Venezuela, from March 1983 through January 1984.

Pollen foragers that also collected nectar were second in numbers to foragers that collected pollen only, and were observed mostly during nectar flow. In the rainy season, when no nectar was available, significant differences due to geographical type were not observed ($P<0{\cdot}7789$), significant differences between geographical type were ($P<0{\cdot}0001$). Once the nectar flow began, samples of pollen foragers from Africanized colonies included higher numbers that also collected nectar ($\bar{x} = 9{\cdot}41 \pm 0{\cdot}42$) than samples from European colonies ($\bar{x} = 4{\cdot}75 \pm 0{\cdot}42$). Non-significant differences with geographical type were observed in the rainy season (for AF, $\bar{x} = 0{\cdot}61 \pm 0{\cdot}29$ and for EU, $\bar{x} = 0{\cdot}72 \pm 0{\cdot}29$), contributing to the significant season × geographical-type interaction ($P<0{\cdot}0001$).

Average mass of pollen per successful pollen forager

When the average mass of pollen carried by a successful forager was considered, differences between geographical types ($P<0{\cdot}7991$) were not significant (Table 3). Seasonal differences were significant ($P<0{\cdot}0021$) as a result of successful foragers of both types collecting larger pollen loads during the dry season (Table 4). It was concluded that individual pollen foragers of the two geographical types collected on the average the same amount of pollen during a foraging trip.

TABLE 3. ANOVA procedure for average mass (mg) of pollen carried by a honeybee by geographical type, management strategy and season at Sarare, Venezuela.
Abbreviations as for Table 1.

Source	*df*	*F*	*P*
Season	1	10·03	0·0021*
Eq	1	0·07	0·7944
Season × Eq	1	1·13	0·2900
Geo-type	1	0·07	0·7991
Season × Geo-type	1	0·48	0·4916
Eq × Geo-type	1	0·01	0·9032
Season × Eq × Geo-type	1	0·89	0·3491
Error	98		

* Significant at the 5% level.

TABLE 4. Average mass (mg) of pollen carried by individual Africanized (AF) and European (EU) honey bees during the rainy season (April-September) and the dry season (October-March) near Sarare, Venezuela.
Means followed by the same letter are not significantly different.

Geographical type	*Season*	
	Dry	*Rainy*
AF	4·4 ± 0·3*a*	3·8 ± 0·2*b*
EU	4·6 ± 0·3*a*	3·7 ± 0·2*b*

Discussion

In our experiments Africanized honeybees collected more pollen than European honeybees. Danka (unpublished data) observed, in a study conducted at the same site, that at 07.00 h.min numbers of foragers of both geographical types were significantly greater than at other times of the day, and that throughout the day Africanized pollen foragers were consistently higher in

numbers than European pollen foragers. Comparisons of pollen collection by the two geographical types based on our sampling at 07.00 h.min, therefore, are fair and unbiased. Africanized honeybees also exhibit an unusually high swarming rate (Otis, 1977; Winston, 1979). This higher swarming rate has been considered to be a major factor contributing to the successful spread of Africanized honeybees through the Americas.

Increased pollen collection may be a major supporting mechanism underlying the increased swarm production by Africanized honeybees. If a colony is to increase its reproductive output by producing more swarms and after-swarms in a season, it needs extra protein to provide the bees for such swarms. Increasing the collection of pollen assures the necessary protein (and lipids) to meet the nutritional demands of increased brood rearing, and in turn to provide sufficient numbers of bees to increase swarming rates. Winston (1978) observed large amounts of brood just prior to swarming and absconding in Africanized colonies in French Guiana. Incorporation of pollen into the honeybee diet has been found to result in increased brood production (Sheesley & Poduska, 1968, Standifer et al., 1970; Kulinčević et al., 1982*a*). Kulinčević et al. (1982*b*) reported reductions in brood production for honeybee colonies provided with inadequate protein sources.

For both types of honeybees the lowest number of foragers was observed during the rainy season. These trends correspond with seasonal fluctuations in floral resources in the tropics (Roubik, 1979; Augspurger, 1983). Not only are floral resources less abundant during the rainy season, but their presence is no guarantee that pollen is available. Nonetheless, even under the most adverse conditions of the rainy season, Africanized honeybees consistently had larger numbers of foragers returning to the colony with pollen.

A curious point was the observation of pollen foragers that also were engaged in collecting water. At 07.00 h.min it is most likely that the water was being utilized for dilution of honey for use in feeding larva and not for temperature control of the nest, as the temperature at this time is about 23°C, even during the hot, dry season. Samples of Africanized foragers contained fewer pollen foragers that also collected water in the dry season ($\bar{x} = 0{\cdot}25 \pm 0{\cdot}08$) and the rainy season ($\bar{x} = 0{\cdot}12 \pm 0{\cdot}06$). By comparison, samples of European foragers contained $0{\cdot}71 \pm 0{\cdot}08$ bees returning with pollen and water in the dry season and $0{\cdot}49 \pm 0{\cdot}06$ in the rainy season.

Since Africanized honeybees had a higher proportion of foragers collecting pollen, they could be better pollinators than European honeybees. However, before this conclusion can be reached, more complex studies are needed. Such studies must consider the effects on the commercial pollination of agricultural crops of the defensive, swarming and absconding behaviour of Africanized honeybees and the populations of feral bees.

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