

Response of Honey Bees to Different Concentrations of Sucrose in a Hoarding Test

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ABSTRACT

Newly emerged worker honey bees (*Apis mellifera* L.) were used in a test to evaluate the rate of hoarding of sucrose syrup at concentrations of sucrose between 10 and 60%. The rate increased with concentration up to 50% but decreased slightly when the concentration was increased from 50 to 60%. The rankings among colonies were highly correlated for 20, 30, 40, and 50%; 60% was poorly correlated with 20 and 30%, and 10% was not correlated with the other concentrations.

THE BEE Breeding and Stock Center Laboratory is engaged in a long-range program for the genetic improvement of honey-bee (*Apis mellifera* L.) stocks (Rinderer 1977). However, it is first necessary to determine which factors affect the results of the laboratory tests that will be used and how similar factors affect the results of field tests. It is also desirable to know the effect of varying a factor on the consistency of the results of a laboratory test. It is important that accurate and consistent predictions of field performance can be made based on the laboratory results.

This paper reports the effect on hoarding rate of various concentrations of sucrose in sugar syrup and discusses how this compares to feeding-station experiments in the field.

Materials and Methods

Nine colonies were randomly chosen from one of the laboratory's field yards. Brood was removed from these 9 colonies and allowed to emerge in an incubator at 35° C and 50% RH during August 1977. Bees 0-24 hours old were removed the next day, and 30 bees were confined to each of 162 hoarding-test cages (Sylvester and Rinderer 1978) that were each provided with a 9 x 8 cm piece of dark comb. For the hoarding test (carried out in an incubator at 35° C) the sugar syrup was prepared in 6 different concentrations of sucrose (10, 20, 30, 40, 50, and 60% wt/wt). Each concentration was offered to 3 cages of bees from each of the 9 source colonies. The data, amount of syrup hoarded per bee

per day averaged over the 3rd, 4th, and 5th days after the bees were placed in the hoarding test cages, were subjected to analysis of variance and least significant difference tests. Also, for each concentration, the mean scores for each of the colonies were calculated, and the colonies were ranked. Spearman rank correlation coefficients (Sokal and Rohlf 1969) were calculated between all possible pairs of concentrations.

Results and Discussion

Hoarding of sucrose syrup by the caged bees increased as the concentration of sucrose increased from 10 to 50% (Table 1). These increases were all statistically significant ($P < 0.05$) except for the difference between 30 and 40%. However when the concentration increased from 50 to 60%, the hoarding of syrup decreased by 5.5%, which was not statistically significant. The hoarding of 60% syrup was still significantly greater than the hoarding of any concentration except 50%. Thus, when bees in a hoarding test cage have only one syrup feeder available, they will hoard increasing amounts of syrup as the concentration of sucrose increases to 50-60%.

The Spearman rank correlation coefficients between 10% sucrose and the

other concentrations were negative (-0.03 to -0.45). The coefficients among 20, 30, 40, 50, and 60% were all positive, and only 2 were less than 0.75, (i.e. 20-60% = 0.67 and 30-60% = 0.47). Therefore, the results obtained when syrups containing 10% sucrose are used in an experiment are of no value in predicting the results of similar experiments carried out with syrups containing 20 to 60% sucrose. It would also be unwise to predict the results of an experiment using 20 or 30% concentration from the results of an experiment using 60%. However the high correlation coefficients among the other values indicate that the results of an experiment would be quite similar if any of these intermediate concentrations were used. Therefore, the choice of concentration within these limits can be made on the basis of other factors such as convenience in formulation. Although a hoarding test in the laboratory using only a few worker bees may measure only a part of the complex behavior we call nectar foraging, it can still be a suitable way to predict honey production of a colony if it tests the right part of nectar foraging.

Since the hoarding test described did not test preference, it is not strictly comparable to preference tests carried

TABLE 1. HOARDING OF SUCROSE SOLUTIONS OF DIFFERENT CONCENTRATIONS BY HONEY BEES IN HOARDING CAGES (MEAN OF DAYS 3, 4, AND 5 OF THE TEST).

% Sucrose (wt/wt) concentration	ml/bee/day* X ± SE
10	0.057 ± 0.001 a
20	0.075 ± 0.002 b
30	0.089 ± 0.003 c
40	0.095 ± 0.004 c
50	0.127 ± 0.006 d
60	0.120 ± 0.008 d

*Means with same letters are not significantly different at the 0.05 level of probability as determined by LSD test.

out in the field using foraging bees. However, some comparison seems worthwhile since hoarding tests are designed to be laboratory tests with as high a correlation as possible with honey production, (i.e. nectar collection). For example, when Waller (1972) used artificial flower feeders in the field, he found that foraging honey bees preferred solutions with 30-50% sucrose (wt/wt). The discrimination against 10 and 20% concentrations was statistically significant ($P < 0.05$) while that against 60% was not. Likewise, Woodrow (1968) found that bees feeding from open-dish feeders preferred syrup with concentrations of sucrose in the order $50 > 40 > 30 > 60 > 20\%$ while bees feeding from artificial-flower feeders preferred $60 >$

$50 > 40 > 30 > 20\%$ (wt/wt). Therefore, in the present hoarding experiment, the bees removed sugar syrup of different concentrations in a pattern similar to that of bees in field-conducted, artificial-flower preference-tests though the bees in the laboratory test had a much greater relative uptake of 50% concentration compared to 30 and 40%. Also, they did not exhibit the strong reduction in uptake of 60% concentration exhibited by bees in open-dish feeder tests.

The similarity of the results of the hoarding test and the results of the sucrose-syrup field tests and the consistency of the results with the intermediate concentrations in the present experiment indicate that the hoarding test measured a behavior that is re-

lated to nectar foraging. That this behavior is repeatable and consistent indicates that hoarding tests are of value in evaluating honey production in a breeding program.

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