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HONEY BEE HOARDING BEHAVIOUR: EFFECTS OF PREVIOUS STIMULATION BY EMPTY COMB

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Abstract. Hoarding experiments were performed utilizing the transfer of honey bees (*Apis mellifera*) from cages with large or small amounts of empty honeycomb to cages with equal, greater, or lesser amounts. Results confirmed that empty comb stimulates hoarding. Furthermore, bees that were transferred from a small to a greater amount of comb hoarded significantly more than control bees, indicating that stimulus deprivation followed by stimulus enrichment increases the strength of the hoarding response.

Honey bee (*Apis mellifera*) nectar-hoarding behaviour has been hypothesized to be stimulated by empty comb (Rinderer & Baxter 1978). This hypothesis was based on laboratory experiments utilizing bees caged with pieces of comb having either 46·75, 93·5, or 140·25 cm^2 of surface area. The amount of sucrose solution removed from a feeding vial per bee per day was used to measure hoarding rate (see also Kulinčević & Rothenbuhler 1973; Kulinčević et al. 1974). The removed sucrose solution is stored in comb cells except for a very small portion used as food. An experiment conducted with field colonies provided further support for the comb stimulation hypothesis (Rinderer & Baxter 1978).

To further test the comb stimulation hypothesis, the experiments reported here were conducted. They were based on the thought that if empty comb does stimulate hoarding behaviour, then bees transferred from one level of empty comb surface area to another would show predictable changes in their hoarding behaviour.

Materials and Methods

Adult worker bees, 0 to 24 h old, from three colonies of an open-mated commercial stock were collected after they emerged from brood combs held in a 35 C incubator. These bees were placed by groups of 50 (either 16 or 17 from each source colony) into 24 hoarding cages similar to those described by Kulinčević et al. (1973). Bees in 12 cages were supplied with one piece of dark comb (46·75 cm^2 of surface area) and those in 12 other cages were supplied with three pieces (140·25 cm^2) (Rinderer & Baxter 1978). These combs provided a place for the bees to store 50% (by weight) sucrose solution supplied in a gravity feeder vial.

The cages of bees were placed in an incubator at 35 C and 50% relative humidity and inspected daily. Removal of sucrose solution from the feeder vial was recorded. Observations were made for three full days of hoarding. After the three days, the numbers of comb cells used for storage were also recorded.

The bees were then transferred to freshly prepared cages. Four classes of transfers were made: from cages with three combs to cages with three combs (3–3), from three combs to one comb (3–1), from one comb to three combs (1–3), and from one comb to one comb (1–1). These transfers were made by hand, after the bees had been chilled for 10 to 20 min in a −20 C freezer. After transfer, the bees in the fresh hoarding cages were returned to the incubator, and further hoarding observations were made for four additional days.

Two complete replications of this procedure were carried out with bees from two different sets of source colonies. Hoarding data, expressed as millilitres of sucrose solution removed from the feeder per cage for each of the two test periods and the numbers of comb cells used for storage, were analysed separately with analyses of variance and least significant difference tests.

Results

Before transfer, the bees with three pieces of comb hoarded more sucrose solution than the bees with one piece ($P < 0{\cdot}01$) and used almost twice as many cells for storage ($P < 0{\cdot}01$) (Table I). While the percentage of total cells used for the storage of sugar syrup by those bees with one comb was greater than the percentage of cells used for storage by those bees with three combs ($P < 0{\cdot}01$), more than 90% of the cells remained empty in both cases.

On the basis of millilitres of sucrose solution consumed, bees transferred to three pieces of comb hoarded more than those bees transferred to one (Table II). Bees in treatment group 1–3 hoarded more sucrose solution than bees in any other treatment group ($P < 0.05$). Bees in group 3–3 continued a relatively high rate of hoarding. The hoarding of group 3–3 was numerically but not statistically higher than that of bees in group 3–1, and it was statistically higher ($P < 0.05$) than that of group 1–1 bees. Group 3–1 bees hoarded numerically but not significantly more than group 1–1 bees.

The numerical trend of the number of comb cells used for storage of the sucrose solution followed the numerical trend seen with millilitres of consumption. Both groups of bees transferred to three combs used more comb cells for storage of sucrose solution than bees of either group transferred to one comb ($P < 0.05$). In all cases the percentage of cells with stored sucrose solution indicates that ample storage space remained at the end of the experiments.

Discussion

Overall, the results of these experiments are consistent with the hypothesis that empty comb stimulates hoarding behaviour. The data collected before bees were transferred are similar to the data reported by Rinderer & Baxter (1978) even though different sources of bees were used. Furthermore, the transfer of bees from high or low amounts of comb resulted in a raising or lowering of the hoarding rate that would be predicted based on the comb-stimulation hypothesis.

The results of the experiments also suggest the hypothesis that past experience with comb affects hoarding behaviour. Bees in group 3–1 tended to hoard (numerically although not statistically) more than bees in group 1–1. This may indicate a small time lag of response to stimulus generated by any number of possible mechanisms. Also, those bees in group 1–3 statistically ($P < 0.05$) hoarded more than the controls in group 3–3. These results indicate that bees are additionally stimulated by large amounts of empty comb after a time period of limited exposure to empty comb.

The effect of previous experience with limited amounts of comb may be usefully employed in the management of commercial honey-bee colonies. The ideal management system may involve restricting the space in bee colonies

Table I. Hoarding Response of Bees Caged with One of Two Amounts of Comb for Three Days

Surface areas of comb (cm^2)	Nos. of replicates	Sucrose solution consumption (ml) ($\bar{x} \pm$ SE)	Cells with stored sucrose solution ($\bar{x} \pm$ SE)	Percentage of cells with stored sucrose solution ($\bar{x} \pm$ SE)
46·75	24	5·58 ± 0·09*	12·0 ± 0·45*	6·7 ± 0·003*
140·25	24	7·25 ± 0·11*	21·5 ± 0·77*	3·4 ± 0·001*

*$P < 0.01$.

Table II. Hoarding Response of Bees for Four Days after Their Transfer from One Level of Comb Surface Area to Another

Transfer type (cm^2 of surface area of comb)	No. of replications	Sucrose solution consumption (ml) ($\bar{x} \pm$ SE)	Cells with stored sucrose solution ($\bar{x} \pm$ SE)	Percentage of cells with stored sucrose solution ($\bar{x} \pm$ SE)
1–3 (47–140)	12	15·0 ± 0·50 a*	61·4 ± 3·3 a	11·4 ± 0·01 a b
3–3 (140–140)	12	11·7 ± 0·56	53·8 ± 2·8 a	9·9 ± 0·01 b
3–1 (140–47)	12	9·7 ± 0·45 b c	34·3 ± 3·6 b	19·1 ± 0·02 a
1–1 (47–47)	12	8·8 ± 0·34 c	29·5 ± 1·9 b	16·4 ± 0·01 a b

*Numbers in each category connected by common letters were not significantly different, ($P < 0.05$) when analysed by ANOVA and LSD.

until just before a nectar flow and then supplying the colonies with an abundance of storage combs. Of course, this ideal requires compromise based on time considerations and management techniques required for swarm control.

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