Maximal Stimulation by Comb of Honey Bee[1] (*Apis mellifera*) Hoarding Behavior[2]

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ABSTRACT

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Honey bees, *Apis mellifera* L., in laboratory cages were supplied with from 46.75 to 280.55 cm^2 of comb surface area (CSA). Bees with more CSA hoarded more sucrose solution ($P < 0.01$). The regression of CSA and food storage was linear within the range of 46 to 280 cm^2 CSA ($P < 0.001$). In a second experiment, amounts hoarded by bees with 280.55 or 420.80 cm^2 of CSA were not significantly different. Consequently, maximal stimulation of hoarding under laboratory conditions resulted from exposure to ca. 280 cm^2 or more of CSA.

Hoarding behavior of the honey bee, *Apis mellifera* L., in laboratory cages (Free and Williams 1972, Kulinčević and Rothenbuhler 1973) is related to honey production by field colonies (Kulinčević et al. 1974, Kulinčević and Rothenbuhler 1973). Increased amounts of empty comb increased both hoarding in laboratory cages and honey production in field colonies (Rinderer and Baxter 1978a, 1980), and empty comb in a honey bee nest strongly influences honey bee nectar harvesting. A more complete evaluation of the influence of empty comb requires information on maximal or optimal levels of hoarding that result from comb stimulation. This experiment was designed to supply that information.

Materials and Methods

Laboratory hoarding cages (Kulinčević et al. 1973), 25.5 cm high, were fitted with one to six pieces of comb, resulting in cages containing 46.75, 93.50, 140.25, 187.00, 233.75, or 280.55 cm^2 of comb surface area (CSA). Each cage was supplied with a feeder containing 50% (wt/wt) sucrose in water solution; a second feeder contained water; a third contained a pollen substitute (Rinderer and Elliott 1977).

Combs of emerging brood obtained from seven colonies were held in an incubator (35°C, 50% relative humidity [RH]) until the bees were 0 to 24 h old. In a first experiment, using 168 cages, bees from each of the seven colonies were placed into four of each of the six types of cages. In a second experiment, using 56 cages, bees from each of the seven colonies were placed in four cages with 280.55 cm^2 (six pieces) of CSA and four cages with 420.80 cm^2 (nine pieces) of CSA. All cages received 30 bees (Rinderer and Baxter 1978b).

After the hoarding cages were stocked with the bees, they were placed in an incubator (35°C, 50% RH). Each cage was inspected daily for 7 days, the amount of sucrose solution removed from the feeders was measured, and all feeders were replenished. Data on the amount of sucrose solution removed were submitted to analyses of variance and, where appropriate, an analysis of regression.

Results

In the first experiment, different surface areas of comb resulted in different hoarding rates ($P < 0.01$) (Table 1). Bees from all seven colonies responded similarly. Regression analysis showed a positive linear relationship between CSA and the amount of sucrose solution hoarded ($P < 0.001$). The regression had a slope of 1.02 ± 0.13 ml (SE) of hoarded solution per comb piece. The correlation coefficient was 0.97 ($P < 0.01$).

In the second experiment, six and nine pieces of comb resulted in insignificantly different hoarding rates (Table 1). Again, bees from all seven colonies responded similarly. The 19.5 ml hoarded per cage by bees with nine pieces of comb (280 cm^2 CSA) was 0.6 ml greater than the 18.9 ml hoarded per cage by bees with six pieces of comb (420 cm^2 CSA) and 2.6 ml less than the 22.1 ml predicted for cages with nine pieces of comb from the regression analysis of data from experiment 1.

Discussion

These results indicate that bees hoard more rapidly with greater amounts of available empty comb but that the effect has an upper limit. In laboratory cages the greatest stimulation to hoard occurs in cages with ca. 280 cm^2 CSA.

A strong field colony having a similar bee-to-comb-area ratio would require a ca. 840-liter cavity to contain the comb. This direct conversion of the data to a field situation is probably unreliable. Nevertheless, the data suggest that the highest levels of nectar harvesting stimulation may result from amounts of comb in excess of the amounts normally used in commercially managed hives. Rinderer and Baxter (1978a) have observed that increased amounts of comb increase honey production by bees in hives of up to 320 liters. This size is near the limit for practical commercial management.

Although feral colonies of honey bees occasionally occupy large cavities, most feral colonies with evolutionary origins in temperate climates select and occupy smaller cavities with a volume of ca. 40 liters (Seeley 1977, Seeley and Morse 1976), whereas

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Table 1.–Laboratory hoarding of sucrose solution by bees provided with several different surface areas of empty comb (30 bees in each of four cages for each of seven colonies and each amount of comb)

Expt. No.	Empty comb		Sucrose solution (ml) hoarded ($\bar{x}$ ± SE)[a]
	No. of pieces	Total area (cm^2)	
1	1	46.75	13.9 ± 0.45a*
	2	93.50	14.9 ± 0.45abc
	3	140.25	16.5 ± 0.38bc
	4	187.00	16.1 ± 0.60acd
	5	233.75	18.1 ± 0.47de
	6	280.55	19.2 ± 0.55e
2	6	280.55	18.9 ± 0.40**
	9	420.80	19.5 ± 0.43**

*, Numbers not followed by common letters are significantly different ($P < 0.05$) as measured by LSD tests; **, not significantly different.

those that evolved in the tropics select somewhat larger cavities, ca. 80 liters (Rinderer et al. 1981). Such small cavities can only contain amounts of comb well below the amounts that result in maximal nectar harvesting. This suggests that nectar harvesting by bees is regulated through physiological events influenced by empty comb and by other, as yet unidentified, factors. These other factors perhaps raise nectar harvesting activities to levels above those normally achieved by empty comb. If this is true, these other factors are likely to be related to emergency situations in which unusually intense nectar foraging is appropriate for colony survival.

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