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

In Press with

Annals of the Entomological Society of America
Lorraine Gilbert, Managing Editor

Honey Bee Characters That Aid Pollination

A condensation of "Variation in Honey Bee Morphology, Behavior, and Seed Set in White Clover" by T. E. Rinderer, B. G. Harville, J. J. Lackett, and J. R. Baxter to be published this fall in *Annals of the Entomological Society of America*. Rinderer, Lackett, and Baxter are with the Bee Breeding and Stock Center Laboratory, Agricultural Research Service, Science and Education Administration, U.S. Department of Agriculture, Baton Rouge, LA 70808. Harville is with the Department of Agronomy, Louisiana State Agricultural Experiment Station of Louisiana State University, Baton Rouge, LA 70803.

Several morphological and behavioral characteristics of honey bees, (*Apis mellifera*, L.) contribute to their efficiency as pollinators. Martin (1975) listed branched hairs, pollen baskets (corbiculae), specialized mouth parts, a crop modified for nectar transport, nests with storage areas, and specific behavioral characteristics associated with pollen and nectar collection. One such behavioral characteristic is the intensity of body movement (scrabbing behavior) associated with foraging for pollen (Free 1970). Possibly these and other characteristics vary among bees. In this study, we determined the variability of several bee characteristics and their correlation with the bees' pollination effectiveness on white clover (*Trifolium repens* L. var. Louisiana S-1).

Twenty-four honey bee colonies were used in the study, each composed of workers from a single mating of a drone and queen. The worker bees, therefore, were highly related (r = 0.75). All queens and drones were reared from different colonies. Each colony contained the appropriate queen, about 1 kg of workers, and equal amounts of brood and stored food. Each colony was placed in a screened cage (2.75 × 3.65 × 1.98 m) in a field of white clover.

Before placing the colonies in the cages, 50 immature clover flower heads in each cage were individually tagged and covered with glassine bags. An area of one square meter was marked in each plot for future observation. New plots were

TABLE 1. Means, standard errors, ranges and results of analyses of variance (P indicates significance of differences among colonies) for 12 measurements of honey bees from 24 colonies caged over white clover plots.

Colony Characteristic	$\bar{X}$ ± S.E.	Range	P
Seeds set/flower head (SS)	51.4 ± 8.3	31.1 – 85.1	0.0001
Flower heads visited in 2 min. (FV)	9.2 ± 0.9	7.0 – 11.0	0.0001
Bee entering 1 m^2 in 10 min. (BE)	39.8 ± 3.2	1.6 – 75.4	0.0001
Percentage of flower head covered during visit (PC)	38.0 ± 5.6	27.5 – 51.6	0.0001
Duration of visit (sec.) (DV)	12.3 ± 2.7	8.0 – 16.7	0.1033
Intensity of movement during visit (IM)	1.9 ± 0.1	1.4 – 2.7	0.0001
Hair length on tibia (mm) (HT)	0.60 ± 0.02	0.44 – 0.81	0.0001
Hair length on basitarsus (mm) (HB)	0.48 ± 0.02	0.29 – 0.68	0.0001
Width of basitarsus (mm) (WB)	1.08 ± 0.02	1.00 – 1.15	0.0994
Length of basitarsus (mm) (LB)	1.69 ± 0.04	0.94 – 2.30	0.0001
Length of tongue (mm) (LT)	5.77 ± 0.11	4.86 – 6.38	0.0001
Hair density (no./mm^2) (HD)	84.3 ± 2.8	60.5 – 106.3	0.0001

TABLE 2. Correlation coefficients of 12 measurements of honey bees from 24 colonies caged over white clover plots.*

	FV	BE	PC	DV	IM	HT	HB	WB	LB	LT	HD
SS	0.303§†	0.201‡	0.050	−0.001	0.249‡	0.315	0.271	0.013	−0.261	−0.264	0.058
	70	70	70	70	70	22	22	22	22	22	22
FV		0.351§	−0.114	−0.131	0.213	0.471‡	0.391	0.081	−0.272	−0.149	0.097
		70	70	70	70	22	22	22	22	22	22
BE			0.034	0.047	0.193	0.018	0.182	−0.045	−0.131	−0.055	−0.040
			70	70	70	22	22	22	22	22	22
PC				0.700§	0.342§	0.133	0.248	−0.111	−0.253	−0.050	−0.035
				1068	70	22	22	22	22	22	22
DV					0.250§	0.255	0.055	−0.122	−0.150	0.070	0.233
					1068	22	22	22	22	22	22
IM						0.267	0.261	−0.086	−0.204	0.041	−0.167
						22	22	22	22	22	22
HT							0.612§	0.057	−0.594§	−0.179§	−0.003
							238	238	238	238	238
HB								0.013	−0.760§	−0.140‡	−0.108
								238	238	238	22
WB									0.089	0.372§	−0.064
									238	238	238
LB										0.241§	0.112
										238	238
LT											0.180
											238

*measurement codes are explained in Table 1. †correlation coefficient, d. f. ‡$P < 0.05$, §$P < 0.01$

used for each of three replications. After the flower heads had been covered for approximately 5 days, the bags were removed and the bees allowed to work the heads for 30 min. Then flower heads were re-covered.

The foraging behavior of 15 bees was observed for 5 characteristics (Table 1). After the behavioral portion of the study was completed, tagged flowers were grown to maturity, harvested, and seeds from each head counted. Also, 10 bees from each colony were collected and examined for 6 morphological characteristics (Table 1).

Data collected were analyzed using standard analysis of variance procedures. Correlation coefficients were calculated among the characteristics. Significant differences were found among colonies for most measurements of bees, including the number of seeds set per flower head (Table 1). Three characteristics (flower heads visited in 2 min, number of bees entering a 1 m^2 plot in 10 min, and the intensity of motion when bees were on the flower heads) were weakly, but significantly, correlated to seed set (Table 2).

The observed significant variation among colonies for almost all characteristics measured indicates that these characteristics could be changed by selective breeding. Since all measurements were made under similar environmental conditions, large portions of the observed variation probably have a genetic basis. Furthermore, the measurements of the characteristics were normally distributed, which suggests that the characteristics are influenced by polygenic systems.

The low correlations between the measured honey bee characteristics and seed set show that no one characteristic is a superior candidate for improving bees' pollination ability through selective breeding. However, single bee-single flower studies should be undertaken to clarify the relationships we have identified. Such work might show how several such characteristics could be collected into a selection index (Rinderer 1977) to provide a sound basis for improving pollination ability through selective breeding.

REFERENCES CITED

Free, J. B. 1970. *Insect pollination of crops*. Academic Press, Inc. London.

Martin, E. C. 1975. The use of bees for crop pollination. Pages 576–613 in Dadant and Sons ed. *The hive and the honey bee*. Dadant and Sons, Hamilton, IL.

Rinderer, T. E. 1977. A new approach to honey bee breeding at the Baton Rouge USDA Lab. *Am. Bee J.* 117: 146–147.