Honey Bees:[1] Individual Feeding of Large Numbers of Adult Workers[2,3]

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ABSTRACT

A system was devised which is used to individually feed worker honey bees, *Apis mellifera* L., microdroplets of food at the rate of 300–400 bees/hour. The system reduces extraneous stimuli and utilizes the bees' positive phototaxis to lead them to the food. Data on food consumption are reported for bees of different ages fed for varying lengths of time. With an appropriate feeding time, nearly 100% of the worker bees tested consumed the available food.

Bee researchers periodically require individually fed honey bees, *Apis mellifera* L., in their experiments. Simple mass feeding of suspensions is often not useful, for bees have the capacity to filter particles from liquid food (Bailey 1952). With mass feeding, many bees in a group receive their food from other bees rather than from the feeding container. This leads to an uneven distribution of the particulate matter to be tested, with some bees never exposed to the material (Furgala and Maunder 1961). Recently, investigators have fed bees individually with a laborious and time-consuming, hand-feeding technique (Bailey 1972, Wilson 1971). With this technique, each bee is held by the wings and has its mouthparts touched to a small droplet of food. The technique is too slow for experiments which require large numbers of individually fed bees. The recent use of the hand-feeding technique underlines a recognition of the deficiencies of earlier attempts to feed large numbers of bees individually. Bailey (1955) confined starved bees in glass shell vials and permitted them to feed on microdroplets of food placed in glass cups attached to an enclosing cork. In my experience with this technique, many bees became agitated, ran rapidly around the vial, sometimes with their wings extended, and often touched the food with their legs, wings or abdomen rather than their mouthparts. I encountered the same events with Furgala and Maunder's (1961) technique of confining bees to vials and feeding them from the end of a pipet. Again, the bees often become smeared with the food.

During attempts to use the feeding systems of Bailey (1955) and Furgala and Maunder (1961), I developed 3 requirements for a feeding system. The feeding chamber must have opaque walls, a walking surface easily grasped by the bees, and food associated with light. In meeting the 1st 2 requirements, most stimuli extraneous to the feeding event are minimized. In meeting the 3rd requirement, the bees' positive phototaxis is utilized to lead them to the food. Reported here is a feeding system which meets these requirements and gives data on its efficiency.

MATERIALS AND METHODS.—The feeding device consists of 25 feeding chambers made by drilling holes 3.0 cm deep × 1.2 cm diam along the length of a 1.7×5.0×48.5-cm pine board. A no. 3 tapered cork, fitted with a 2-cm piece of siliconized glass tubing (OD 4 mm; ID 3 mm) through its length, confines a single bee in a feeding chamber (Fig. 1). Prior to confinement, the inside end of the glass tubing is loaded with a 5-μl droplet of liquid food. These droplets are dispensed from a 1-cc tuberculin syringe mounted on an Instrumentation Specialties microapplicator. Suspensions can be stirred constantly during dispensing if a small, bent piece of ferreous wire is placed in the barrel of the syringe and the syringe, while mounted on the microapplicator, is placed over a magnetic stirrer.

Tests of the feeding device were conducted with adult bees 1, 2, 3, and 4 days old. Bees of each age category were fed for 10, 20 or 30 min. Also, 2-day-old bees were fed for 40 minutes. In all tests, bees were starved for one hour, anesthetized 3–4 min with CO_2 to facilitate handling, and placed in the feeding chambers. When each bee had apparently revived from the CO_2 treatment, it was enclosed in a chamber with a food-containing cork. After the last bee of a test group was enclosed, the feeding boards were placed with the corks facing, from a distance of 12–15 cm, two 44-cm, 15-w daylight fluorescent tubes. At this point, timing was begun for the feeding period. After each feeding test, feeding corks were removed and examined with an illuminated hand lens for the presence or absence of the food droplet. Those bees removing only part

[1] Hymenoptera: Apidae.
[2] In cooperation with Louisiana Agric. Exp. Stn. Received for publication March 8, 1976.
[3] Mention of a commercial or proprietary product does not constitute an endorsement by the USDA.

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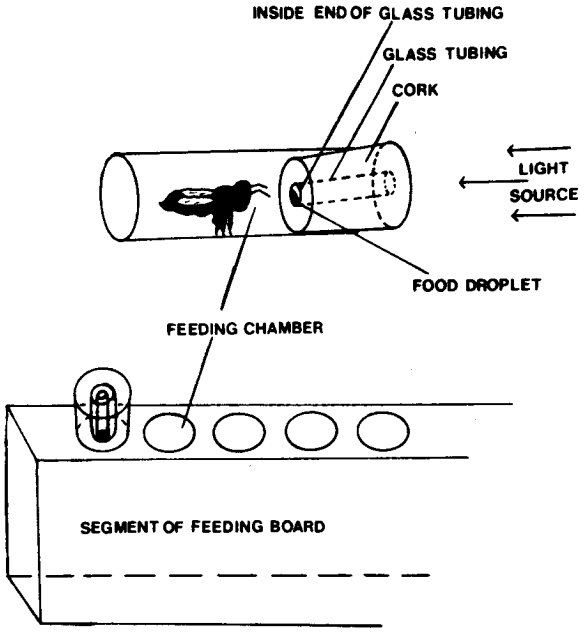

FIG. 1.—Device used to feed individual bees measured amounts of sugar syrup.

of the food were classed with those removing none of it.

To provide bees for these tests, combs of emerging brood of a commercial stock of bees were placed in an incubator held at 35°C. All adult worker bees that emerged in a 24-h period were collected in cages similar to those described by Kulinčević et al. (1973) and returned to the incubator until they had reached the appropriate age. Cages did not contain a comb. Without a comb containing hoarded food, bees could be starved by removing the feeding vial.

The system also was tested without bees, to determine the effects of evaporation and obtain an index to the visibility of the food droplet. In this test, food droplets, placed in the glass tubing of corks which were fitted into feeding chambers, were exposed to the fluorescent lights for 2.5 hours. The corks were then examined for the presence or absence of the food droplet.

RESULTS AND DISCUSSION.—The bees readily consumed the food (Table 1). While the 10-, and 20-min feeding periods are insufficient to insure a high percentage of food removal, the 30-min period for 1-, 3-, and 4-day-old bees resulted in 99, 99, and 100% food removal, respectively. For some reason, the 2-day-old bees removed less during the 30-min period than did bees of other ages. However, their performance of 99% removal at the 40-min feeding period is equal to the performance of the other 3 age groups at 30 minutes. None of the food removal can be attributed to evaporation since the control tests without bees still contained 100% of the food droplets after 150 min.

With longer feeding periods the system becomes reliable. There is heterogeneity between replicates with 1-, 2-, and 3-day-old bees at the 10-, and 20-min feeding periods. This heterogeneity may result from slight differences in duration of exposure to CO_2. Such differences could lead to variation in the time required to fully recover from the CO_2 and be reflected in heterogeneity between replicates. In contrast, the replicates at the 30-, and 40-min feeding periods for all age groups are highly homogeneous, and feed removal is consistently high.

As well as being reliable, the technique is rapid. Two people can easily feed 300–400 bees/hour. Thus, studies are now possible that require large numbers of bees individually fed known doses of material.

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Table 1.—Percentage of bees that consumed 5 μl of 50% sugar syrup.[a,b,c,d]

Age of bees	Rep. no.	Time in min: 10	20	30	40
1 day	1	66.6 (55.9–77.3) [e]	96.0 (91.6–100)	100 (99.3–100)	
	2	68.0 (57.5–78.5)	76.0 (66.4–85.6)	98.6 (95.8–100)	
Pooled Percentage		67.3 (59.7–74.9)	[f]	99.3 (98 –100)	
2 day	1	62.6 (51.7–73.5)	68.0 (57.5–78.5)	86.6 (79.0–94.2)	100 (99.3–100)
	2	88.0 (80.7–95.3)	89.3 (82.2–96.4)	92.0 (86.0–98.2)	98.6 (95.8–100)
Pooled Percentage		[f]	[f]	89.3 (84.5–94.1)	99.3 (98 –100)
3 day	1	92.0 (85.8–98.2)	98.6 (95.8–100)	100 (99.3–100)	
	2	73.3 (63.3–83.3)	84.0 (75.7–92.3)	98.6 (95.8–100)	
Pooled Percentage		[f]	[f]	99.3 (98 –100)	
4 day	1	88.0 (80.7–95.3)	96.0 (91.6–100)	100 (99.3–100)	
	2	89.3 (79.2–96.4)	94.6 (89.4–99.8)	100 (99.3–100)	
Pooled Percentage		88.8 (83.6–94.0)	95.3 (91.9–98.7)	100 (99.5–100)	

[a] Before they were fed, bees were starved for one hour.
[b] For each replicate of each age and time, N = 75.
[c] No bee was used more than once.
[d] Two control tests without bees lasted 150 min and resulted in 0 (0–0.5) % food removal.
[e] Percentage with lower and upper 95% confidence limits. Confidence intervals calculated by the method outlined by Freund et al. (1960).
[f] Heterogeneous replicates precluded pooling.

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