THE FORAGING BEHAVIOR OF HONEYBEES ON HAIRY VETCH
FORAGING METHODS AND LEARNING TO FORAGE (1)

by

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The foraging behavior of honeybees is a product of the interaction between bees and the plants foraged. Since both are variable, foraging statistics are likely to be inconclusive, or to apply only to the particular case under study. Observations of larger populations under varying conditions may be of more value in making fruitful generalizations than more limited quantitative data; such observations are also neccesary as a guide to the adequacy of data derived from smaller samples. Generalizations that are not supported by adequate data, on the other hand, must be viewed with suspicion and often the data itself will indicate aspects of behavior which were not discerned during general observations.

MATERIALS AND METHODS

In 1953, 1954, and 1955 studies were conducted on the behavior of honeybees (*Apis mellifera* L.) foraging from hairy vetch (*Vicia villosa* Roth.). The observations were made near Terrell, Texas, U. S. A., the main vetch seed producing area of the state. Most of the observations in any one year were made in the same vetch field. A majority of the bees were of the Italian race, though some were mixtures of two or more races.

During this study measured or estimated one square yard areas were used for several purposes. These are reported below as one square meter areas since, in the manner in which they are used, this does not vitiate the data. Weights taken in pounds have been converted to kilograms.

The amount of bloom was estimated weekly from the number of open, unwithered blossoms in 1 square meter of vetch without skips between the vines. The number of foragers was determined by staking off five one square meter areas and counting the number of bees working in the areas on different days and at different times of the day. For estimates of the number of foragers in other fields, or in other parts of the same field, the number of bees working in an estimated one square meter area was counted, and then the observer moved three paces and made another count.

A colony of bees on scales was used to measure the nectar flow. The daily nectar flow was determined as the gain in weight of the colony from early morning before flight began to late afternoon when it had ceased. In 1955 the amount of nectar available in the blossoms was measured by the centrifuge method of SWANSON and

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SHUEL (1950). The concentration of nectar from the honey stomachs of bees was determined daily between 1 300 and 1 600 hours with a hand refractometer; the mean of at least two uncorrected readings was considered to be the sugar concentration. Details of these techniques, of the culture, blooming period, nectar flow, and pollination, of the vetch are published elsewhere (WEAVER, 1956 *a*).

The proportion of foragers of each of two general types was determined by observing the foraging method of all bees immediately in front of the observer, moving three paces, and making another count of the bees of each type. This was continued until a predetermined number of bees had been observed. If more information on each bee was needed, the pertinent information was gathered on only the first bee that came into view at any one place, then the observer moved three paces to gather information on another bee.

To determine the amount of forage gathered by a bee on one foraging trip, bees returning from the field were caught at the hive entrance; the honey stomach was removed and weighed with its contents to the nearest 1 mg. The weight of the two pollen pellets was also determined to the same accuracy.

Data were analyzed statistically by the X^2 test or by the method of paired differences. These methods, as well as the method of determining the correlation coefficient, are taken from SNEDECOR (1946).

RESULTS

A honeybee must insert her tongue to the base of the corolla tube in order to reach the nectary, and if she approaches the blossom from the mouth she must trip the blossom, depress the keel, and force her head into the corolla tube. Both tripping the blossom and reaching the nectar are difficult for a honeybee. The tongue is inserted into the blossom between the keel and the standard and is thrust sharply toward the base of the corolla tube. The head is then used as a wedge and lever while the legs press downward on the keel. The sexual column of vetch, unlike that of alfalfa, usually is not released with a snap, but the bee's tongue is sometimes caught between the sexual column and the standard, and occasionally there is a short struggle before it is pulled free. The head usually is twisted to one side when the blossom trips and the position of the tongue apparently determines whether or not it is caught; some bees got their tongues caught in almost every blossom, others almost never. The bee depresses the keel to at least a right angle with the corolla tube and clings to it as she thrusts her tongue to the nectary on the dorsal side of the sexual column at its base. A bee can also reach the nectary without tripping the blossom by inserting her tongue between the petals of the standard and the keel at the base of the corolla tube. Most of the bees that work in this manner alight on the ventral side of the blossom facing the axis, but some bees usally face at almost a right angle to the corolla tube, and there may be some variation in the position of a bee foraging successive blossoms. The position depends, in part, upon the direction from which the bee approaches the blossom. In order to avoid confusion, all bees that trip the blossoms will be called trippers, and all non-trippers that reach the nectar by inserting the tongue between the petals will be called base workers.

In order to study the process by which the foraging method became fixed, colonies of bees that had never worked vetch were moved, one at a time, into a field with a good nectar flow and a low population of foragers. After three or four hours with little flight from the colony, there would be a sudden burst of activity and the vetch near the hive would be filled with bees that appeared frantic in their efforts to forage from the blossoms. Some bees made no real effort to forage from any blossom that had not previously been tripped. Others would alight and randomly attempt to insert the tongue into a blossom at any point; a bee that had succeeded in foraging from one blossom as a base worker might alight on the dorsal side of the next flower and attempt to insert the tongue; a bee would often insert the tongue between two contacting blossoms, or against a standard or keel of a previously tripped blossom, and thrust the head sharply downward in a typical tripping motion. Upon successfully working one blossom, or a very few blossoms in succession, most bees immediately became oriented in their behavior patterns, and calmly and methodically foraged from additional flowers by whatever method had proved successful. This change in the approach to foraging sometimes was gradual, but it usually was quite sharp and dramatic. Before they learned their foraging method the bees were so nervous in their actions and flew great distances so often that none was observed from the time she arrived in the field until she established her foraging method, so it is not known how many successful visits may have occurred before the foraging method was learned. One bee, however, was followed while she visited well over a hundred blossoms and finally returned to the hive without becoming oriented in her foraging behavior. This bee successfully foraged from 34 blossoms as a base worker, 23 blossoms as a tripper with the tongue entering the blossom on the right side of sexual column, and 14 blossoms as a tripper entering to the left; 32 unsuccessful attempts to work blossoms were recorded, and many other unsuccessful or indecisive visits occurred in such rapid succession that no records were made. Several time this bee succeeded in working several successive blossoms by one method, and began approaching each blossom in the same manner and acting less nervous, but a failure would be followed by more disorganized activity. These results are in agreement with those of Reinhard (1952) who studied bees learning to forage from alfalfa blossoms, but the studies need to be extended in order to gain knowledge of the latent period of learning of bees, the effect of experience at foraging from other types of blossoms on the time required to learn to forage medium sized papilionaceous blossoms, and individual and colony differences in learning ability.

Random observations indicated that, after the bees' foraging methods had become established, the percentage of base workers varied with the condition of the vetch plants. In 1954 a series of five paired observations on the number of tripping bees per 100 foragers in areas of a field with scattered blossoms and in areas of the same field with numerous blossoms was therefore undertaken. These data are given in Table 1. In an experi-

ment on the control of destructive insects of vetch the check plots became rather heavily infested with pea aphids and showed slight thrips damage (Weaver and Garner, 1955). On five occasions the number of trippers per 25 bees was counted in a plot in which aphids and thrips were controlled and in a check plot in which they were not. Since there were approximately equal numbers of blossoms in the insect infected and check plots, the number of foragers in 10 randomly selected estimated 1 square meter areas in each plot was also determined on five occasions. Table 1 gives the data on the number of trippers and the pooled data on the number of bees in

TABLE 1. — Paired counts of the proportion of tripping honeybees, and the number of foraging honeybees in hairy vetch under the conditions indicated.

TRIPPERS PER 100 BEES.		TRIPPERS PER 25 BEES.		BEES IN 10 SQ. METERS.	
Numerous blossoms.	Scattered blossoms.	Insects controlled.	Insects not controlled.	Insects controlled.	Insects not controlled.
80	51	20	13	9	7
77	36	13	9	4	2
85	60	17	13	19	10
82	46	16	12	13	5
66	30	22	14	16	21
Means.		Means.		Means.	
78.0	44.6	17.6	12.2	12.2	9.0
t = 11.93 **		t = 6.21 *		t = 1.28	

* Probability < 0.01.

10 square meter areas. The mean difference in the proportion of trippers was highly significant in both sets of data, but the mean difference in the number of foragers was not significant. In fields with a few clumps of vigorous vetch surrounded by weak plants, the increased proportion of trippers in the better vetch was obvious. Similarly, in 1954 fields with vigorous appearing vetch always had a higher percentage of trippers than fields of weak vetch. Observations late in the season in 1955 were similar to those in 1954, but those early in the season were not. Since there was no objective method of measuring the vigor of plants, these conclusions are based on many brief observations; little data were gathered and none are presented.

The primary classification of bees was as trippers or base workers, but for some purposes the trippers were divided into 3 classes according to forage gathered, and into 3 classes according to foraging method. The complete classification according to forage gathered was as follows: (1) Pollen gatherers: bees that foraged only in the mouth of the blossom for pollen; (2) Pollen and nectar gatherers: tripping bees that extended the tongue into

the blossom to the nectary, and that had pollen visible on the corbiculae; (3) Nectar gatherers: bees behaving like (2) but with no pollen visible on the corbiculae; (4) Base workers. The complete classification according to foraging method was as follows: (1) Pollen gatherers; (2) Trippers reaching the nectary by inserting the tongue into the blossom to their right, or (3) To their left of the sexual column; (4) Base Workers; (5) Mixed: bees working some blossoms as trippers and others as base workers. Because the systems overlap, there is a total of 7 classes.

On each of six occasions during 1955, 50 bees were observed while working two to ten blossoms and then were classified according to foraging method and forage gathered. The number of bees in each classification is given in Table 2. Similar but less extensive data were obtained in 1953 and 1954. There were never many bees that foraged alternately as trippers and base workers; this was particularly true in 1954. Most of the bees that did mix their methods attempted to trip all blossoms, but if one did not trip easily, the bee changed positions and foraged as a base worker; a few bees, especially late in the season, foraged most blossoms as base workers but inserted the tongue into the mouth of some of the previously tripped blossoms. The number of bees foraging for pollen only was always small, but the number of bees in most of the other classes was quite variable and some of this variability could be related to the nectar flow. From May 5 to May 10, 1955 the amount of nectar brought into a colony each day diminished from 10 to 6 kg; on May 12 the colony stored 2½ kg; and there after never more than ½ kg in a day. After several days with a poor nectar flow the percentage of trippers gathering nectar only fell sharply, the percentage of trippers gathering both nectar and pollen increased slightly, and the percentage of base workers increased sharply. This can be seen for 1955 from the data in Table 2. The nectar flow and the proportion of each type of forager on the first and last observations in 1953 were almost identical with the corresponding data in 1955. In 1954 when the nectar flow was slow throughout the year, there were never many trippers gathering nectar only, and the percentage of base workers was high all season long. The slight increase in the proportion of bees with pollen visible on the corbiculae during the slow nectar flow may have been due to the longer time required for a bee to gather a load, and the consequent reduction in observations on bees that had just arrived in the field, but prolonged observations on a large number of foragers during the three years established the reality of the change in the proportions of base workers and trippers gathering nectar only.

Although a large proportion of the trippers gathered both nectar and pollen, few of them foraged specifically for pollen. When the blossoms were tripped the anthers hit the head or thorax of most bees, and varying amounts of the pollen that clung to the bees was packed on the corbiculae ; nectar gathering trippers would sometimes cleanse the body of pollen, but not pack it.

On two days, when the colony on scales gained 0.5 and 1.6 kg of

nectar containing 40 per cent sugar, returning foragers were caught at the hive entrance and their forage was removed and weighed. Thirty-two bees with pollen on the corbiculae carried 4.5 ± 0.5 mg of pollen and 14.7 ± 1.3 mg of nectar; the amount of pollen and nectar carried by individual bees was not correlated ($r = 0.088$). Eight bees without pollen carried 19.8± 2.7 mg of nectar. One of these bees, with 9 mg of nectar, had pollen on the pollen brushes and on the under side of the head. This bee was probably a tripper, and the remaining bees without pollen were probably base workers. The loads carried by these bees were small in comparison to the loads recorded from other species of plants (eg. Park, 1922). Visual observations indicated that bees gathering only pollen from vetch usually gathered larger loads than any which were weighed in this series, and that during a better honey flow more nectar was carried per load by both trippers and base workers. Analytical balances were not available in the field at other times.

TABLE 2. — Number of honeybees using foraging method and gathering forage as indicated from hairy vetch on 6 occasions in 1955.

DATE.	TIME.	TRIPPERS.					Base workers.	Mixed method (4)	TOTAL No. bees.
		Nectar only (1).		Nectar and pollen (2)		Pollen only.			
		Right (3)	Left (3)	Right (3)	Left (3)				
5/5	1100	15	8	10	10	1	2	4	50
5/5	1530	9	8	10	10	1	9	3	50
5/7	0830	16	7	14	5	2	6	0	50
5/7	1100	15	6	11	7	4	7	0	50
5/12	1330	8	7	14	11	1	8	1	50
5/17	1100	2	3	16	8	1	18	2	50
Total.		65	39	75	51	10	50	10	300

(1) No pollen visible on corbiculae.
(2) Foraging for nectar and with pollen on corbiculae.
(3) Inserting tongue into blossom to the right or the left of the sexual column.
(4) Foraging some blossoms as trippers and others as base workers.

Of the trippers that gathered some nectar, 59 per cent inserted the tongue to the right of the sexual column, and 41 per cent to the left. As can be seen from the part of the data which is shown in Table 2, there was considerable variation from one count to the next, but the proportion departed significantly from both a 1:1 and 2:1 ration by the X^2 test. Bees that were oriented in their foraging behavior were more constant in inserting the tongue into the same side of the blossom than in foraging exclusively as trippers or base workers. The direction of foraging became fixed while the

bees were learning to forage, so it would seem that there is an innate tendency for bees to enter the blossom from one direction or the other, or there is an asymmetry in the vetch blossom not visible to the human eye.

DISCUSSION

One of the more useful concepts of foraging behavior is that the relative attractiveness of a source of forage depends upon a balance between the factors that attract bees and those that repel them. For an interpretation of some of the results obtained in this study a more specific concept would be useful. Experiments by von FRISCH (1923, 1934, 1942), WYKES (1952), BEUTLER (1950), and LINDAUER (1949) demonstrated that bees prefer certain sugars to others of the same concentration; that bees prefer high concentrations of any attractive sugar to low concentrations of the same sugar; and that the preferences are determined by the sense of taste, the sense of smell, and other physiological factors. Among these factors is the time, energy, or bother required to gather a load. Bees feeding on dishes abundantly supplied with sugar syrup gathered larger loads, gathered loads more quickly, danced more vigorously, and attracted more recruits than bees fed on a thin film of syrup of the same concentration that had to be sucked from blotting paper (von FRISCH, 1923).

It is postulated that, all else being equal, honeybees will gather nectar which yields the greatest amount of sugar (potential energy) per unit expenditure of energy, and that when the amount of sugar gathered becomes too low in relations to the amount of energy expended, the bee will either cease to forage or seek a new source of forage. It is not assumed that the bees perceive the food value of the sugars per se, but only the taste and other characteristics of the solution. There are, of course, many factors which influence a bee's selection of and adherence to a source of forage (RIBBANDS, 1949, 1953), and the other factors will affect the ratio of incoming to outgoing energy required by each individual to cause a change in foraging.

The blossoms of hairy vetch are difficult for a honeybee to forage, and the fact that during a poor nectar flow bees returned to the hive with small loads of nectar can be explained by the assumption that the return in forage was not sufficiently large in relation to the energy expended in gathering it to cause bees to continue to forage on that particular trip to the field. Alternate explanations would be that bees will expend only a limited amount of energy or will forage for only a limited amount of time regardless of the richness of the forage.

The decrease, during poor nectar flows, in the proportion of tripers gathering nectar only while the proportion gathering both nectar and pollen remained almost constant can be similarly explained. A greater return of forage per blossom and per unit expenditure of energy is obtained by the bees gathering both. The need of the colony for pollen probably helped

to cause some bees to gather both pollen and nectar, especially since there was no other good source of pollen available to the bees, and the few bees foraging for pollen only probably had to trip about 200 vetch blossoms in order to gather a load.

Data on the foraging speed of bees indicate that base workers forage about 90 more blossoms per hour than tripping nectar gatherers (WEAVER, 1956 *b*). Furthermore, base workers did not appear to expend nearly so much muscular energy in reaching the nectar as trippers. This was particularly true in 1954 when the vetch blossoms were more difficult for the bees to trip than in 1953 or 1955 (WEAVER, 1956 *b*). Both the difficulty of tripping the blossoms and the small return in nectar could have contributed to causing the large proportion of base workers in the vetch throughout 1954 and late in 1953 and 1955. The field of vetch that lacked vigor and had many trippers early in 1955 had little nectar available in the blossoms, but the blossoms looked weak and were quickly and easily tripped, so it is possible that there was little difference in the amount of energy expended by trippers and base workers in that field.

The data taken in 1954 and summarized in Table 1 can also be explained on the basis of energy relations. It would be expected that vetch heavily infested with aphids would secrete less nectar than uninfested vetch. Moderate numbers of thrips would not be expected to affect nectar secretion, but might make the vetch less attractive to bees in other ways; foragers appeared to be irritated by thrips that mounted their bodies. Scattered bloom would be less attractive to bees than crowded blossoms both because of the flight distance between racemes and the searching time required. The same factors which resulted in scattered bloom might also have caused poorer nectar yield by the blossoms. This was probably the case during these observations, since the vetch with scattered blossoms was maturing many seed, and this seems to reduce the amount of nectar secreted (WEAVER, 1956 *a*).

Regardless of the cause of the change in the proportions of trippers and base workers when the nectar flow deteriorates, the mechanism of the change is not at all clear. All of several possible mechanisms may operate to some extent. Observations at the hive entrance and hourly weighings of the colony on scales indicated that a smaller percentage of the colony population was going into the field late in 1953 and 1955 than early in those seasons. If more base workers than trippers continued to forage, this could account the change in the proportions of the two types of foragers as the nectar flow deteriorated.

The data in Table 1 indicates that there were probably fewer foragers in the plot being attacked by aphids than in the plot in which insects were controlled, though the differences were not great enough to be statistically significant. Some of the bees that originally foraged in the infested plot may have quit foraging or they may have changed foraging areas. The evidence indicates that bees are sometimes recruited to a new foraging area in a different field from their old one (WEAVER, 1956 *a*, 1956 *b*). A bee

might also wander into a more satisfactory part of the field since, during a poor nectar flow, bees explore and forage over a wider area than during a good flow.

Competing foragers are important in making bees move about more, both by their physical presence and by removing nectar from the blossoms and thus making the vetch less attractive (WEAVER, 1956 *b*). A tripper's eyes and antennae are partially covered while her head is pushed into the blossom to reach the nectary, but the base worker's eyes and antennae are fully exposed at all times. During prolonged observations on the foraging behavior of individual bees it was noted that base workers appeared to be disturbed more than trippers by the presence of an observer, and several observations indicated that they also might be more sensitive than trippers to the presence of competing foragers; they seemed more prone than trippers to take evasive action when another forager flew fairly close, and often visited a raceme deep in encircling vines, or flew away from the area after such evasive actions. A greater sensitivity to competing foragers would tend to force a bee into an area with less competition. Objective data on the distance of flights by trippers and base workers (WEAVER, 1956 *b*) and on the exposure of the racemes preferred by these types of foragers failed to indicate clearly whether or not trippers and base workers differ in these respects. The techniques available for these studies were either too insensitive to demonstrate any differences that might have occurred, or depended upon subjective decisions by the observer.

It was considered possible that some bees might begin foraging as trippers and change to base workers after the foraging method had been established. The fact that up to eight per cent of the apparently oriented bees observed foraging from only 2 to 10 blossoms worked as both trippers and base workers indicated that tripping bees with some experience as base workers were fairly numerous. It may be that some of these bees changed completely to the base working habit as their experience increased or as the nectar flow deteriorated. This conclusion is supported by the fact that in 1954 when the blossoms were difficult to trip (WEAVER, 1956 *b*) only one bee was observed to forage alternately as a tripper and base worker.

There is also opportunity for a bee that has never foraged except as a tripper accidentally to learn to forage as a base worker. In attempting to trip a blossom, a bee's tongue often slips down the side of the corolla tube between the petals of the standard and the keel. Instead of reaching the nectary from this position, all the bees observed, except one bee visiting one blossom, withdrew the tongue immediately and again attempted to trip the blossom. Several random observations, however, indicated that the base working habit may sometimes have been acquired in this manner. A few bees inserted the tongue at the mouth of the blossom, pushed the head far to the side and reached the nectary from the position normal to trippers, but without tripping the blossom. Others inserted the tongue in the same way, but then moved around and down the corolla tube while the tongue was in the blossom, and reached the nectary from the normal

position of base workers. One of these bees tripped over half of the blossoms before changing positions and foraging as a base worker.

It is believed that most of the trippers that had some experience as base workers, and possibly a few others, changed to base workers as the nectar flow deteriorated, that most of the nectar gathering trippers that did not make this change began foraging for both nectar and pollen or ceased to forage, and that different environmental factors influence trippers and base workers differently in causing them to change their foraging areas.

Summary.

The honeybee can reach the nectar from the mouth of the hairy vetch blossom by tripping it, or she can insert her tongue between the petals at the base of the corolla tube and reach the nectar. These non-trippers are called base workers. The foraging method is learned and becomes fixed through success at foraging from a very few blossoms in one manner during almost random attempts to reach the nectar. A slightly larger percentage of trippers reached the nectar by inserting the tongue to their right than to their left of the sexual column. There were never many bees in the field that foraged some blossoms as trippers and others as base workers, nor were there many that foraged for pollen only. When there was a good nectar flow early in the season there were few bees foraging as base workers, and the number of trippers foraging for nectar only was about equal to the number gathering both pollen and nectar. After a few days with a poor nectar flow the percentage of tripping bees gathering nectar only decreased sharply, the percentage gathering both nectar and pollen increased slightly, and the percentage of base workers increased sharply. There was a larger proportion of base workers in vetch with scattered blossoms than in vetch with numerous blossoms, and also a larger proportion of base workers in vetch with a heavy aphid infestation than in vetch in which these insects were controlled. During a poor nectar flow base worker gathered larger loads of nectar than trippers. To explain these observations, it is proposed that bees prefer to gather nectar which yields the greatest return in sugar per unit expenditure of energy, and that base workers expend less energy in foraging from blossoms than trippers. It is believed that base workers are more sensitive than trippers to competing foragers, and thus are more likely to be forced into areas with the least competition, that as the nectar flow deteriorates more trippers than base workers cease to forage, and that most of the bees that normally trip blossoms but have had some experience as base workers, and possibly some other trippers, begin to forage exclusively as base workers.

Sommaire.

L'Abeille peut atteindre par la bouche le nectar de la fleur de la vesce velue (*Vicia villosa*) en la " tripping " ou elle peut insérer la langue entre

les pétales à la base de la corolle et ainsi atteindre le nectar. Ces Abeilles " non-tripping " s'appellent les ouvrières de base. Cette méthode de butiner est apprise et devient fixe à cause du succès à butiner une petite quantité de fleurs d'une seule façon pendant pour ainsi dire des essais d'atteindre le nectar à l'aventure. Un pourcentage plus grand de " trippers " ont atteint le nectar en insérant la langue à droite de la colonne sexuelle que celles qui l'ont insérée à gauche. Il n'y avait jamais beaucoup d'Abeilles dans le champ qui butinaient les fleurs tantôt comme " trippers ", tantôt comme ouvrières de base. Il n'y avait pas non plus beaucoup d'Abeilles qui butinaient le pollen uniquement. Quand il y avait une bonne miellée dans la première partie de la saison, il y avait peu d'Abeilles butinant comme ouvrières de base, et le nombre d'Abeilles " tripping " butinant le nectar uniquement était à peu près égal au nombre recueillant et le nectar et le pollen. Après quelques jours d'une miellée pauvre, le pourcentage des Abeilles " tripping " recueillant le nectar uniquement diminuait nettement, le pourcentage des Abeilles recueillant et le nectar et le pollen augmentait un peu, et le pourcentage des ouvrières de base augmentait nettement. Il y avait une plus grande proportion d'ouvrières de base dans la vesce aux fleurs dispersées que dans la vesce aux nombreuses fleurs, et aussi une plus grande proportion d'ouvrières de base dans la vesce infestée d'Aphides que dans la vesce dans laquelle les insectes étaient maîtrisés. Pendant une miellée pauvre, les ouvrières de base ont recueilli de plus grandes quantités de nectar que les " trippers ". Pour expliquer ces observations, il pense que les Abeilles aiment mieux recueillir le nectar qui donne le plus grand renvoi de sucre par unité d'énergie dépensée et que les ouvrières de base dépensent moins d'énergie à butiner les fleurs que les " trippers ". Je crois que les ouvrières de base sont plus sensibles que les " trippers " à la concurrence des autres butineuses et, donc, peuvent être plus facilement obligées d'aller dans les sections moins compétitives, que plus de " trippers " que d'ouvrières de base cessent de butiner quand la miellée s'amenuise, et que la plupart des Abeilles qui " trip " les fleurs habituellement, mais qui ont un peu d'expérience comme ouvrières de base, et, probablement quelques autres " trippers ", commencent à butiner exclusivement comme ouvrières de base.

Zusammenfassung.

Die Honigbiene kann vom Munde der behaarten rauhhaarigen Wickenblüte (*Vicia villosa*) aus an den Nektar kommen, indem sie die Blüte oben aufschnellen läßt, oder sie kann den Rüssel, zwischen den Blütenblättern am unteren Ende der Korollenröhre hindurchzwängen und so den Nektar erreichen. Diese Blüten nicht schnellenden öffnenden Arbeitsbienen nennt man Bodenarbeiterinnen. Die Sammelmethode wird erlernt und beibehalten durch erfolgreiches Sammeln nach derselben Methode an einigen wenigen Blüten bei fast planlosen Versuchen, den Nektar zu erreichen Ein

etwas größerer Prozentsatz von blutenschnellendern Bienen erreichten den Nektar, indem sie den Rüssel rechts statt links an dem Stempel vorbeizwängten. Es gab nur wenige Bienen im Felde, die einige Blüten als Schnellerinnen, andere Blüten dagegen als Bodenarbeiterinnen besuchten; auch waren nicht viele da, die nur Pollen einsammelten. Bei reichlicher Nektartracht im Frühjahr gab es nur wenige Bodensammlerinnen, und die Anzahl von Schnellerinnen, die nur Nektar sammelten, war etwa der Anzahl derer gleich, die sowohl Nektar als auch Pollen sammelten. Nach ein paar Tagen mit schlechtem Nektarertrag ging der Prozentsatz von schnellenden Nur-Nektar-Sammlerinnen stark zurück ; der Prozentsatz von Bienen, die zugleich Nektar und Pollen sammelten, nahm um ein weniges zu ; und der Prozentsatz von Bodensammlerinnen erfuhr eine starke Erhöhung. Es wurden mehr Bodensammlerinnen in Wicken mit verstreuten Blüten festgestellt als in denen mit zahlreichen Blüten. Dasselbe gilt für Wicken, die stark mit Blattläusen verseucht sind, gegenüber solchen worin die Schädlinge im Zaum gehalten werden. Wenn wenig Nektar erzeugt wird, sammeln die Bodensammlerinnen mehr Nektar als die Schnellerinnen. Um diese Beobachtungen zu deuten, folgern wir so : die Bienen sammeln am liebsten da, wo die größte Ausbeute an Zucker je Einheit Energieverbrauch zu erzielen ist, und die Bodensammlerinnen verbrauchen weniger Energie beim Besuch der Blüten als die Schnellerinnen. Man glaubt weiter, daß die Bodenarbeiterinnen konkurrierenden Insekten gegenüber empfindlicher als die Schnellerinnen seien, und daß sie so mit größerer Häufigkeit gezwungen werden, Gebiete mit wenigern Konkurrenten zu besuchen ; daß wenn die Tracht versiegt, mehr Schnellerinnen als Bodenarbeiterinnen zu sammeln aufhören, und daß die meisten Bienen, die normalerweise zu den Schnellerinnen gehören, aber außerdem etwas Erfahrung als Bodenarbeiterinnen haben (und vielleicht auch einige andere Schnellerinnen) jetzt ausschließlich als Bodenarbeiterinnen zu sammeln anfangen.

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