

How do Newly Recruited Honey Bees Approach a Food Site? * **

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Summary. 1. During these experiments we observed a total of 70 honey bees. 36 of the observed bees had no contact with a dancer; and, 34 bees attended dances. Of these 34 bees, 14 reached the food site and 20 did not. The food sites were 200—250 m from the hive.

2. The total number of dances followed by any bee, who reached the food site, was never less than 6.

3. A few bees left the hive without attending any dances, but never reached the food site on these attempts. Once they had attended a minimum sequence of 6 dances, these bees could successfully reach the food site.

4. The observed behavior of newcomers reaching a food site indicated that they knew its location before leaving the hive. The dances, not the wind, seemed to be the determining factor.

Zusammenfassung. 1. Wir überwachten 70 Honigbienen in unserem Experiment. 36 Bienen hatten keinen Kontakt mit einer Tänzerin, 34 Tiere folgten einer Tänzerin. Von diesen 34 Tieren fanden 14 den Futterplatz, der zwischen 200 und 250 m vom Stock entfernt lag.

2. Jede Biene, die den Futterplatz fand, war wenigstens 6 Schwänzelläufen gefolgt.

3. Einige Bienen verließen den Stock, ohne einer Tänzerin gefolgt zu sein. Sie fanden den Futterplatz nicht. Nachdem sie aber später wenigstens 6 Tänzen gefolgt waren, erreichten manche den Futterplatz.

4. Die Beobachtung von Neulingen beim Aufsuchen des Futterplatzes zeigte, daß sie die Lage des Futterplatzes vor dem Verlassen des Stockes kennen mußten. Tänze und nicht mit dem Wind herangetragenem Duft schienen der entscheidende Faktor zu sein.

A. Introduction

Newly recruited foragers reach their goal with a higher accuracy than one would expect from the information contained in *one* wagging run (v. Frisch, 1965). Von Frisch suggests that they might follow a couple of dances and average the different values perceived in those dances. He points out that observations of Lindauer (1952) indicate that this might

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be so. Definite observation of the behavior of newly recruited foragers can not be found in the literature.

In our studies on the mechanisms by which foragers and new recruits determine the distance of a food site, we checked what information a recruit receives and how it makes use of that information. We believe that our results are important for the understanding of the foraging behavior of honey bees.

B. Materials and Methods

The experiments were performed with different observation hives of *Apis mellifera (mellifera)* from the stocks of the Department of Biology at the University of Notre Dame. The bees entered the observation hives, 2-frame models very similar to those used by v. Frisch (1965, p. 6), through 30 cm long glass galleries in which arriving and departing marked bees (v. Frisch, 1965) could easily be identified.

The experiments were conducted on the campus of the University of Notre Dame. The experimental area consisted mainly of a flat, open lawn with a few scattered shrubs and trees.

The experiment began with the training of a group of 20 to 30 bees to a food site of the Baumgärtner-type (Baumgärtner, 1928) on a stool, 50 cm high, in front of the hive. On top of the food container was a small dish (3 cm in diameter, 1.5 cm high) covered with a wire screen under which a piece of filter paper was soaked with a drop of scent solution (we used rose oil, peppermint oil, clove oil and a perfume). The bees could not reach the scent solution. Each bee at the food site was marked individually with shellac. Ten animals received additional striking marks, like stripes or dots, so that they could be recognized from a distance of a few meters, even when in flight. As soon as a group was marked, the ten bees with the additional markings were caught and put into a small cage in which they had access to food and water. The cage was stored at 26° C in the laboratory. The rest of the marked foragers were quickly trained to a 200 m distant food site. In some experiments this was not accomplished until the next day, but this delay had no recognizable effect on the rest of the experiment. After we had reached that distance, all foragers visiting the food site, except one, were captured and caged. Only this one bee was allowed to go back and forth between hive and feeding station. Then we released the ten bees caught at the beginning of the experiment. They always returned to the hive immediately. Two observers on each side of the hive recorded all contacts between the ten released bees and the one forager visiting the food site. They also noted the departure and arrival times of the forager and all bees under observation. This information was recorded with a tape recorder and replayed and evaluated later. A third observer sat near the food site and registered all arrivals and departures there. He was in continuous telephone contact with the observers at the hive and all his remarks were recorded on tape. We used a particular hive only for one experiment and then switched to another hive.

C. Results

We performed seven successful experiments between June 17 and July 10, 1969. The locations of the food sites and the wind conditions during the experiments can be found in Table 1. It is important to note

Table 1. *Location of the food sites*

Date	Food site		Wind	
	Distance from hive (meters)	Direction	Velocity (m.p.h.)	Direction ^a
6-17-69	250	S	5.2	E, S-E
6-18-69	200	S	5.4	S
6-21-69	200	S	5.2	NW
6-24-69	220	E	3.8	N, N-E
7-2-69	200	N	2.1	N
7-3-69	200	E	2.1	N
7-9-69	200	W	2.4	S, S-E

^a Wind coming from a certain direction: N = north, S = south, E = east, W = west.

Table 2. *Local climatological data^a*

Date	Temperature			Time exp. began	% Relative humidity	Weather	Sky ceiling	Visibility (miles)
	Max. (°F)	Min. (°F)	Exp. ^b (°F)					
6-17-69	79	58	78	4 p.m.	44	sunny	clear UNL ^c	12
6-18-69	71	60	70	4 p.m.	73	haze	clouds 3,000 ft.	6
6-21-69	70	48	60	4 p.m.	67	partly sunny	clouds 5,000 ft.	8
6-24-69	68	57	65	10 a.m.	87	light fog	clouds 800 ft.	2.5
7-2-69	79	56	78	4 p.m.	54	sunny	clear UNL	15
7-3-69	81	61	80	4 p.m.	54	sunny	high cirriform	10
7-9-69	80	64	79	1 p.m.	77	haze	clouds 12,000 ft.	5

^a Information obtained from the U.S. Weather Bureau, South Bend, Indiana, except for the experimental temperature.

^b Average temperature for the hours during which the experiment was conducted.

^c UNL = Unlimited ceiling.

that the wind direction showed all desirable changes; such as, blowing from the hive to the food site, blowing at a right angle to the flight path from the hive to the food site, and blowing from the food site to the hive. Table 2 describes the other weather conditions.

Table 3. *Bees reaching a food site*

Bee No.	Date	Contacts	Feedings	Dances or wagging runs before a flight (flight time in seconds)	Time of first flight to a food site (seconds)	Total No. of dances followed
564	6-18-69	2	1	3(332), 7	80	10
554	6-18-69	3	0	5(240), 11	153	16
563	6-18-69	5	3	9(367), 6	330	15
557	6-18-69	3	—	0(32), 2(240), 8	72	10
131	6-21-69	8	2	0(300), 0(196), 5(200), 6	64	11
119	6-24-69	6	2	2(82), 0(240), 0(335), 0(262), 0(162), 0(200), 0(394), 0(138), 5(120), 8	660	15
107	7-2-69	7	1	7(367), 8	75	15
112	7-2-69	5	0	7	90	7
120	7-2-69	9	0	13(30), 12	163	25
128	7-2-69	2	0	11(60), 15	300	26
129	7-3-69	6	2	6	56	6
150	7-3-69	4	1	6	58	6
118	7-9-69	1	1	6(200), 3	150	9
133	7-9-69	2	1	6	360	6

n = total number of bees = 14; total number of dances followed = 177; average = 12.6; total time (seconds) of first flights to a food site = 2611; average = 186.

While the recruiting forager moved through the hive, it was frequently touched by the antennae of a recruit. We considered this a "contact". From time to time a food exchange between scout and naive bee occurred; we called this a "feeding".

Table 3 summarizes the behavior of recruits, who found the food site. The column "dances before a flight" indicates the number of waggle runs through which the recruit followed the dances before it left the hive for a flight. The duration (seconds) of that flight is in parentheses. Some recruits left the hive without following any dances (Bee No. 557, for example). These bees contacted the dancer with their antennae and evidently detected the scent they had been trained to recognize earlier.

Table 4. *Bees failing to reach a food site*

Bee No.	Date	Con- tacts	Feed- ings	Dances followed before a flight	Total No. of dances followed
131	6-17-69	5	2	8-5-1	14
120	6-17-69	4	2	8-12-10	30
551	6-18-69	6	0	3-2-3-1-2-15	26
135	6-21-69	13	1	2-2-3-7-5-5-5	29
114	6-21-69	13	2	2-3-5-2-3-2-9-5	31
190	6-24-69	7	2	5-4-4-7-7	27
184	6-24-69	1	0	6	6
170	6-24-69	3	0	4-2-4	10
198	6-24-69	4	0	2-6-5-7	20
116	6-24-69	2	0	5-5	10
1-LS	7-2-69	4	0	1-8-11	20
1-2PS	7-2-69	7	2	2-2-7-12	23
101	7-2-69	5	2	9-8-10	27
124	7-3-69	4	0	3-2-7-7	19
138	7-3-69	3	0	3-4-3	10
139	7-3-69	2	0	6-4	10
128	7-9-69	2	0	9-1	10
130	7-9-69	2	0	5	5
112	7-9-69	1	0	5	5

Since they remembered the scent, they left for the food site (v. Frisch, 1965, p. 33). They never found the new food site, however, and returned to the hive to attend additional dances. Once these bees attended a minimum of 6 consecutive dances, they were able to reach the food site on their next flight.

Recruits followed from 2 to 13 dances in sequence before leaving the hive. Only in 4 out of 14 cases did the recruit reach the food site after it had followed 6 or 7 dances in a row (Bee No. 112). The times it took them to reach the food site range from 56 to 360 seconds. (For the same flight an experienced dancer needed between 20 and 60 seconds.) The other bees, after following a number of dances, left the hive and searched for the food site (time in parentheses), but did not find it. They returned to the hive and followed another series of dances (from 3 to 15) and left the hive again. Most of the foragers reached the food site on this second attempt. Normally, the second attendance of dances followed within minutes after the return. Bee No. 120 on July 23, however, returned from the first flight and sat in the hive for 5 hours before attending another 12 dances and subsequently reaching the food site.

20 other bees, Table 4, attended dances and left the hive in the same manner as the successful foragers, but did not reach the food site during our observation periods. One can see from the column "dances followed

before a flight" that many of these bees followed more than 6 dances in sequence, and still did not reach the food site. Another 36 bees observed during the experiment did not make any contact with the dancers. (A few of them were recruited for natural food sites.)

The time quoted as the time for the first flight to the feeding place is the time between the departure from the hive and the first sighting in a radius of 2 meters of the food site. Frequently, the forager circled around the food site; but, since there was no traffic, it did not land. Some bees flew around for a few minutes and finally landed, while others returned to the hive and attended another series of dances. If they then returned, they came fast (within 60 seconds), were very determined and sat down at the food site immediately. As soon as a bee landed, it was caught with a forceps and transferred to a bottle filled with alcohol.

In two cases (Bees No. 150 and 129 on 7-3-69) we were able to see the newcomers approach the food site from a considerable distance. They came straight from the hive in a zig-zag flight which brought them down from a height of approximately 10 meters at the point where they were spotted to 1 or 2 meters near the food site. It was obvious from their behavior that they were *not* searching at random. One had the impression that they knew the location of the food site.

D. Discussion

Can our experimental conditions be compared to those in an undisturbed hive? Our recruits were trained to the food and scent they had to look for later. They had, however, no knowledge about its location. Experiments, using an observation hive with a thin screen over the dancing area through which recruits following a dancer could be marked, were performed in the summer of 1968 by a student in our department (James Sidie, personal communication). His observations indicate that the non-preselected foragers and our preselected foragers behave similarly. We assume that the samples of food distributed by the dancer and our feeding at the hive entrance both play a similar role, namely, attracting the attention of the hive mates.

The percentage of bees a single dancer attracts, however, is probably much lower in an undisturbed hive. We noticed that all the caught foragers, when released into the hive, first focused their interest on our experimental forager. Only after the experimental forager infrequently appeared in the hive, did some of the caught foragers switch to other dancers, who recruited them to other food sites.

Independent of the previous deliberations, a number of our observations emphasize the importance of the bee dances in determining the

location of a food site. Many newcomers approached the food site with a knowledge about its position. Since they could not have searched the entire experimental area in such a short time; and, since the wind in the experiment with the shortest flight times (7-3-69) came at a right angle to the connection hive-food site and could not have blown the scent from the food site to the hive; these dances do seem to be the decisive factor at work here. When a recruit did not find the food site within a few minutes, it did not search until it finally found it, but returned to the hive and looked for additional information.

The importance of the dancers is stressed in another observation: We always worked with a single forager-dancer, who frequently, for one reason or another, would not dance for hours, but only go back and forth between hive and food site. During these danceless periods newcomers never appeared at the food site. However, from one to fifteen minutes after the forager resumed dancing, the newcomers started to arrive at the food site. These newcomers were frequently unmarked animals recruited from the hive.

It is interesting to note that v. Frisch calculated that a newcomer has to attend 5 or 6 dances before it can reach the food site with the accuracy observed in his step-wise experiments (v. Frisch, 1965, p. 106). All bees in our experiments had attended at least 6 or 7 dances before reaching the food site. Judging from our observations, v. Frisch's calculations must be based on correct assumptions.

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