

SOME FACTORS AFFECTING THE HONEY STOMACH CONTENTS
OF WORKER HONEY BEES (Apis mellifera L.)

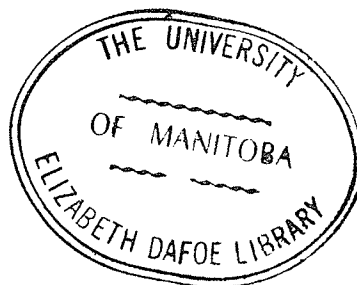
A Thesis

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Master of Science

by

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ABSTRACT

Various factors were studied in the field and in the laboratory to ascertain their effects on the weights of honey stomachs of worker honey bees.

Methods were devised for killing bees instantly, to prevent regurgitation of food from the honey stomach or its passage backwards to the midgut, and for removing honey stomachs from the bees.

Factors which were thought to influence the weight of honey stomachs were examined in the following experiments:

(a) groups of bees of various ages were removed from a hive and either starved or fed continuously or first starved for various time periods and then fed for 0.5 hours.

(b) groups of bees of various ages were fed with high or low concentration honey solutions continuously or for various time periods followed by various periods of starvation.

(c) groups of 5 bees of various ages were supplied with food and allowed to feed groups of 25, 50, or 100 bees of various ages through a screen for various time periods.

(d) groups of bees were collected on given days from hives at 900-1000, 1300-1400, and 1700-1800 hours throughout the spring and summer season. They were collected on open and sealed honey comb cells, on

open and sealed brood cells, when leaving the hive, and when returning to it with loads of nectar and/or pollen.

It is concluded, from these experiments, that ages, length of feeding and starvation periods, sugar concentration of food, position of bees on various combs in the hive, foraging activities, season, time of day, honey flows, and the feeding of large groups of bees by small ones affects the weights of honey stomachs of worker honey bees.

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CHAPTER I
INTRODUCTION

1

The transfer of regurgitated material from the honey stomachs of bees, in the form of water, nectar, honey, and probably glandular secretions, occurs commonly between adult members of honey bee colonies. Some or all of these materials may be transferred from worker to worker or from worker to queens and drones.

Recently, this transfer of materials between adult workers has been shown to be important in feeding, recruitment of foragers, defense, interattraction of workers, colony cohesion, division of labour, and in the sharing of certain chemical materials (e.g. "queen substance") which affect colony life.

Although several studies, relating to the extent and frequency of food transfer in colonies as well as the behavioral patterns used during transfer have been done little data are available concerning the factors which affect the amount of food held in the honey stomachs of workers. One problem that has made studies of food transfer difficult is that it has not been easy to predict with reasonable accuracy what amount of food a bee has in its honey stomach according to its age and its previous treatment.

In this thesis various factors (e.g. length of feeding and starvation periods, sugar concentration of foods, position of bees on various combs in the hive, age, foraging duties, season, time of day, honey flows, feeding of large groups of bees by small groups) which might affect the amount of food in the honey stomachs of bees were examined both in the field and in the laboratory.

REVIEW OF LITERATURE

Free (1959) reviewed the literature about the transfer of food between the adult members of a honey bee colony(i.e. trophallaxis); a summary of this review, is given below.

Food transfer by honey bees was first observed by Doolittle (1890, 1907); he noticed that most nectar gatherers with loaded honey stomachs, on returning to their hive, passed the nectar to house bees, and did not deposit the nectar directly into storage cells. Park (1923) found that in a small colony, when some workers were allowed to collect coloured water, that the next day about 50% of the workers of the colony had coloured abdomens, indicating that the coloured water had been distributed among them. Nixon & Ribbands (1952) trained 6 workers to a dish from which the worker collected 20 ml. of sugar syrup containing radioactive phosphorus. The distribution of radioactivity among the bees was then studied; the results showed that 62% of the foragers and 16-21% of all the workers were radioactive within 4 hours, and 76% of the foragers and 43-60% of all workers were radioactive within 27 hours. The nurse bees were significantly less radioactive than the foragers. This widespread radioactivity indicated oral transmission of the syrup rather than spread by external contact, since

heads, legs and wings of radioactive bees were not themselves radioactive. The food which is transferred is water, nectar, or honey regurgitated from the honey stomach, but on some occasions it may also be glandular secretions.

Food transmission helps the community to feed itself. The larvae are fed by workers, but there is no indication that larvae pass any material to the adult honey bees (Lindauer, 1952).

The transfer of food between two worker bees, as Free (1957) described it, starts by one of them either soliciting or offering food to the other. When a bee is soliciting food, she thrusts her tongue toward the mouth-parts or some part of another bee's body. A bee who offers food opens her mandibles and regurgitates a drop of fluid between the mouth-parts. Free (1956) found that offering and begging behaviour is directed more to the head than to other parts of the body.

Lindauer (1954) and Free (1956) found that during feeding, both giver and receiver stroked each other actively with their antennae; the antennae of both the giver and receiver of food are usually in constant motion and are continually coming into contact. The antennae appear to be very important in releasing both soliciting and offering behaviour (Free,

1956) in honey bees.

Rösch (1925) found that a worker bee which is younger than 3 days old obtains all of its food directly from other bees, and does not feed itself with food from the storage cells. Perepelova(1928) found that bees 1-3 days old were fed by others whose age ranged from 7 to 14 days, but Free (1957) found that there was a wide variation in the ages of bees which fed young bees. Istomina-Tsvetkova (1953) found that bees of all ages (including those 1-3 days old) both give food to, and receive food from other bees; there was no definite age sequence.

Both Free (1959) and Istomina-Tsvetkova (1953) agree that bees, 1 and 2 days old, give food as well as receive it, but such bees do not give it as frequently as older bees. However, Pershad (1966) found that within groups of the same age and from the same colony, there was no food exchange between bees 1 day old; exchange reached a maximum at 4 days. Free (1959) suggested that as a consequence there was a tendency for food to pass from the older to the younger bees. Almost all of the older workers were foragers, which passed their nectar loads to the younger house bees. Free (1957) also found that there was a tendency for food to be transferred between two bees of about the same age. This may in part account for the fact that Nixon & Ribbands (1952) had found in their experiment

that the proportion of radioactive individuals was greater among the foragers than among the house bees.

Delvert-Salleron (1963) found that in the first 48 hours worker kept in cages, fed their sisters rather than bees from another colony; after this no preference appeared to be shown. This fits in with Pershad's (1967) observation that during the first 24 hours, food transmission was more frequent between bees of the same origin than between bees of different origins.

In general in the transfer of food, the giver has a fuller honey stomach than the receiver. But there is sometimes an overlap in the amount of food in the honey stomachs of both giver and receiver. Whether a bee offers, or begs for, food is certainly not governed entirely by the amount it possesses in its honey stomach but may be influenced by several factors (Free, 1959). When bees perform duties such as brood rearing and wax production, or when they are on the outside of a winter cluster, they normally retain large amounts of food in their honey stomachs.

Istomina-Tsvetkova (1958) found that the amount of food which foragers retain in their honey stomachs after passing some of it to house bees depends upon the length of their next flight.

Free (1959) suggested that the amount of food which different bees have in their honey stomachs when they are willing to give or receive it probably also depends upon their previous experience; for example, previous starvation, subsequently caused them to retain more food than those bees which had been well fed.

Istomina-Tsvetkova (1957, 1958) found that there was a direct relationship between the number of times a bee exchanged food with other bees and the number of times it visited larvae. When brood rearing was reduced, there were fewer exchanges of food, and these exchanges showed no diurnal variation. There was also a positive relationship between the duration of feeding contacts and the quantity of food transferred.

Food transmission among the members of a bee colony sometimes serves as a form of communication. A small amount of nectar given by a returning forager to potential foragers within the hive informs them of the quality of the forage they are to seek (Frisch, 1946). Johnson & Wenner (1966) found that conditioned bees can be recruited to a food source in the field, by giving them a small amount of the food (or just

the scent of the food) carried by the returning foragers (see also Frisch, 1968). The experienced bees which attend dancers are recruited to the source at which they had earlier success and not necessarily to locations indicated by the dance information (Johnson, 1967).

Ribbands (1952) suggested that in the honey bee community food transmission is the foundation of both division of labour and mutual recognition. Worker bees can recognize their hivemates by the distinctive odour which is given out from the scent gland. Sharing of food among workers ensures that the aromatic waste products of their metabolism are similar, thus facilitating the defence of the community against either robbers or social parasites (Ribbands, 1953).

Butler (1954) showed that "queen substance" circulates through the whole colony by food transmission, and inhibits the development of the ovaries of worker bees and the building of queen cells.

CHAPTER III

GENERAL METHOD

A. METHOD OF KILLING BEES

In all experiments, each bee must be killed before the honey stomach (crop, or honey sac) is taken out and weighed. After any test, the bees in the same group, or different groups in the same test, must be killed at precisely the same time; this is done to avoid any variation in honey stomach contents between bees which are killed last and those which are killed first. It is also necessary to use a method which kills the bees instantly so that regurgitation, or passage of the contents of the honey stomach into the midgut, does not occur due to the method itself.

Five different methods of killing bees were tested with the above in mind. These were:

1. Cyanide gas method
2. Carbon dioxide gas method
3. Freeze method (temperature -20° to -30°C)
4. Dry ice method (temperature -60° to -70°C)
5. Liquid nitrogen method (temperature -195°C)

Four different ages of bees were used in each experiment (2, 7, 14, and 21 days old). In order to obtain large number of bees of the same age, several frames of emerging young bees were put into an incubator with the temperature at about 35°C . After 24

hours, the emerged young bees were marked and put back into a hive in the field. Much time and labour can be saved if one does not have to mark the bee; thus only yellow strains of bees kept in a black strain colony, were used in each experiment. A certain number of yellow bees were taken out from the black strain colony when they were 7 days old, 14 days old, etc. as required. Ten black strain colonies were used in turn in the summer for the purpose of obtaining bees of the same age.

Before each experiment, the bees of the different ages were collected from the hive in the morning (900-1000 hours), and were starved for 2 hours in a plastic cage (5 x 7.5 x 10 cm., Figure 1); they were then fed for 30 minutes with a 50% honey and water solution with carmine dye added. The feeder consisted of a glass tube (0.8 cm. in diameter) located on the top of the cage. All of the cages were kept in the laboratory at room temperature with the lights left on.

Twenty bees of the same age were used in each test. After the bees were killed ten bees, selected at random, were examined for regurgitation first, and the other half were dissected and examined for passage of food into the midgut. If the percentage of bees regurgitating food for all ages combination was high (i.e. arbitrarily set at 30%) then the other 10 bees per test were not

dissected.

Each test was replicated six times in this experiment, except for the 2 day old bees which were replicated only 3 times.

After being killed, the bees were transferred to petri dishes, sealed in a plastic bag, and kept in the deep freezer at a temperature of -30°C . for 1-3 months. The bees can be kept for several months in this condition with little desiccation or change of honey stomach tissues.

1. CYANIDE GAS METHOD

The poisonous gas of calcium cyanide (free-flowing powder) was introduced into a cage with 20 bees in it, and in each test the bees were killed within 2 minutes. After the bees were killed, they were checked for regurgitation. The results are shown in Table 1. Because the percentage of regurgitation was higher than 30% for all ages combined, the passage of food into the midgut was not checked.

Table 1. Movement of food from the honey stomachs of bees killed with cyanide gas (Total number of bees per age group is 120, except only 60 in 2 day old group)

movement of food from		age of bees (days)				Total	%
honey stomach	2	7	14	21			
Foreward	3	15	33	26	75	36	
Backward	-	-	-	-	-	-	

2. CARBON DIOXIDE GAS METHOD

Carbon dioxide gas was introduced into the cage containing 20 bees, after the cage was sealed in a plastic bag. After 2 minutes all of the bees were anaesthetized. The results (Table 2.) show that the percentage of regurgitation for all age combined was higher than 30%.

In both the cyanide and carbon dioxide methods, a few bees will recover within 3-5 minutes from the effects of the gas.

Table 2. Movement of food from the honey stomach of bees killed with carbon dioxide gas (Total number of bees per age group ; 120) *

movement of food from honey stomach	Age of bees (days)				Total	%
	2	7	14	21		
Foreward	24	25	17	23	89	43
Backward	-	-	-	-	-	-

3. FREEZE METHOD

The cages containing the bees were kept at -20° to -30°C . Twenty minutes were required to kill all of the bees, because they clustered and kept warm for a short period of time. The results are shown in Table 3. More than 30% of bees of all ages combined regurgitated.

Table 3. Movement of food from the honey stomach of bees killed with freezer method (Total number of bees per age group : 120) *

* except only 60 in 2 day old group

Table 3.

Movement of food from honey stomach	Age of bees (days)				Total	%
	2	7	14	21		
Foreward	15	38	30	35	118	56
Backward	-	-	-	-	-	-

4. DRY ICE METHOD

A thermos jug containing small pieces of dry ice in a 95% alcohol water mixture will lower the temperature to -60° to -70°C . A test tube was put into the wide mouth thermos jug. After the air temperature in the test tube reached that of the dry ice alcohol mixture, the bees were transferred from the cage into the test tube; they were killed by this low temperature in about 1 minute. If the bees were kept in the test tube longer than 5 minutes, they become very hard and broke easily when being transferred from the test tube to the petri dish. In this study no bee was kept in the test tube longer than 3 minutes.

The results are shown in Table 4. The percentage of bees of all ages combined which either regurgitated or passed food into their guts was lower than 30%.

Table 4. Movement of food from the honey stomach of bees killed with dry ice method (Total number of bees per age group : 120)*

movement of food from honey stomach	Age of bees (days)				Total	%
	2	7	14	21		
Foreward	5	10	9	14	38	18
Backward	1	5	4	7	17	8

5. LIQUID NITROGEN METHOD

Liquid nitrogen produces a temperature as low as $-195^{\circ}\text{C}.$, but it evaporates very quickly when the container is warm or when air currents pass over it. Therefore it is best used in the laboratory rather than in the field.

The bees appear to be killed by liquid nitrogen in less than 1 second. The cage, screened on both sides and containing bees, was dipped into the liquid nitrogen for 1 or 2 seconds in this study. The bees break into pieces if the cage is dipped into the liquid nitrogen for longer than 3 seconds.

The results are shown in Table 5. Very few bees were found to have regurgitated or to have red honey in their guts caused by this method

Table 5. Movement of food from the honey stomach of bees killed with liquid nitrogen method (Total number of bees per age group : 120) *

* except only 60 in 2 day old group

Table 5.

movement of		Age of bees (days)			Total	%
food from	honey stomach	2	7	14		
				21		
Foreward	0	0	1	2	3	1
Backward	1	0	1	1	3	1

SUMMARY

Five methods of killing bees were tested (See Table 1-5), these were: cyanide gas method, carbon dioxide method, freeze method, dry ice method and liquid nitrogen method. The first three methods caused a high number of bees to regurgitate (more than 30%); using dry ice and liquid nitrogen 18% and 1% of the bees respects regurgitated and 8% and 1% of the bees respects passed food into their guts.

According to the results, the liquid nitrogen method gave the lowest percentage of regurgitation, or passage of food into gut, but due to the practical difficulties of using it (i.e. its rapid rate of evaporation), this method was used only in the laboratory and the dry ice method was used in the field during the summer of 1968.

B. METHOD FOR REMOVING AND WEIGHING HONEY STOMACHS

After the bees are taken out of the deep freezer, it takes between 15 to 20 minutes to soften the hard, frozen bodies for dissection. There are two ways to remove the honey stomach from the abdomen of bees:

1. Removal of the honey stomach through the anterior end of the abdomen (Figure 2.).
2. Removal of the honey stomach through the posterior end of the abdomen (Figure 3.).

The first method is used when the bee has an empty honey stomach or a small amount of food (less than 5 mg.) in the honey stomach, and the second method is used when the bee has a large amount of food (more than 20 mg.) in the honey stomach.

Usually one can differentiate between a bee with a full or empty honey stomach as follows: The full bee has a round, distended abdomen, due to the full honey stomach located within the first two or three segments of the abdomen. When viewed from the ventral side of abdomen, the size of the honey stomach can be estimated fairly well with practice. The starved or empty bee does not have a round, distended abdomen, and the abdominal segments are telescoped together. (Figure 4.).

After being removed from the abdomen, the honey stomach is put on a precision torque balance and weighed. This weighing should be done within 10 seconds as the honey stomach will dry quickly when exposed to the air.

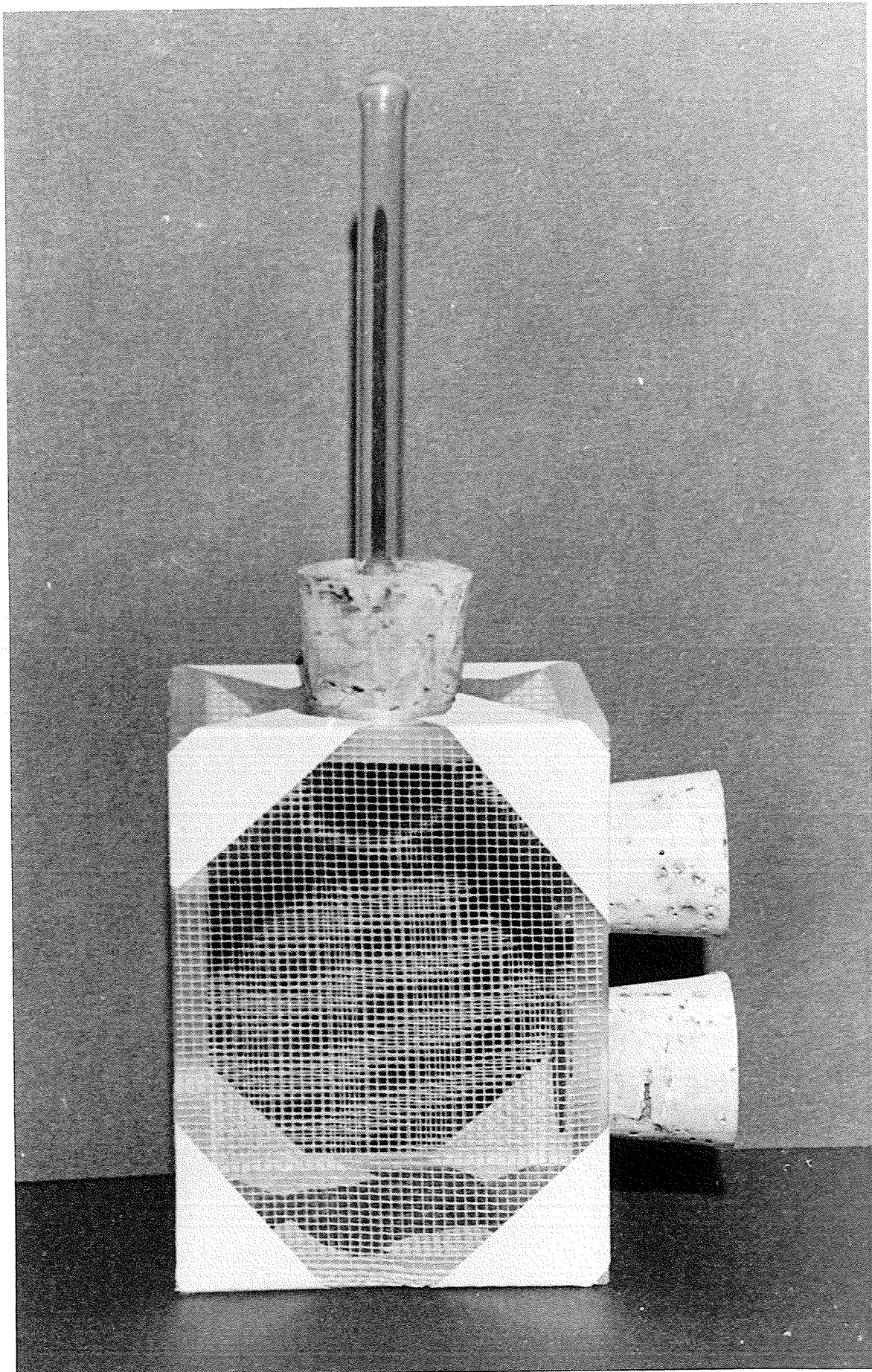


Figure 1 Standard plastic cage with glass tube feeder and screened sides used in most experiments

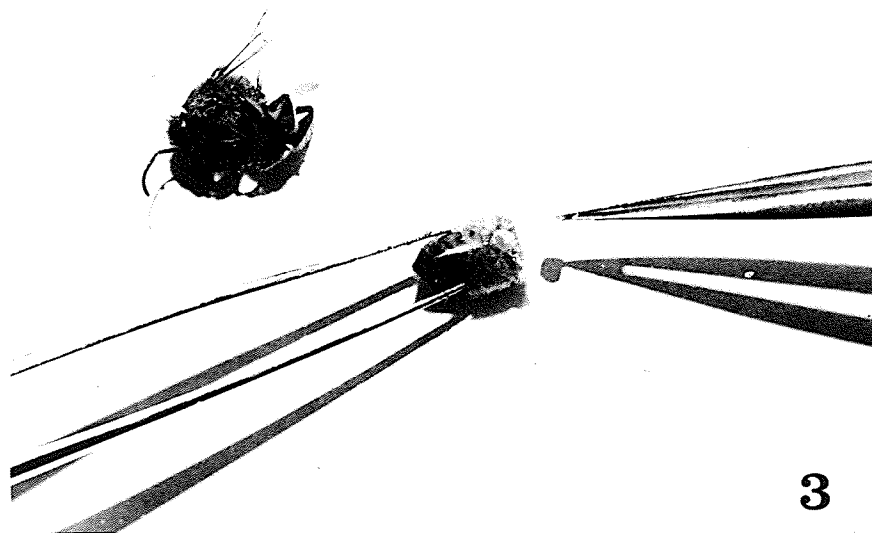
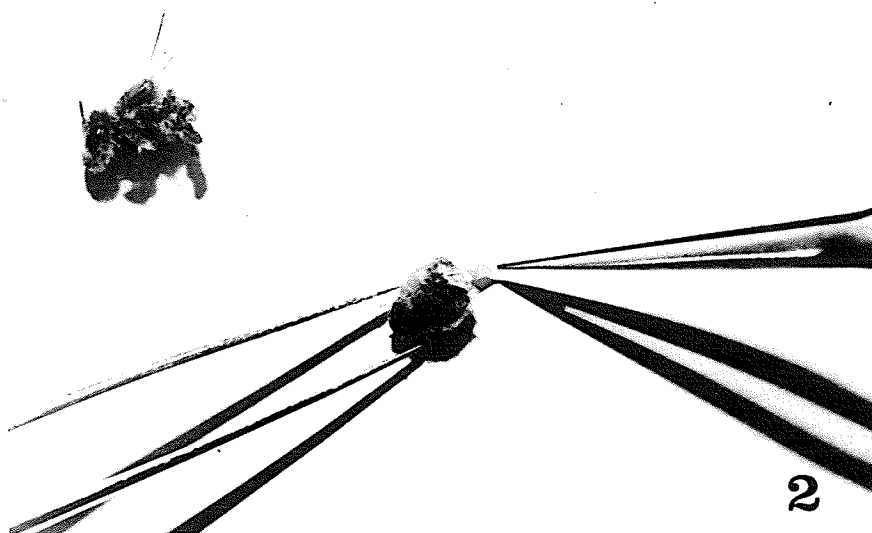
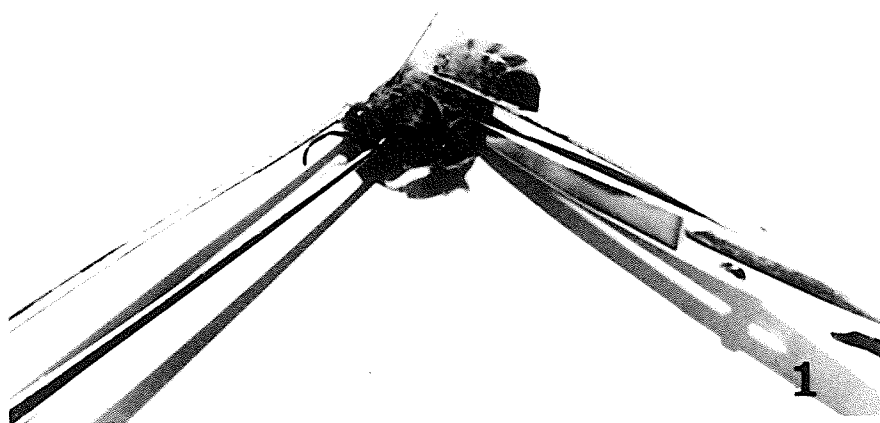
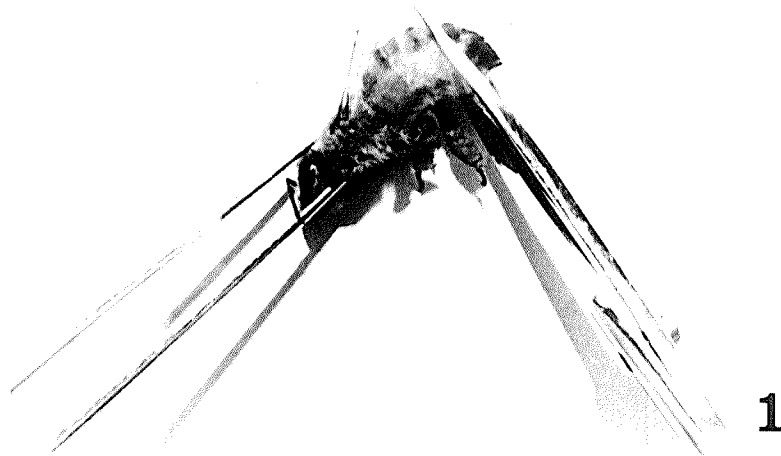
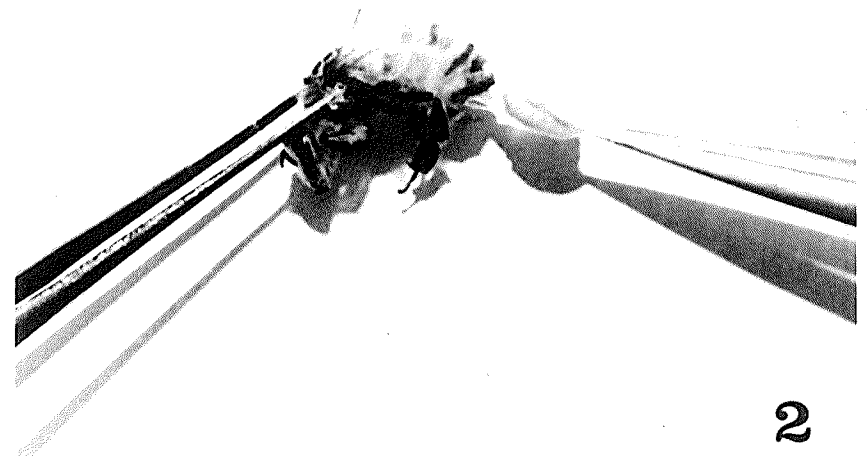


Figure 2 Method of removing the honey stomach through the anterior end of the abdomen after the abdomen has been separated from the thorax



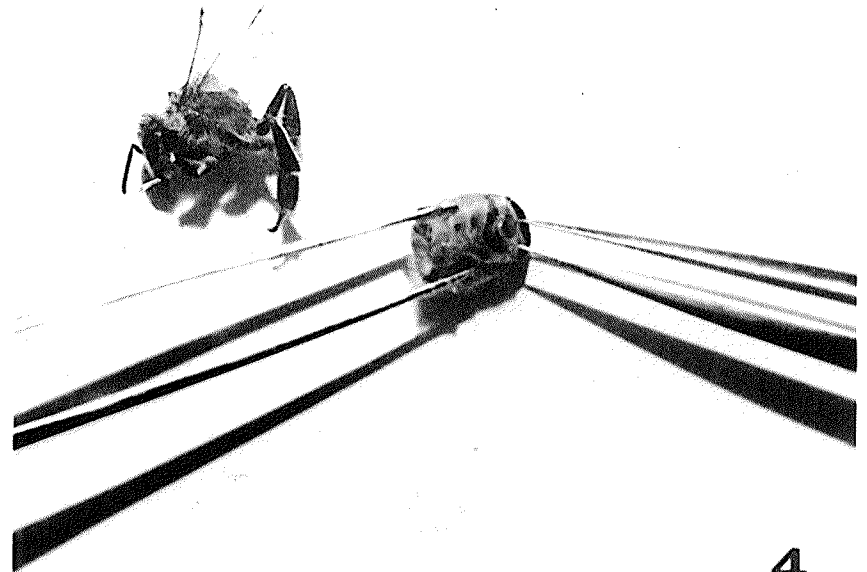
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2



3



4

20

Figure 3 Method of removing the honey stomach through the posterior end of the abdomen after the tip of the abdomen has been removed and it has been separated from the thorax

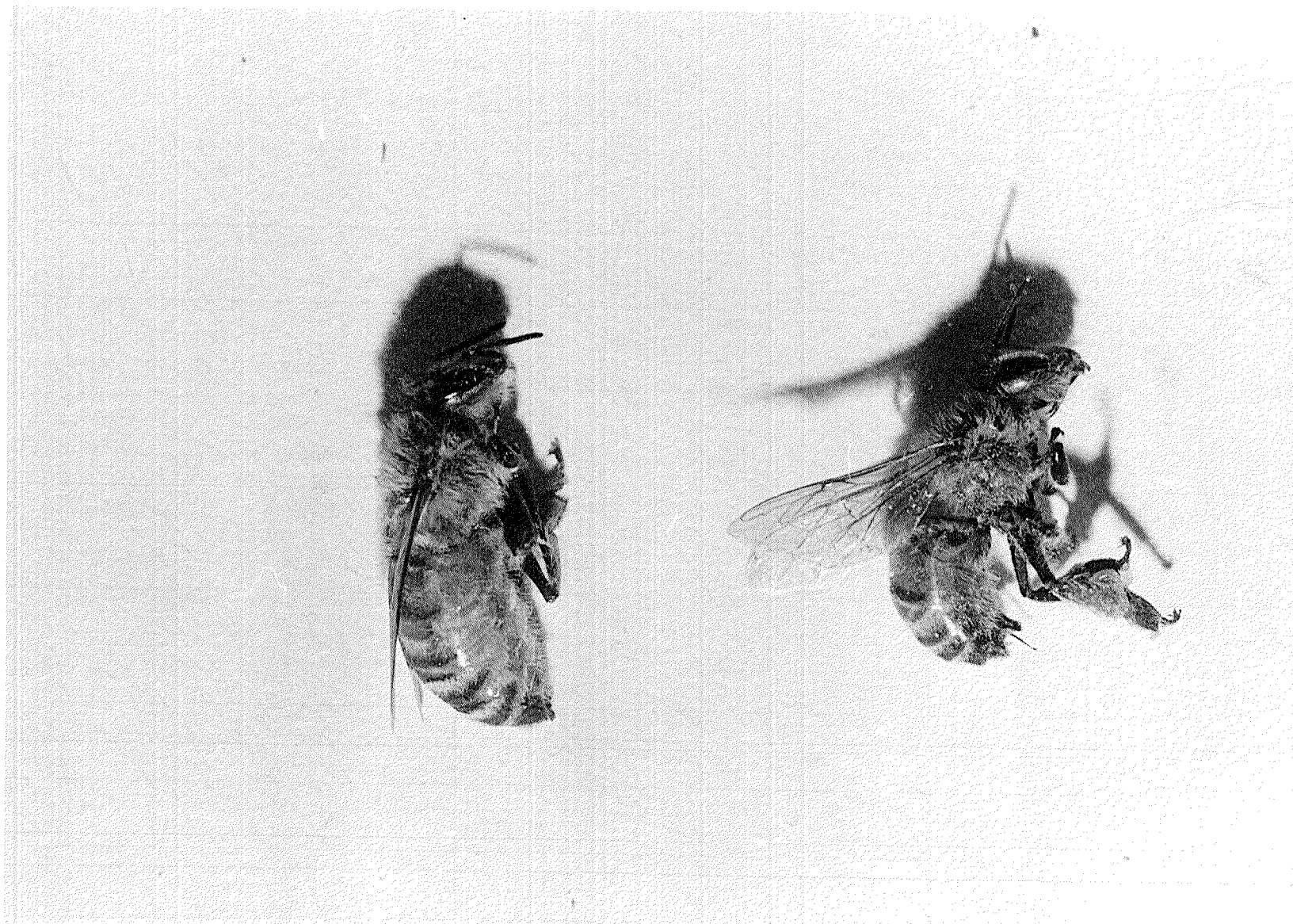


Figure 4 Comparative size of bees with full and empty honey stomachs

CHAPTER IV

EFFECT OF STARVATION ON HONEY STOMACH CONTENTS

INTRODUCTION

Laboratory experiments involving the transfer of food between adult worker bees are best done with bees which have large amounts of food in their honey stomachs and bees with small amounts. This is because the transfer of food occurs most readily between bees with full and bees with empty honey stomachs. The experiments are best conducted however when one knows, within narrow limits, what amount of food a given bee carries in its honey stomach and what its age is before any given experiment is begun.

The following experiments were done in an attempt to ascertain what effect age and starvation has on honey stomach weights and in an attempt to predict what amount of food a bee might contain in its honey stomach according to its age and various periods of food supply.

A different set of bees, 2, 7, 14, and 21 days old, were used in each of the tests described below. During the testing period, bees of the same age, from the same hive, were collected at random from the combs at the same time (900-1000 hours).

After the bees were removed from the hive, 25 bees were dissected for each replicate and the weight of their honey stomachs recorded.

Three different types of tests were done:

- A. Continuously starved
- B. Continuously fed
- C. Starved first for various periods of time and then fed for 30 minutes

Each test contained 100 bees of the same age in four cages, 25 bees per cage. In both tests A and B, the bees of one cage were dissected and their honey stomachs weighed after they had been removed from the hive 2 hours. This procedure was repeated at 4, 6, and 8 hours also. In test C, the bees in the first cage were dissected after they had been starved for 1.5 hours followed by a 0.5 hours feeding, the second, third, and fourth cages of bees were dissected after they had been starved for 3.5, 5.5, and 7.5 hours respectively followed by a 0.5 hours feeding. In both tests B and C the bees were fed with a 50% honey and water solution with carmine dye added. Each test was replicated 3 times.

RESULTS

The results are shown in Table 6, 7, and 8 and in Figures 5, 6, and 7. Generally speaking when

older bees (14 and 21 days old) were first removed from the hive they had more food in their honey stomachs than did the younger ones (2 and 7 days old) (See Table 6.).

In test A, where the bees were continuously starved, the honey stomach weights of the bees of all ages tended to drop off at about the same **rate** except for the honey stomach weights of the 14 **day** old bees which were starved for 4 hours after removal from the hive (see Figure 5.). Mortality of bees occurred among the 21 day old bees; 43 out of the 75 (3 replicates x 25 bees) bees were moribund at 6 hours and therefore were not dissected and 70 out of 75 (3 replicates x 25 bees) bees were dead or moribund at 8 hours and were not dissected.

To obtain bees with low amounts of food in their honey stomachs (i.e. less than 5 mg.) for experimental purpose, 2 day old bees can be used at about 2 hours, 7 day old bees at 4 hours, 14 day old bees at 8 hours and 21 day old bees at 8 hours.

In test B, inspite of being fed continuously, the amount of food in the honey stomach of the bees, tended to decrease at about the same rate for the first 2 hours for all ages and thereafter at the same rate for the 2 and 7 day old bees (except for the 7 day old bees at 2 hours).

The younger bees in test B kept less food in their honey stomachs than the older bees. The amount of food in the honey stomachs of the 14 and 21 day old bees increased after 2 and 4 hours respectively but for the younger bees, 2 and 7 days old it increased after 4 and 6 hours respectively (see Figure 6.). There is a greater variation in the amount of food in the honey stomachs of older bees than in those of the younger ones (see Table 7.).

The results of test C, (when bees were starved for various periods followed by a 0.5 hours feeding) showed that the different age groups behave quite differently to the same treatment. In the first treatment (1.5 hours starvation followed by a 0.5 hours feeding), the honey stomachs of each age group, except for those of the 2 day old bees increased in weight. In the last treatment (7.5 hours starvation followed by a 0.5 hours feeding), the honey stomachs of each age group lost weight (except for the 14 day old bees). Between these two time limits the weights of the honey stomachs varied considerably although it was evident that the younger bees held less food than did the older ones (see Figure 7.). Some of the 21 day old bees died during the test; 7 out of the 75 bees were

moribund at 6 hours and therefore were not dissected and 34 out of the 75 bees were dead or moribund at 8 hours and were not dissected.

DISCUSSION AND CONCLUSIONS

Whether or not bees were kept in the hive or in a cage, the older ones (14 and 21 days old) tended to have more food in their honey stomachs than the younger ones (2 and 7 days old). It is not known why the older bees have more food than the younger ones in the hive unless it is directly related to the duties they are performing when taken from the hive (e.g. foraging for nectar). However, this does not explain the tendency in older caged bees.

Different age groups of bees showed considerable variation in weight of honey stomachs; the older bees had a greater variation in the amount of food in their honey stomachs than did those of the younger bees. Possibly this is because the older bees had more food in their honey stomachs to start with, which allowed for a greater range in weight to occur. Earlier Free (1957) found a wide range in the amount of food in the honey stomachs of bees of mixed ages both when they were removed from their hive as well as after they had received similar treatment.

In test A, as expected, after the bees had been removed from their hive and had been starved for various periods, the honey stomach weights of all ages of bees decreased in proportion to the length of the starvation periods. The 14 day old bees dissected after 4 hours starvation were the exception and this may have been due to some of the bees in this particular cage of 14 day old bees having slightly more food than the bees in other cages when collected from the hive.

In test B when bees were continuously fed, all age groups of bees, for some unknown reason, did not maintain a steady supply of food in their honey stomachs; this is particularly true of the older bees.

Free (1957) found that among bees of mixed ages, previous starvation caused them to retain more food in the honey stomachs after 24 hours feeding than control bees which were continuously fed. He also found that constant and plentiful supply of food caused the bees to retain less food in the honey stomachs.

The results of Test C are difficult to explain, when bees were starved for various periods followed by a 0.5 hours feeding; in the younger bees (2 days old) there was a tendency that the longer the starvation period, the more food the bees took. Among 21 day old

bees, there was a sharp reduction in honey stomach weights when bees were starved longer than 3.5 hours, probably because some of the bees were dying of hunger and were too weak to take any food in the following 0.5 hours feeding period. Among the 14 day old bees, there was an unexplained tendency for them to take more food when the starvation period was longer (except for the 3.5 hours starvation period followed by a 0.5 hours feeding).

To obtain bees with small amounts of food in their honey stomachs (i.e. less than 5 mg.) for experimental purposes, 2 day old bees can be used after about a 2 hours starvation period, and 7, 14, and 21 day old bees can be used after about a 4, 8, and 8 hours starvation period respectively. To obtain bees with a minimum of 10 mg. of food in their honey stomachs for experimental purposes, only 14 day old bees can be used according to the treatments in test B and C.

It is concluded that age, length of various periods of feeding, and starvation are at least partly responsible for the amount of food in the honey stomachs of worker honey bees. The weight of honey stomachs can be predicted when test A is used and one requires a low amount (less than 5 mg.) of

food in the honey stomachs of bees of various ages for experimental purposes. However, due to the large variation in honey stomach contents of the bees of various ages and in various tests one can not accurately predict which bees have large amount (i.e. more than 20 mg.) of food in their honey stomachs.

TABLE 6

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN STARVED

Replicates		Age (days) of Bees									
		0**	2				7				
			2	4	6	8	0	2	4	6	8
*I	Total wt.	209	25	26	25	25	536	25	25	25	25
	Mean	8.4	1.0	1.0	1.0	1.0	21.4	1.0	1.0	1.0	1.0
	Range	1-38	1	1-2	1	1	1-40	1	1	1	1
II	Total wt.	193	25	35	25	25	87	315	25	25	26
	Mean	7.7	1.0	1.4	1.0	1.0	3.5	12.6	1.0	1.0	1.0
	Range	1-30	1	1-6	1	1	1-31	1-41	1	1	1-2
III	Total wt.	103	25	26	25	25	242	278	25	25	25
	Mean	4.1	1.0	1.0	1.0	1.0	9.7	11.1	1.0	1.0	1.0
	Range	1-19	1	1-2	1	1	1-29	1-38	1	1	1
***	Total wt.	505	75	87	75	75	865	618	75	75	76
	Mean	6.7	1.0	1.2	1.0	1.0	11.5	8.2	1.0	1.0	1.0
	S.D.	8.4	0	.4	0	0	11.8	9.8	0	0	.1
	Range	1-38	1	1-6	1	1	1-40	1-41	1	1	1-2

*25 bees per sample

**Hours after removal from hive

***Total of 75 bees

S.D. Standard deviation

continued ...

TABLE 6 (continued)

Replicates		Age (days) of Bees									
		14					21				
		0**	2	4	6	8	0	2	4	6	8
*I	Total wt.	698	333	345	236	29	634	375	260	234/22	6/3 bees
	Mean	27.7	13.3	13.8	9.4	1.2	25.4	15.0	10.4	10.6	2.0
	Range	5-45	1-35	1-39	1-30	1-2	3-47	2-41	1-40	1-37	1-2
II	Total wt.	784	280	422	223	27	699	239	122	33/8	0
	Mean	31.4	11.2	16.9	8.9	1.1	28.0	9.0	4.9	4.1	0
	Range	8-51	1-35	1-60	1-25	1-2	3-66	1-28	1-16	1-8	0
III	Total wt.	425	517	416	291	27	663	382	400	8/2	4/2 bees
	Mean	17.0	20.7	16.6	11.6	1.1	26.5	15.3	16.0	4.0	2.0
	Range	3-54	1-46	1-39	1-28	1-2	9-50	1-49	1-43	1-6	1-2
***	Total wt.	1907	1130	1183	750	83	1996	996	782	275/33	10/5 bees
	Mean	25.4	15.1	15.8	10.0	1.1	26.6	13.3	10.4	8.6	2.0
	S.D.	13.2	13.2	12.1	8.0	.3	15.0	10.4	10.3	9.8	0
	Range	3-54	1-46	1-60	1-30	1-2	3-66	1-49	1-43	1-37	1-2

* 25 bees per sample

** Hours after removal from hive

*** Total of 75 bees

S.D. Standard deviation

TABLE 7

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN FED CONTINUOUSLY

Replicates			Age (days) of Bees								
			2				7				
		0**	2	4	6	8	0	2	4	6	8
*I	Total wt.	209	133	78	102	47	536	330	234	112	412
	Mean	8.4	5.3	3.1	4.1	1.9	21.4	13.2	9.4	4.5	16.5
	Range	1-38	1-22	1-13	1-13	1-12	1-40	1-37	1-28	1-20	3-42
II	Total wt.	193	132	75	109	58	87	288	175	122	153
	Mean	7.7	5.3	3.0	4.4	2.3	3.5	11.5	7.0	4.9	6.1
	Range	1-30	1-18	1-12	1-12	1-12	1-31	1-43	1-28	1-23	1-22
III	Total wt.	103	98	101	78	50	242	271	211	141	145
	Mean	4.1	3.9	4.0	3.1	2.0	9.7	10.8	8.5	5.6	5.8
	Range	1-19	1-10	1-17	1-11	1-14	1-29	1-29	1-28	1-27	1-14
***	Total wt.	505	363	254	289	155	865	889	620	375	710
	Mean	6.7	4.8	3.4	3.9	2.1	11.5	11.9	8.3	5.0	9.5
	S.D.	8.4	4.2	3.0	3.0	2.6	11.8	9.5	7.6	5.6	8.8
	Range	1-38	1-22	1-17	1-13	1-14	1-40	1-43	1-28	1-27	1-42

* 25 bees per sample

** Hours after removal from hive

*** Total of 75 bees

S.D. Standard deviation

continued ...

TABLE 7 (continued)

Replicates		Age (days) of Bees									
		14					21				
		0**	2	4	6	8	0	2	4	6	8
*I	Total wt.	692	805	753	565	437	634	513	287	637	357
	Mean	27.7	32.2	30.1	22.6	17.5	25.4	20.6	11.5	25.5	14.3
	Range	5-45	3-69	13-51	3-56	2-44	3-47	1-58	1-34	1-58	4-35
II	Total wt.	784	465	534	642	653	699	421	334	422	338
	Mean	31.4	18.6	21.4	25.7	26.1	28.0	16.8	13.4	16.9	13.5
	Range	8-51	1-41	2-49	6-48	3-47	3-66	1-43	1-39	3-51	2-36
III	Total wt.	425	361	866	461	591	663	499	478	494	290
	Mean	17.0	14.5	34.7	18.5	23.6	26.5	20.0	19.1	19.8	11.6
	Range	3-54	1-40	8-60	4-36	4-50	9-50	1-60	2-45	3-55	2-42
***	Total wt.	1901	1631	2153	1668	1681	1996	1433	1099	1553	985
	Mean	25.4	21.8	28.7	22.2	22.4	26.6	19.1	14.7	20.7	13.1
	S.D.	13.2	15.4	12.4	11.1	13.1	15.0	13.4	12.4	14.3	9.1
	Range	3-54	1-69	2-60	3-56	2-50	3.66	1-60	1-45	1-58	2-42

*25 bees per sample

**Hours after removal from hive

***Total of 75 bees

S.D. Standard deviation

TABLE 8

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES
WHEN STARVED AND FED FOR VARIOUS TIME PERIODS

Replicates		Age (days) of Bees									
		2					7				
		A**	B	C	D	E	A	B	C	D	E
*I	Total wt.	209	139	187	134	105	536	280	228	311	185
	Mean	8.4	5.6	7.5	5.4	4.2	21.4	11.2	9.1	12.4	7.4
	Range	1-38	1-20	1-36	1-20	1-14	1-40	1-40	1-33	1-33	1-22
II	Total wt.	193	138	143	162	45	87	384	353	267	198
	Mean	7.7	5.5	5.7	6.5	1.8	3.5	15.4	14.1	10.7	7.9
	Range	1-30	1-20	1-21	1-25	1-6	1-31	1-37	2-27	1-33	1-24
III	Total wt.	103	128	120	232	26	242	361	347	196	116
	Mean	4.1	5.1	4.8	9.3	1.0	9.7	14.4	13.9	7.8	4.6
	Range	1-19	1-15	1-24	1-30	1-2	1-27	1-31	1-41	1-23	1-19
***	Total wt.	505	405	450	528	176	865	1025	928	774	499
	Mean	6.7	5.4	6.0	7.0	2.4	11.5	13.7	12.4	10.3	6.7
	S.D.	8.4	4.4	6.1	5.8	2.9	11.8	9.6	9.4	8.3	6.2
	Range	1-38	1-20	1-36	1-30	1-14	1-40	1-40	1-41	1-33	1-24

*25 bees per sample

**Hours after removal from hive

***Total of 75 bees

S.D. Standard deviation

A When removal from hive

B Starved 1.5 then fed 0.5 hr.

C Starved 3.5 then fed 0.5 hr.

D Starved 5.5 then fed 0.5 hr.

E Starved 7.5 then fed 0.5 hr.

continued ...

TABLE 8 (continued)

Replicates		Age (days) of Bees									
		14					21				
		A**	B	C	D	E	A	B	C	D	E
*I	Total wt.	692	701	651	680	673	634	720	939	273/23	251/14 bees
	Mean	27.7	28.0	26.0	27.2	26.9	25.4	28.8	37.6	11.9	17.9
	Range	5-45	12-63	6-51	6-56	8-45	3-47	5-60	10-62	1-27	1-38
II	Total wt.	784	547	507	606	690	699	576	705	351/22	72/8 bees
	Mean	31.4	23.8	20.3	24.2	27.6	28.0	23.0	28.2	16.0	9.0
	Range	8-51	3-60	2-40	7-43	1-62	3-66	3-58	4-59	1-36	1-21
III	Total wt.	425	682	432	751	715	663	983	751	343/23	234/19 bees
	Mean	17.0	29.7	17.3	30.0	28.6	26.5	39.3	30.0	14.9	12.3
	Range	3-54	1-60	3-29	13-52	6-55	9-50	12-73	6-52	1-36	1-26
***	Total wt.	1901	1930	1591	2037	2078	1996	2279	2395	967/68	557/41 bees
	Mean	25.4	27.2	21.2	27.2	27.7	26.6	30.4	31.9	14.2	13.6
	S.D.	13.2	14.0	11.1	11.9	13.4	15.0	16.2	13.3	8.9	9.9
	Range	3-54	1-63	2-51	6-56	1-62	3-66	3-73	4-62	1-36	1-38

* 25 bees per sample

** Hours after removal from hive

*** Total of 75 bees

S.D. Standard deviation

A When removal from hive

B Starved 1.5 then fed 0.5 hr.

C Starved 3.5 then fed 0.5 hr.

D Starved 5.5 then fed 0.5 hr.

E Starved 7.5 then fed 0.5 hr.

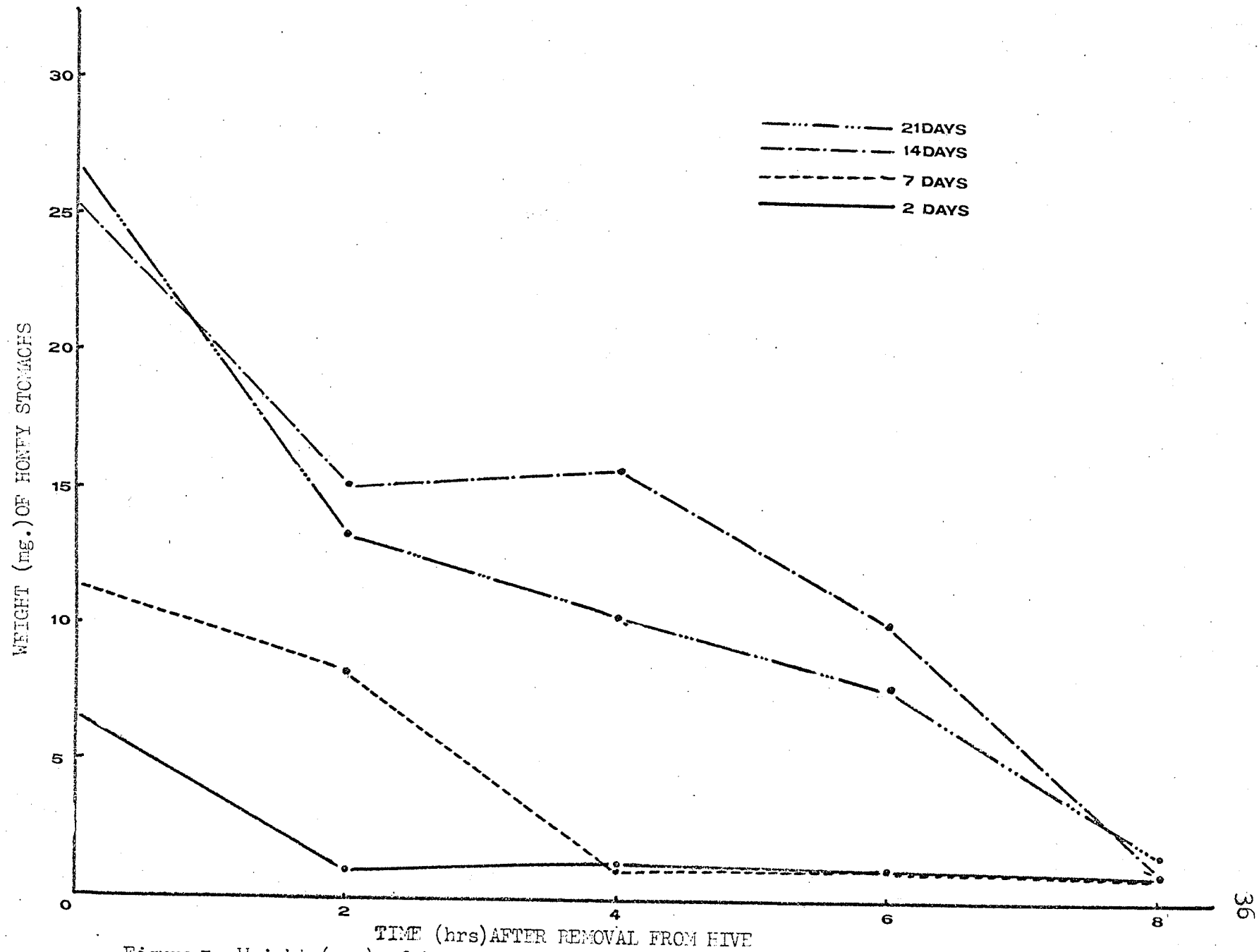


Figure 5 Weight (mg.) of honey stomachs of bees of various ages when starved

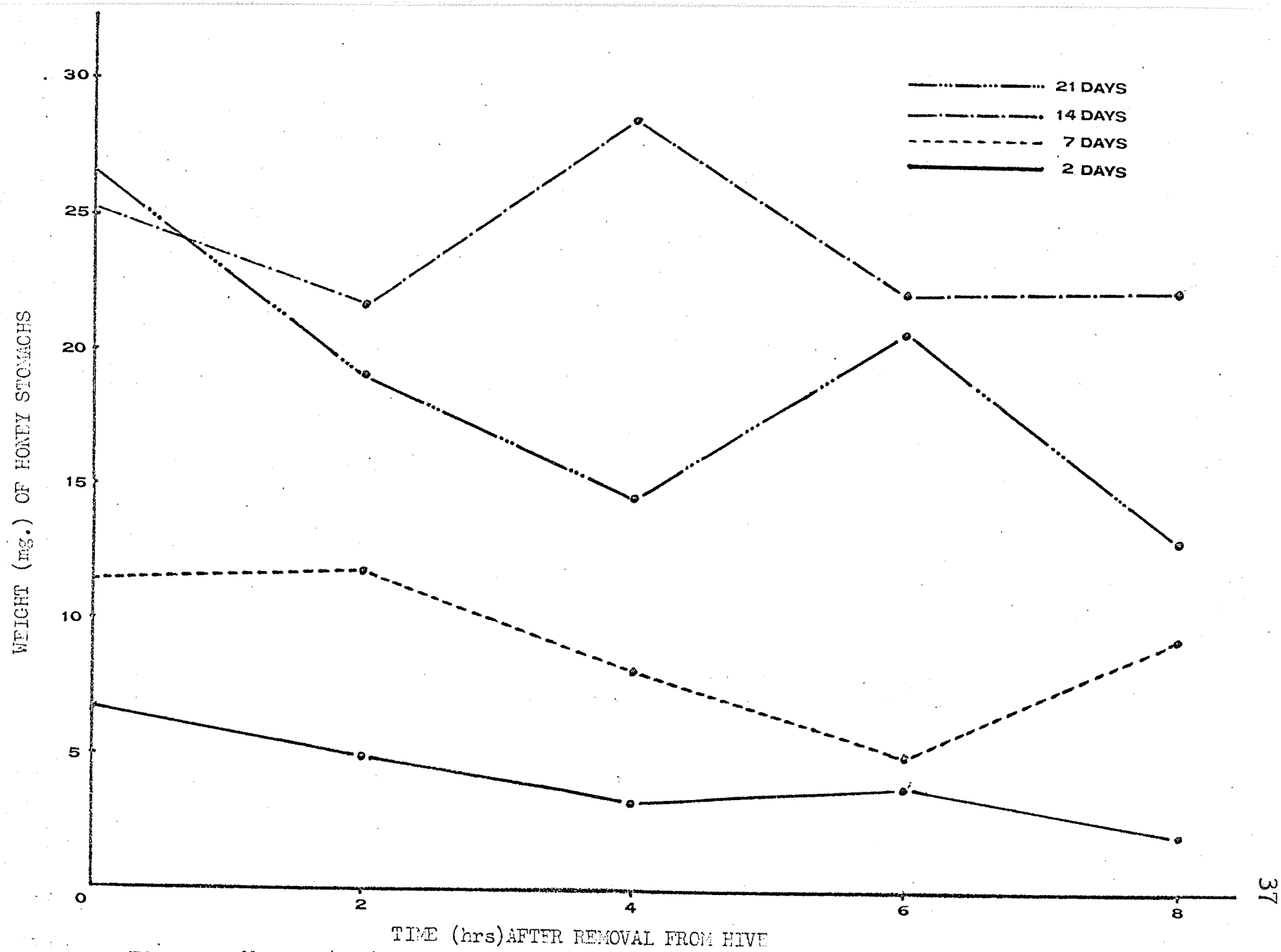


Figure 6 Weight (mg.) of honey stomachs of bees of various ages when fed continuously

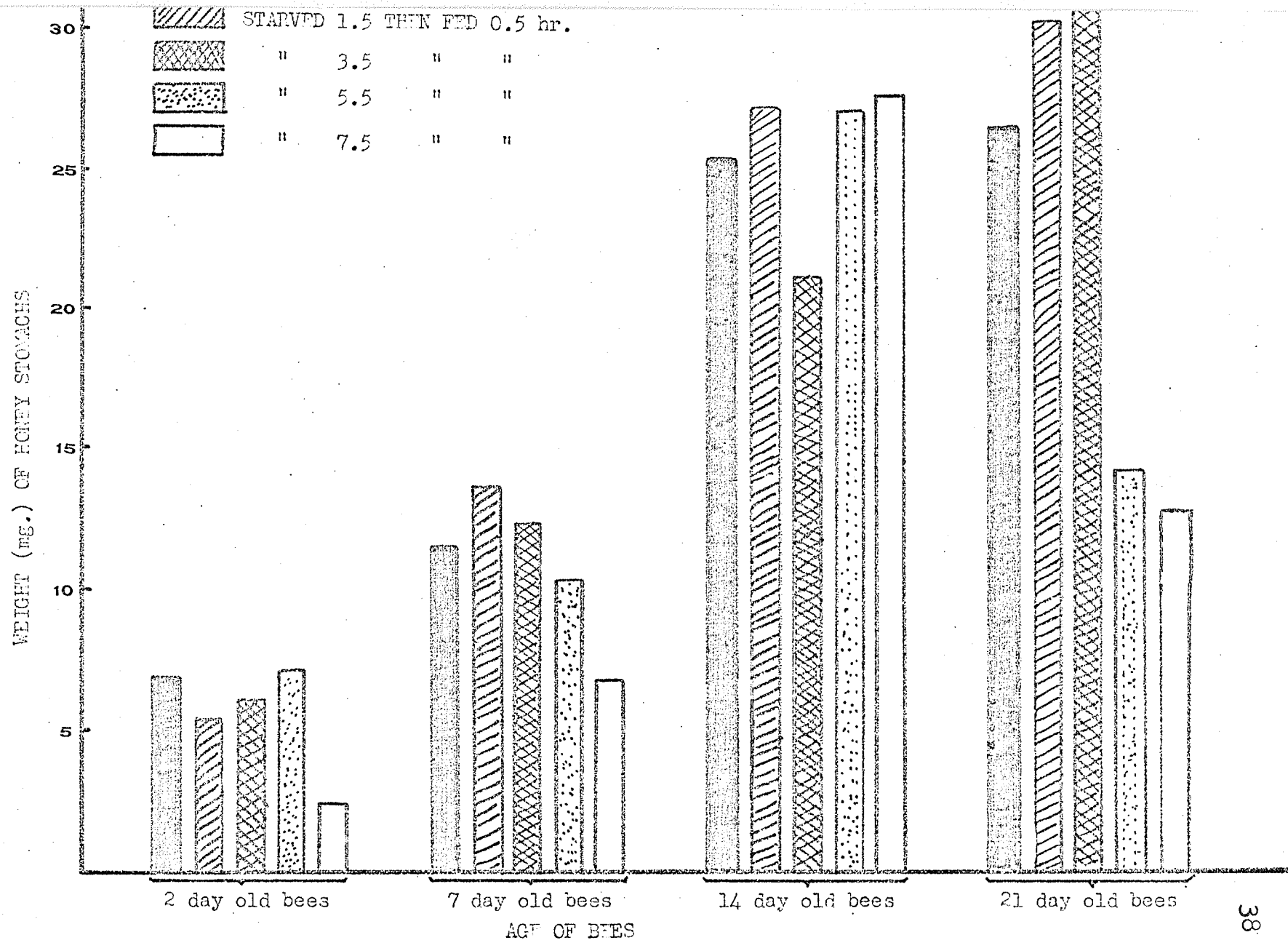


Figure 7 Weight (mg.) of honey stomachs of bees of various ages when starved and fed for various time periods

CHAPTER V

EFFECT OF SUGAR CONCENTRATION ON HONEY STOMACH CONTENTS

INTRODUCTION

It is well known that the sugar concentration of nectars, when collected, varies considerably (about 2-40%) depending on the types of flower, season, soil conditions etc.. When the nectar is converted to honey through enzyme action and the removal of moisture the sugar content is at least 80%.

Several experiments were done to ascertain if sugar concentration of the food affects the amount of food that bees of various ages ingest and retain, and to determine (for experimental purposes) if one can predict what amount of food bees of various ages contain when they have been starved and fed for various time periods on different food concentrations.

METHOD

Bees of various ages (2, 7, 14, and 21 days old) were collected from hives at 900-1000 hours and 25 bees from each age group were dissected immediately after removal from the hive and the weight of their honey stomachs recorded. Other bees, of the various age groups, were kept in cages in the laboratory at room temperature, for 3 hours during which time they were given no food.

Three different types of tests were done:

- A. Continuously fed.
- B. Fed 0.5 hours followed by a starvation period of 1, 2, or 3 hours.
- C. Fed 2 hours followed by a starvation period of 1, 2, or 3 hours.

In each test two different concentrations (15% and 65%) of honey and water solution were fed to each of two groups of bees of the same age. Each test contained 200 bees of the same age in eight cages, 25 bees per cage; half of them were fed with honey of high concentration (65%), and the other half were fed with the honey of low concentration (15%).

After a feeding period in Test B (0.5 hours), Test C (2 hours), and Test A (0.5 hours) two cages of bees (one in which the bees were fed with 65% honey, and the other in which the bees were fed with 15% honey) were dissected and their honey stomachs weighed. This same procedure was repeated after 1, 2, and 3 hours (after the feeding periods) in each test. Each test was replicated 3 times.

RESULTS

When removed from the hive, the older bees (i.e. 21 days old) had more food in their honey stomachs than the younger ones as also found in the previous starvation tests (Figures 8-13).

The amount of food which various age groups of bees had in their honey stomachs after 3 hours starvation were calculated from the data of Table 6 of Chapter IV; the weights were 5.8, 9.2, 6.2, and 18.4 mg. for 2, 7, 14, and 21 day old bees respectively. Because the initial honey stomach weights of the bees shown in Tables 9-11, Figures 8-13 were higher than those shown in Table 6, Figure 5 when the bees were removed from their hives, therefore the calculated honey stomach weights after a 3 hour starvation period were also higher.

Regardless of how long the bees fed (0.5 or 2 hours) after having been starved for 3 hours, and regardless of what concentration the food was, nearly all of the bees showed an increase in weight in their honey stomach contents (Figures 8-13; Table 9-11). The bees which fed on higher concentration food took more food and/or retained more food in their honey stomachs than those bees fed on the lower concentration food. (see Tables 9-11; Figures 8-13). As before, the older bees took more food than the younger bees whether the food was of high or low concentration.

In test A (Table 9, Figures 8,9) when bees fed continuously on 15% honey there was a gradual decrease in the weight of their honey stomachs with the passage of time; the honey stomach weights of the older bees

tended to drop off steadily whereas those of the younger bees stayed in the same range (about 5 mg.). When 2, 7, and 14 day old bees fed continuously on 65% honey, the amount of honey stomach contents varied within a narrow range, but that of the 21 day old bees increased first and then decreased after one hour.

In test B (Table 10, Figures 10, 11), when bees were fed for 0.5 hours on either 65% or 15% honey followed by various periods of starvation, the amount of honey stomach contents decreased more rapidly in the older bees (i.e. 14 and 21 days old) than in the younger ones (i.e. 2 and 7 days old). Figures 10, 11 and Table 10 show that the prediction of honey stomach weights of bees, for experimental purposes, is not practical.

In test C (Table 11, Figures 12, 13), when bees were fed 2 hours and followed by various periods of starvation most age groups of bees gained in honey stomach weight (except for 2, 7, and 14 day old bees which fed on 15% honey) during the feeding period. When the results of test C are compared to that of test A and B, one finds that, after 3 hours starvation, most of the food is ingested by bees of all ages between 0.5 and 1 hour; after this period the amount of food in their honey stomachs decreases even when the food is still available. As in test B the amount of honey stomach contents

decreased more rapidly in the older bees (i.e. 14 and 21 days old) than in the younger ones (i.e. 2 and 7 days old).

A slight increase in the weight of honey stomach contents was found in four tests (2 and 7 day old bees fed on 15% honey and starved for 1 and 2 hours respectively, and 2 and 7 day old bees fed on 65% honey followed by a 2 hour starvation period) during the starvation period; this is probably due to the fact that each point on the graphy represents a dissection of bees of different cages.

DISCUSSION AND CONCLUSIONS

Regardless of whether the bees were taken from the hive, or fed in cages on either 65% or 15% honey, the older bees tended to have more food in their honey stomachs than the younger ones (see Tables 9, 10, and 11). Three hours after the bees of all ages had been removed from the hive and fed again, they showed an increase in weight of their honey stomachs with most of the food being ingested between 0.5 and 1 hour. After 1 hour no large increases in honey stomach contents were recorded; the honey stomach contents of bees fed continuously on 15% honey decreased after 1 hour probably because of its low food value.

Frisch (1934), Ribbands (1955), Free (1957), and Nunez (1966) found that for the bees of mixed ages

there was a preference for sugar syrup of high concentration rather than of low concentration. But Mommers (1966) found that when the times of visiting nectar plants increased, the foragers were attracted by the quantity of nectar but not the concentration of the nectar. Wells and Giacchino (1968) found that there was no evidence that the loads of sugar solution carried by foragers depend on its sugar concentration, its scent, or the type of sugar.

In test A, B, and C bees of all ages (2, 7, 14, and 21 days old) took more food when fed on high concentration of food than on low concentration of food; when bees were fed continuously on 15% honey, the honey stomach weights of the older bees tended to drop off steadily whereas those of the younger bees stayed in the same range, possibly because the threshold of acceptance (Frisch, 1950) of sugar concentration in the older bees was higher than that of the younger ones. When 2, 7, and 14 day old bees were fed continuously on 65% honey, their honey stomach weights increased in the first 0.5 hours; the amount of honey stomach contents varied within a narrow range during the next 2.5 hours. However, the honey stomach contents of the 21 day old bees increased greatly for 1 hour and then decreased gradually during the next 2 hours. Perhaps this is because older bees are influenced to a greater degree by previous starvation

experience and hence ingest more food than do the younger ones.

When bees fed for only 0.5 hours on either 65% or 15% honey followed by various periods of starvation, the amount of honey stomach contents decreased more rapidly in the older bees than in the younger ones. This may be the result of increased "excitability" and activity of the older bees; Jordan (1966) found that when bees of mixed ages were disturbed they consumed more food. A slight increase in the weight of honey stomach contents was found in four tests (2 and 7 day old bees fed 2 hours on 65% honey then starved for 2 hours, and in the same age groups of bees fed on 15% honey then starved for 1 and 2 hours respectively) during the starvation period; this is probably due to the fact that each point on the graph represents the dissection of bees of different cages.

Although the author is aware that a 15% honey solution weighs 19% by volume less than a 65% honey solution, this does not affect the slope of the lines of the graph of the two concentrations. Although this fact should be borne in mind no compensations were made in the graphs because the concentration of the honey stomach contents was unknown when bees were collected from the hive.

It is concluded, that the concentration of food is one of the more important factors affecting the amount of food contained in the honey stomachs of bees as well as the behaviour of the bees (Lensky, 1961; Esch, 1963; Levchenko, 1961; Free and Durrant, 1966; Nunez, 1966).

TABLE 9

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES
WHEN FED CONTINUOUSLY ON TWO CONCENTRATIONS OF HONEY

Replicates	Age (days) of Bees									
	2									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	311	138	351	98	415	62	297	124	340	
*I Mean	12.4	5.5	14.0	3.9	16.6	2.5	11.9	5.0	13.6	
Range	2-30	1-12	2-28	1-12	2-42	1-10	1-30	1-14	2-39	
Total wt.	284	175	267	173	357	92	386	81	550	
*II Mean	11.4	7.0	10.7	6.9	14.3	3.7	15.4	3.2	22.0	
Range	2-32	1-18	1-37	1-28	2-39	1-28	4-40	1-11	5-55	
Total wt.	249	173	401	171	272	152	303	105	236	
*III Mean	10.0	6.9	16.0	6.8	10.9	6.1	12.1	4.2	9.44	
Range	1-35	1-23	1-43	1-37	2-29	1-30	2-21	1-14	1-39	
Total wt.	844	486	1019	442	1044	306	986	310	1126	
***Mean	11.3	6.5	13.6	5.9	13.9	4.1	13.2	4.1	15.0	
S.D.	8.4	4.7	9.1	6.4	8.9	5.8	7.8	3.8	12.1	
Range	1-35	1-23	1-43	1-37	2-42	1-30	1-40	1-14	1-55	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 9

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES
WHEN FED CONTINUOUSLY ON TWO CONCENTRATIONS OF HONEY

Replicates	Age (days) of Bees								
	7								
	A	B		C		D		E	
	-	15**	65	15	65	15	65	15	65
Total wt.	541	110	294	182	461	115	393	141	511
*I Mean	21.6	4.4	11.8	7.3	18.4	4.6	15.7	5.6	20.4
Range	11-41	1-16	1-40	1-19	1-41	1-15	2-39	1-26	4-48
Total wt.	193	169	361	151	498	218	498	95	516
*II Mean	7.7	6.8	14.4	6.0	19.9	8.7	19.9	3.8	20.6
Range	1-20	1-21	1-31	1-29	3-31	1-20	6-36	1-13	1-54
Total wt.	482	208	387	166	513	175	385	152	451
*III Mean	19.3	8.3	15.5	6.6	20.5	7.0	15.4	6.1	18.0
Range	5-39	1-27	2-37	1-19	6-46	1-20	2-39	1-19	2-53
Total wt.	1216	487	1042	499	1472	508	1276	388	1478
*** Mean	16.2	6.5	13.9	6.7	19.6	6.8	17.0	5.2	19.7
S.D.	10.4	6.3	10.8	6.0	10.4	5.5	9.9	5.5	13.5
Range	1-41	1-27	1-40	1-29	1-46	1-20	2-39	1-26	1-54

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 9

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES
WHEN FED CONTINUOUSLY ON TWO CONCENTRATIONS OF HONEY

Replicates	Age (days) of Bees								
	14								
	A	B		C		D		E	
	-	15**	65	15	65	15	65	15	65
Total wt.	627	281	566	664	506	260	426	26	385
*I Mean	25.1	11.2	22.6	26.6	20.2	10.4	17.0	1.0	15.4
Range	7-50	1-33	1-52	3-47	2-42	1-31	2-45	1-2	1-38
Total wt.	306	348	910	278	674	153	876	132	986
*II Mean	12.2	13.9	36.4	11.1	27.0	6.1	35.0	5.3	39.4
Range	1-30	1-36	2-69	1-45	2-62	1-19	17-52	1-17	5-70
Total wt.	284	275	922	200	908	209	981	108	872
*III Mean	11.4	11.0	36.9	8.00	36.3	8.4	39.2	4.3	34.9
Range	1-46	1-24	17-65	1-27	7-51	1-25	10-59	1-18	19-67
Total wt.	1217	904	2398	1142	2088	622	2283	266	2243
***Mean	16.2	12.1	32.0	15.2	27.8	8.3	30.4	3.6	29.9
S.D.	11.8	9.3	15.6	12.4	14.5	7.7	15.5	4.3	17.3
Range	1-50	1-36	1-69	1-47	2-62	1-31	2-59	1-18	1-70

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 9

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES
WHEN FED CONTINUOUSLY ON TWO CONCENTRATIONS OF HONEY

Replicates	Age (days) of Bees									
	21									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	853	958	735	777	989	482	524	156	763	
*I Mean	34.1	38.3	29.4	31.1	39.6	19.3	21.0	6.2	30.5	
Range	10-62	10-66	9-67	7-59	11-78	3-41	3-48	1-17	5-56	
Total wt.	813	863	1051	756	991	444	571	93	450	
*II Mean	32.5	34.5	42.0	30.2	39.6	17.8	22.8	3.7	18.0	
Range	20-67	17-49	12-68	8-51	11-63	6-48	6-42	1-11	1-40	
Total wt.	838	824	786	405	979	538	948	160	671	
*III Mean	33.5	33.0	31.4	18.6	39.2	21.5	37.9	6.4	26.8	
Range	8-60	8-59	8-52	1-84	3-52	4-44	4-68	1-21	4-57	
Total wt.	2504	2645	2572	1998	2959	1464	2043	409	1884	
***Mean	33.4	35.3	34.3	26.6	39.5	19.5	27.2	5.5	25.1	
S.D.	12.3	12.2	15.2	16.7	13.3	10.8	14.2	4.0	15.0	
Range	8-67	8-66	8-68	1-84	3-78	3-48	3-68	1-21	1-57	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours.
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 10

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	2									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	311	149	246	41	262	36	183	42	110	
*I Mean	12.4	6.0	9.8	1.6	10.5	1.4	7.3	1.7	4.4	
Range	2-30	1-20	2-27	1-5	2-34	1-6	1-28	1-7	1-15	
Total wt.	284	235	248	39	222	116	229	36	261	
*II Mean	11.4	9.4	9.9	1.6	8.9	4.6	9.1	1.4	10.4	
Range	2-32	1-21	1-26	1-4	1-20	1-18	1-27	1-6	1-23	
Total wt.	249	92	377	65	389	37	457	31	62	
*III Mean	10.0	3.7	15.1	2.6	15.6	1.5	18.3	1.2	2.5	
Range	1-35	1-12	2-49	1-10	2-46	1-4	1-34	1-4	1-9	
Total wt.	844	476	871	145	873	189	867	109	433	
***Mean	11.3	6.4	11.6	1.9	11.6	2.5	11.6	1.5	5.8	
S.D.	8.4	5.2	8.0	1.6	9.5	2.9	9.6	1.1	5.6	
Range	1-35	1-21	1-49	1-10	1-46	1-18	1-34	1-7	1-23	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 10

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	7									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	541	92	655	44	466	27	244	142	208	
*I Mean	21.6	3.7	26.2	1.8	18.6	1.1	9.8	5.7	8.3	
Range	11-41	1-13	3-37	1-10	1-53	1-2	1-29	1-25	1-24	
Total wt.	193	226	565	90	556	78	162	25	363	
*II Mean	7.7	9.0	22.6	3.6	22.2	3.1	6.5	1.0	14.5	
Range	1-20	1-26	4-51	1-17	1-51	1-12	1-33	1-1	2-29	
Total wt.	482	274	353	27	402	63	548	28	204	
*III Mean	19.3	11.0	14.1	1.1	16.1	2.-	21.9	1.1	8.2	
Range	5-39	1-31	2-29	1-2	2-51	1-14	3-50	1-2	1-28	
Total wt.	1216	592	1573	161	1424	168	954	195	775	
***Mean	16.2	7.9	21.0	2.2	19.0	2.2	12.7	2.6	10.3	
S.D.	10.4	7.1	11.0	2.8	12.6	2.7	11.5	4.4	8.1	
Range	1-41	1-31	1-51	1-17	1-53	1-14	1-50	1-25	1-29	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 10

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees								
	14								
	A	B		C		D		E	
	-	15**	65	15	65	15	65	15	65
Total wt.	627	533	422	616	483	227	208	30	97
*I Mean	25.1	21.3	16.9	24.6	19.3	9.1	8.3	1.2	3.9
Range	7-50	1-45	1-47	5-51	2-60	1-33	1-32	1-3	1-25
Total wt.	306	382	1063	155	778	29	649	27	456
*II Mean	12.2	15.3	42.5	6.2	31.9	1.2	26.0	1.1	18.2
Range	1-30	1-45	19-61	1-21	6-57	1-3	1-63	1-2	1-44
Total wt.	284	174	812	151	988	110	589	27	648
*III Mean	11.4	7.0	32.5	6.0	39.5	4.4	23.6	1.1	259
Range	1-46	1-22	4-58	1-21	23-59	1-15	1-45	1-2	3-54
Total wt.	1217	1089	2297	922	2269	366	1446	84	1201
***Mean	16.2	14.5	30.6	12.3	30.3	4.9	19.3	1.1	16.0
S.D.	11.8	11.9	17.2	12.7	15.4	7.1	14.7	0.1	14.9
Range	1-50	1-45	1-61	1-51	2-60	1-33	1-63	1-3	1-54

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 10

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	21									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	853	831	832	879	1017	371	417	225	295	
*I Mean	34.1	33.2	33.3	35.2	40.7	14.8	16.7	9.0	11.8	
Range	10-62	14-57	11-55	6-68	15-62	2-38	3-35	1-23	1-25	
Total wt.	813	831	893	613	720	415	648	250	410	
*II Mean	32.5	33.2	35.7	24.5	28.8	16.6	25.9	10.0	16.4	
Range	20-67	14-58	1-61	3-48	4-53	1-45	6-57	1-44	2-38	
Total wt.	838	814	1121	657	915	121	805	294	469	
*III Mean	33.5	32.6	44.8	26.3	36.6	4.8	32.2	11.8	18.8	
Range	8-60	12-54	28-63	4-51	12-63	1-15	4-51	1-40	2-48	
Total wt.	2504	2476	2846	2149	2652	907	1870	769	1174	
***Mean	33.4	33.0	38.0	28.7	35.4	12.1	24.9	10.3	15.7	
S.D.	12.3	10.7	15.3	14.7	13.6	11.0	13.1	8.7	10.0	
Range	8-67	12-58	1-63	3-68	4-63	1-45	3-57	1-44	1-48	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 11

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	2									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	311	84	245	58	250	58	200	27	177	
*I Mean	12.4	3.4	9.8	2.3	10.0	2.3	8.0	1.1	7.1	
Range	2-30	1-11	1-28	1-7	1-20	1-28	1-23	1-2	1-21	
Total wt.	284	82	449	97	170	26	377	49	145	
*II Mean	11.4	3.3	18.0	3.9	6.8	1.0	15.1	2.0	5.8	
Range	2-32	1-12	3-35	1-16	1-21	1-2	2-67	1-10	1-15	
Total wt.	249	59	290	130	150	59	102	60	92	
*III Mean	10.0	2.4	11.6	5.2	6.0	2.4	4.1	2.4	3.7	
Range	1-35	1-8	1-32	1-13	1-19	1-8	1-25	1-8	1-14	
Total wt.	844	225	984	285	590	143	679	136	414	
***Mean	11.3	3.0	13.1	3.8	7.6	1.9	9.1	1.8	5.5	
S.D.	8.4	2.7	8.8	3.6	5.8	3.4	10.2	1.8	4.8	
Range	1-35	1-12	1-35	1-16	1-21	1-28	1-67	1-10	1-21	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 11

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	7									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	541	87	460	32	408	137	355	25	197	
*I Mean	21.6	3.5	18.4	1.3	16.3	5.5	14.2	1.0	7.9	
Range	11-41	1-18	2-44	1-5	2-45	1-24	2-30	1-1	1-27	
Total wt.	193	105	301	28	232	40	398	50	167	
*II Mean	7.7	4.2	12.0	1.1	9.3	1.6	15.9	2.0	6.7	
Range	1-20	1-15	1-35	1-2	1-30	1-6	1-50	1-6	1-19	
Total wt.	482	59	210	36	313	58	235	39	175	
*III Mean	19.3	2.4	8.4	1.4	12.5	2.3	9.4	1.6	7.0	
Range	5-39	1-8	2-25	1-7	1-40	1-10	1-25	1-10	1-18	
Total wt.	1216	251	971	96	953	235	988	114	539	
***Mean	16.2	3.4	13.0	1.3	12.7	3.1	13.2	1.5	7.2	
S.D.	10.4	3.4	10.4	1.0	8.9	4.3	10.1	1.4	6.4	
Range	1-41	1-18	1-44	1-7	1-45	1-24	1-50	1-10	1-27	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 11

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	14									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	627	8	456	136	469	40	228	26	50	
*I Mean	25.1	3.5	18.2	5.5	18.8	1.6	9.1	1.0	2.0	
Range	7-50	1-17	1-45	1-24	2-55	1-7	1-25	1-2	1-7	
Total wt.	306	74	949	42	847	33	883	31	254	
*II Mean	12.2	3.0	38.0	1.7	33.9	1.3	35.3	1.2	10.2	
Range	1-30	1-13	15-56	1-15	1-68	1-5	2-64	1-3	1-27	
Total wt.	284	115	890	50	799	32	504	58	616	
*III Mean	11.4	4.6	35.6	2.0	32.0	1.3	20.2	2.3	24.6	
Range	1-46	1-14	8-56	1-13	1-59	1-3	2-46	1-6	3-54	
Total wt.	1217	277	2295	228	2115	105	1615	115	920	
***Mean	16.2	3.7	30.6	3.0	28.2	1.4	21.5	1.5	12.3	
S.D.	11.8	3.9	15.3	4.8	17.0	1.0	16.8	2.0	12.6	
Range	1-50	1-17	1-56	1-24	1-68	1-7	1-64	1-16	1-54	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

TABLE 11

WEIGHT (mg.) OF HONEY STOMACHS OF BEES OF VARIOUS AGES WHEN
STARVED AND FED ON TWO CONCENTRATIONS OF HONEY FOR VARIOUS
TIME PERIODS

Replicates	Age (days) of Bees									
	21									
	A	B		C		D		E		
	-	15**	65	15	65	15	65	15	65	
Total wt.	853	361	769	32	416	106	448	31	388	
*I Mean	34.1	14.4	30.8	1.3	16.6	4.2	17.9	1.2	15.5	
Range	10-62	1-35	9-48	1-5	1-45	1-19	3-38	1-4	3-40	
Total wt.	813	741	788	461	386	133	583	26	339	
*II Mean	32.5	29.6	31.5	18.4	15.4	5.3	23.3	1.0	13.6	
Range	20-67	5-64	11-55	2-33	1-36	1-32	7-50	1-2	1-25	
Total wt.	838	807	898	372	876	40	430	25	169	
*III Mean	33.5	32.3	35.9	14.9	35.0	1.6	17.2	1.0	6.8	
Range	8-60	15-59	12-57	2-49	15-67	1-7	3-48	1-1	1-35	
Total wt.	2504	1909	2455	865	1678	279	1461	82	896	
***Mean	33.4	25.5	32.7	11.5	22.4	3.7	19.5	1.1	12.0	
S.D.	12.3	13.8	12.1	11.2	15.0	5.5	11.9	0.4	9.3	
Range	8-67	1-64	9-57	1-49	1-67	1-32	3-50	1-4	1-40	

*25 bees per sample

**Concentration (%) of food

***Total of 75 bees

- A - Weight of honey stomachs when bees were removed from hive
- B - Weight of honey stomachs when bees were starved for 3 hours and then fed for 0.5 hours
- C - Weight of honey stomachs when bees were starved for 3 hours and then fed for 1 hour
- D - Weight of honey stomachs when bees were starved for 3 hours and then fed for 2 hours
- E - Weight of honey stomachs when bees were starved for 3 hours and then fed for 3 hours

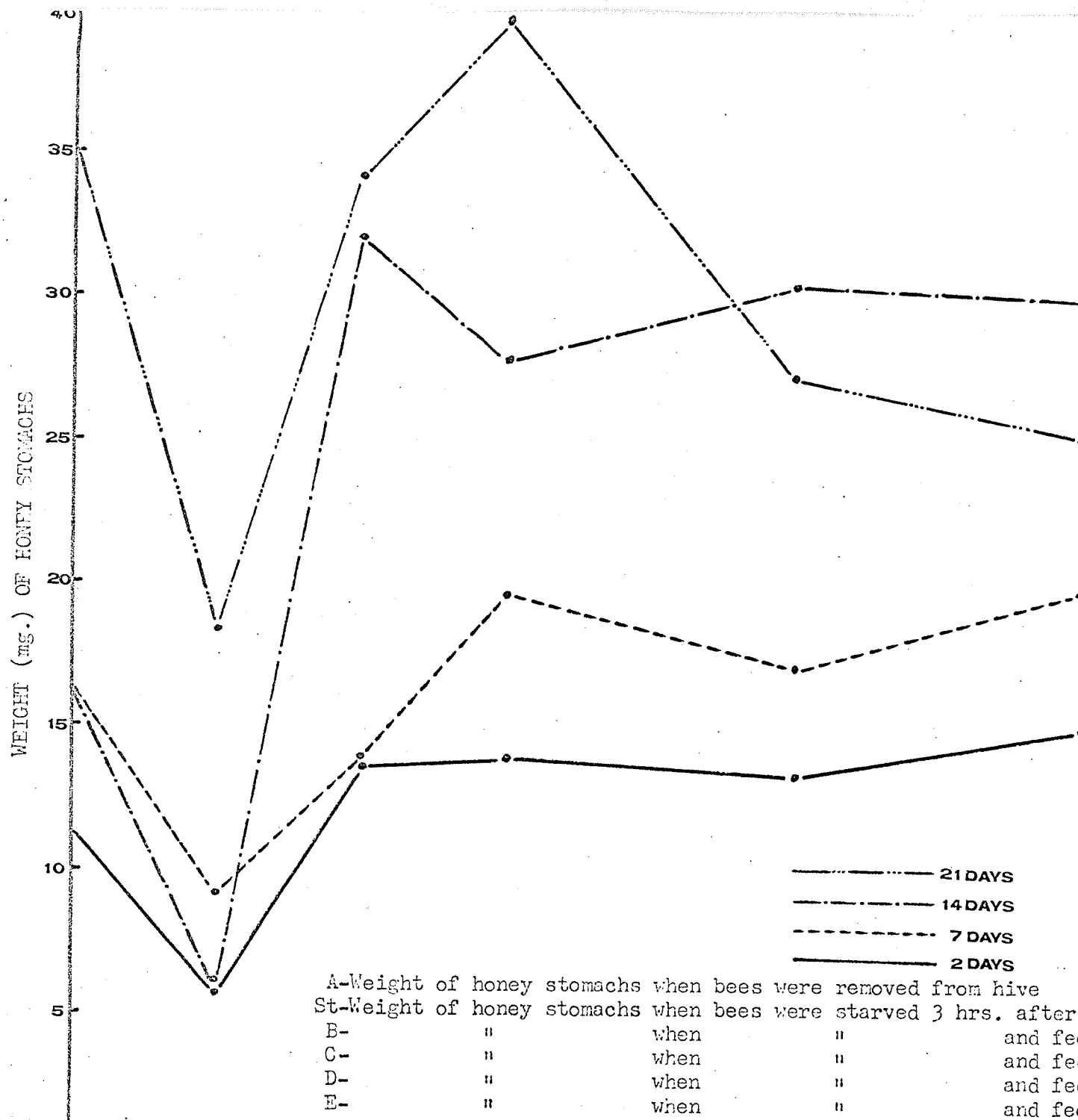


Figure 8 Weight of honey stomachs of bees of various ages when fed continuously on 65% honey

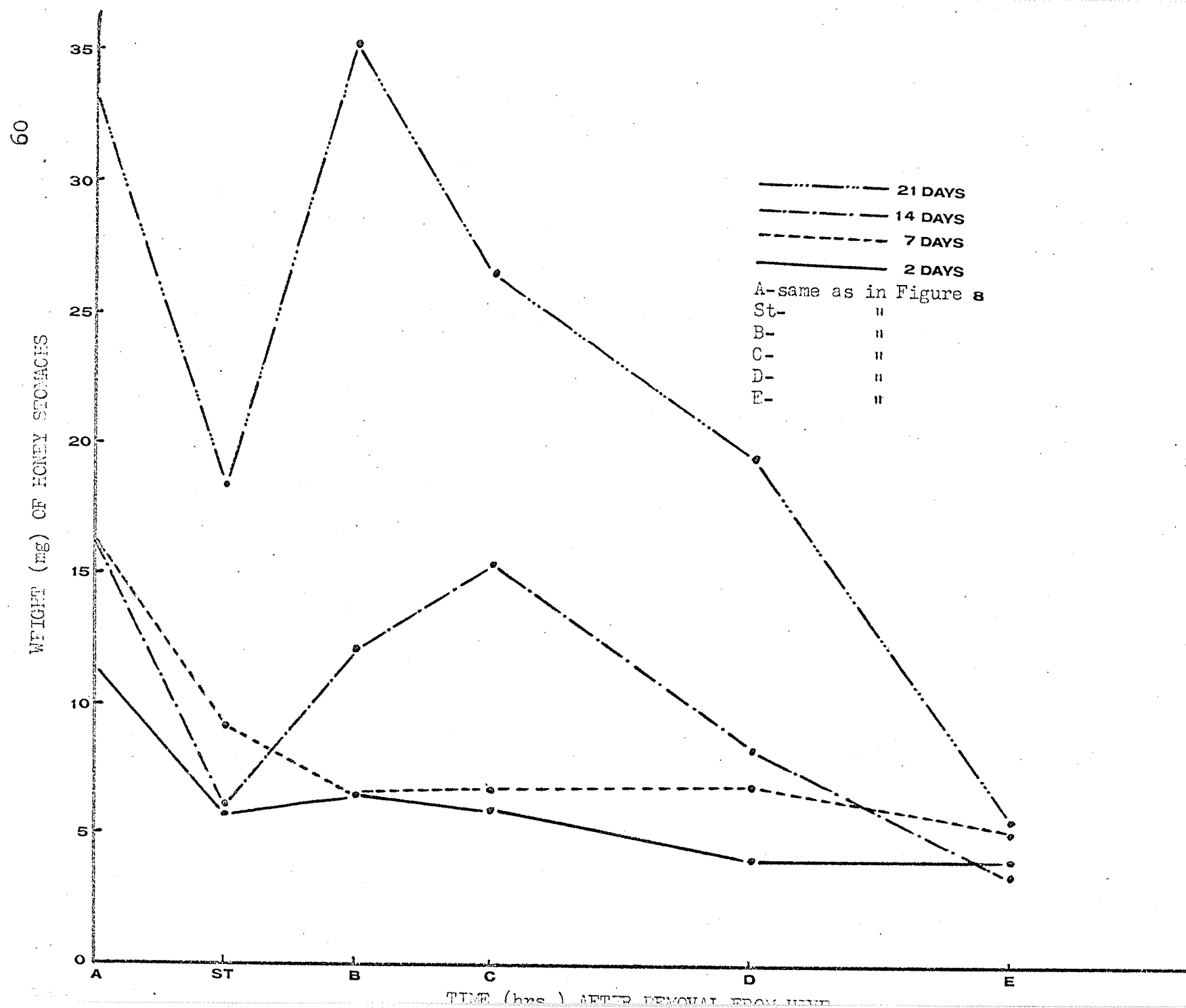


Figure 9 Weight of honey stomachs of bees of various ages when fed continuously on 15% honey

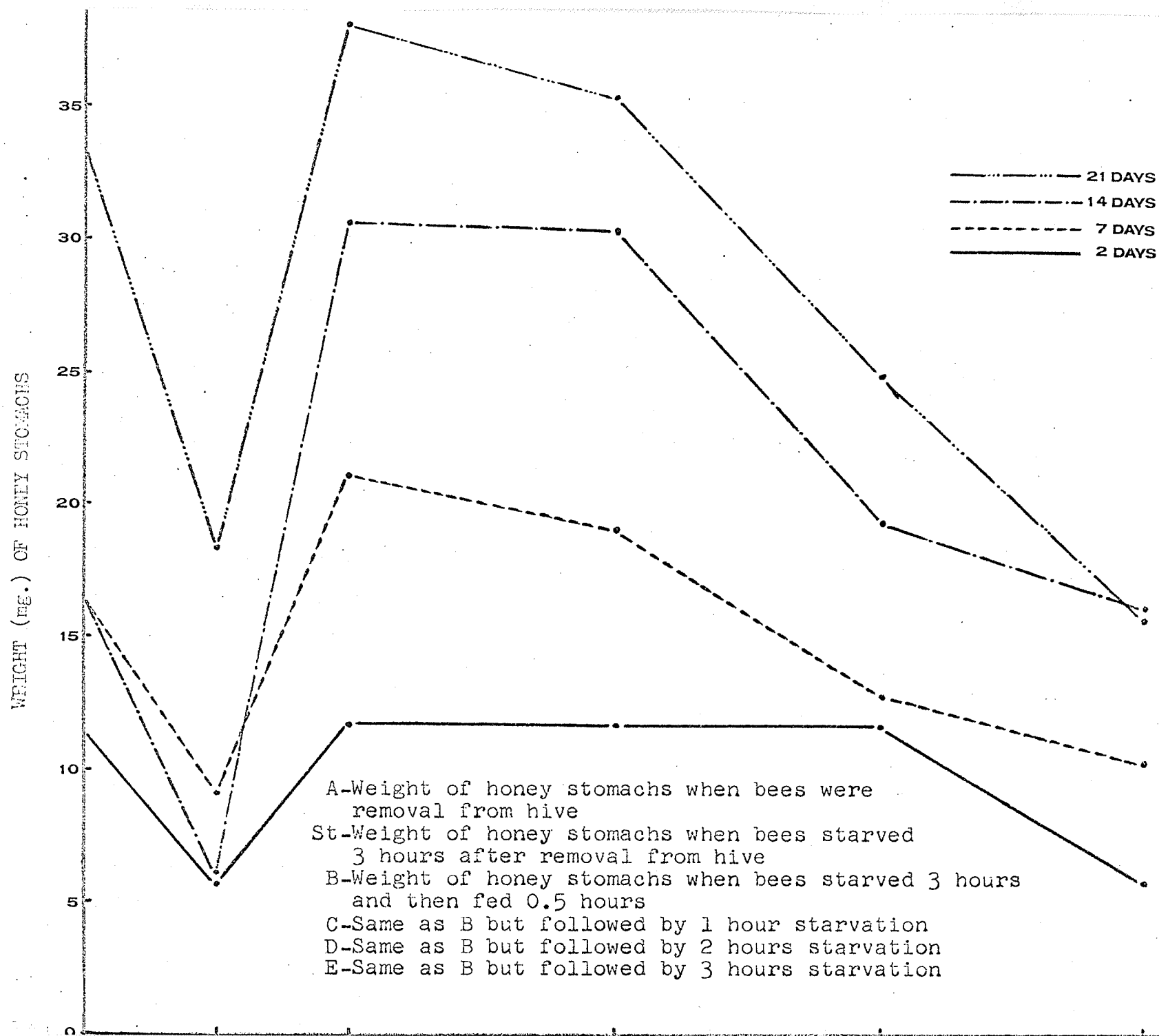


Figure 10 Weight of honey stomachs of bees of various ages when starved and fed on 65% honey for various time periods

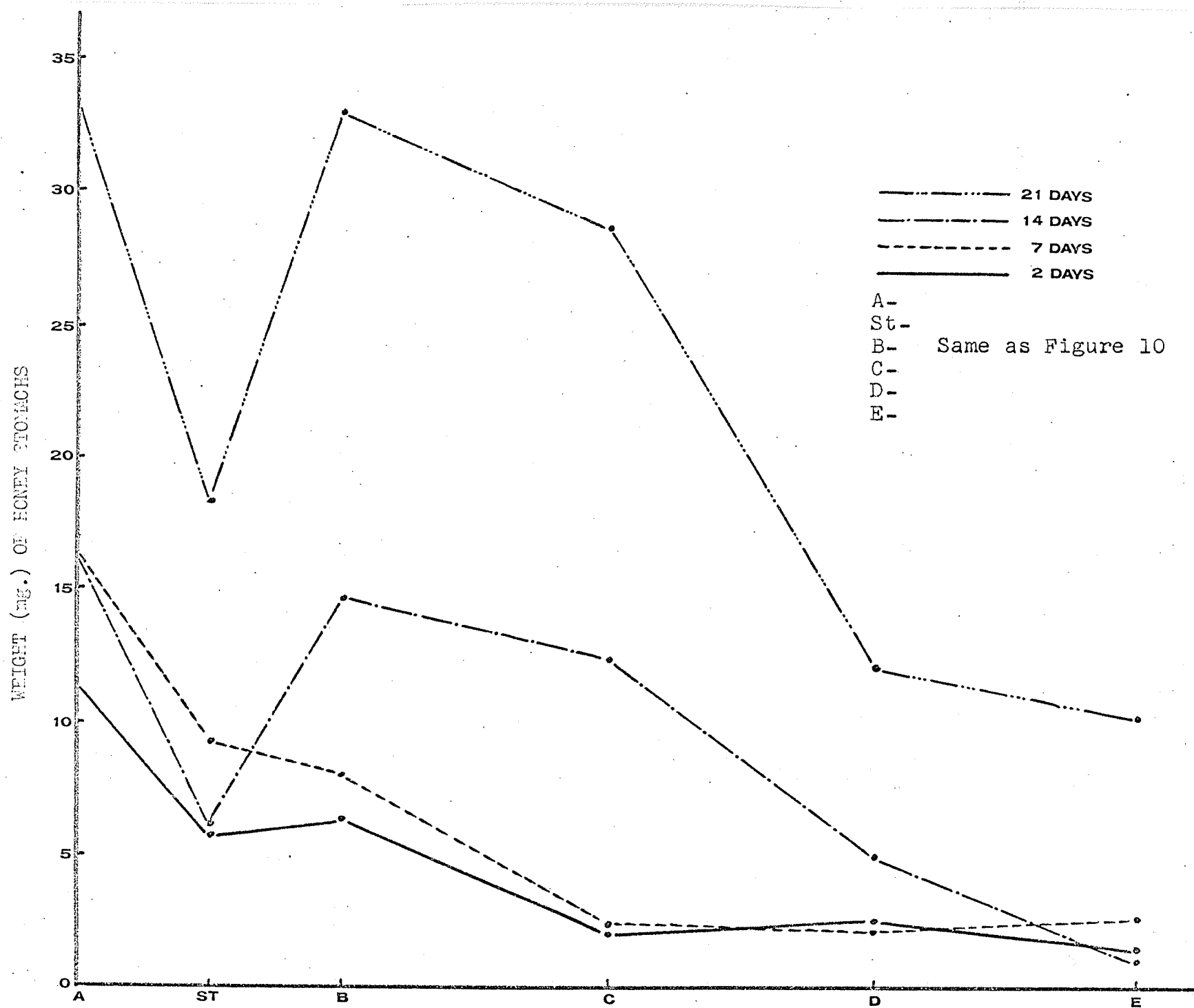


Figure 11 Weight of honey stomachs of bees of various ages when starved and fed on 15% honey for various time periods

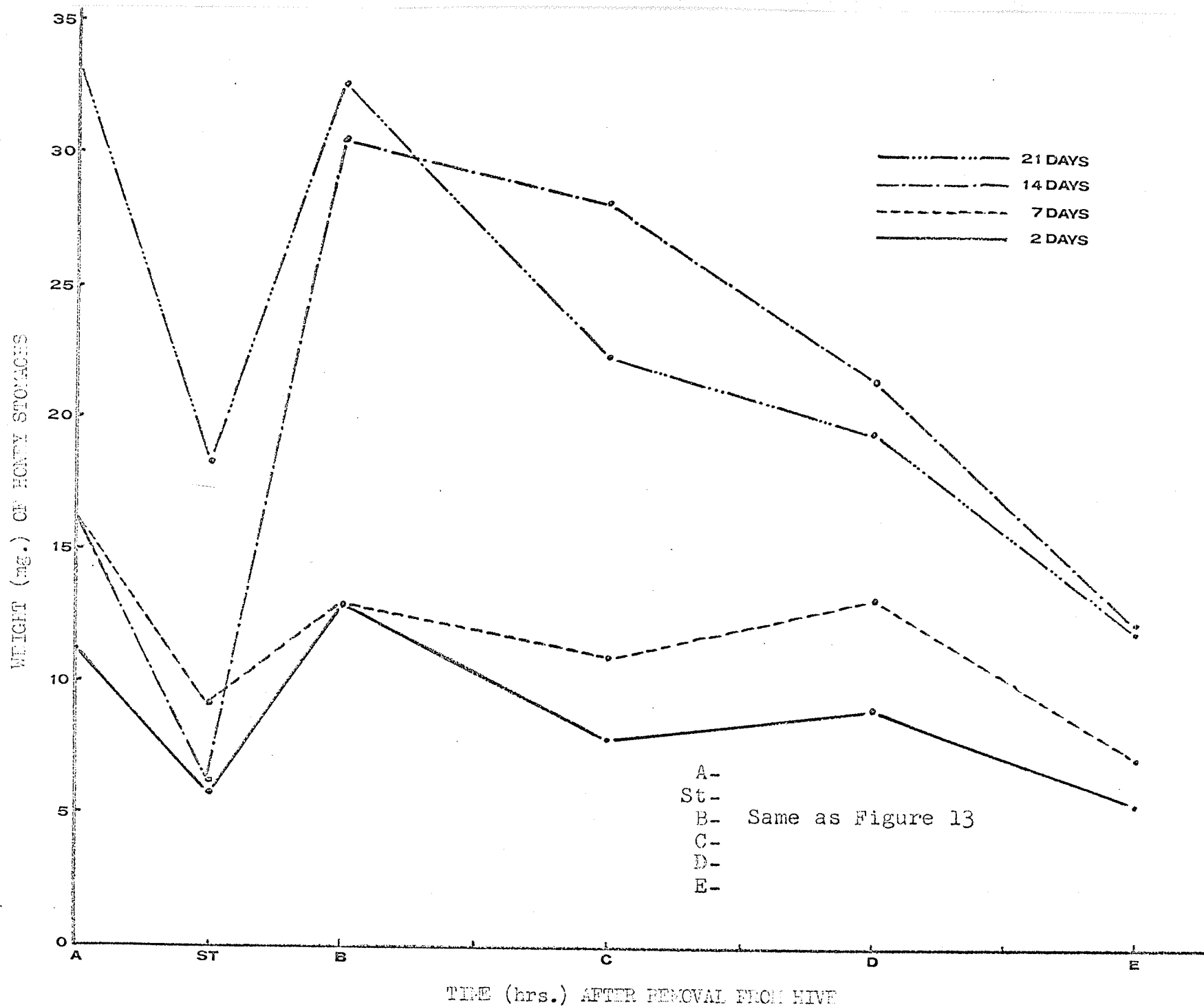


Figure 12 Weight of honey stomach of bees of various ages when starved and fed on 45% honey for various time periods

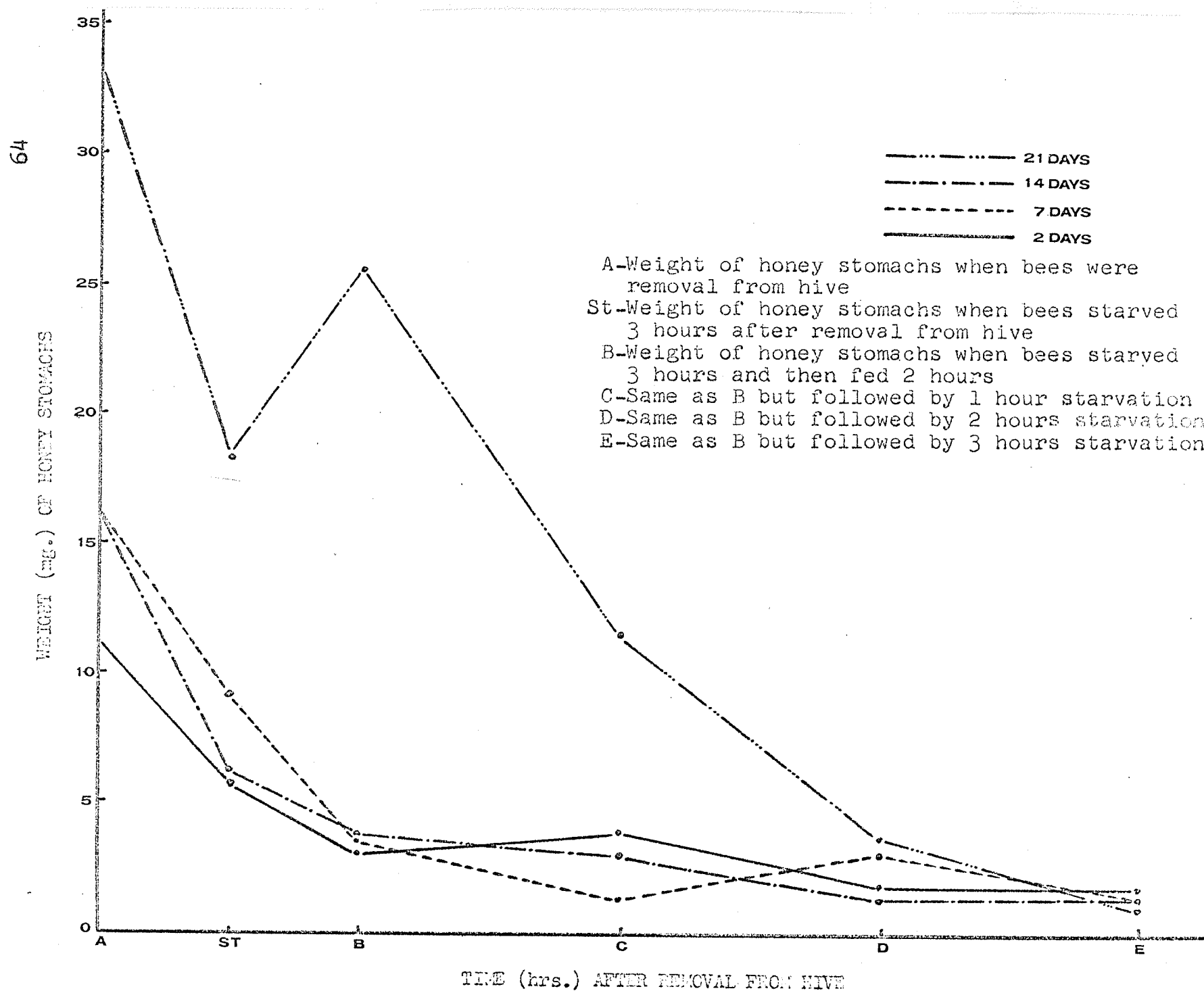


Figure 13 Weight of honey stomach of bees of various ages when starved and fed on 15% honey for various time periods

CHAPTER VI

EFFECT OF SMALL GROUPS OF BEES FEEDING
LARGE GROUPS ON HONEY STOMACH CONTENTS

INTRODUCTION

It has been observed that when bees are producing wax they gorge themselves and form "curtains" by attaching themselves to each other within the hive (Grout, 1966). As wax secretion proceeds, and the food supplies of the wax secreting bees decreases other bees feed them. It is possible also, that when bees are engaged in various hive duties (e.g. feeding larvae, building cells, and capping cells) that they may not make individual trips to food cells but are fed by particular bees with full honey stomachs.

The following experiments were done partly to ascertain how efficient small groups of bees of various ages are in feeding large groups of bees of various ages that have no access to food and partly to ascertain to what extent this system of feeding affects the amount of food that bees of certain age groups have in their honey stomachs at various times.

METHOD

In test A 7, 14, and 21 days old bees were used. Bees of the same age were removed from their hives at 900-1000 hours, and kept in cages which had two

compartments separated by a screen (64 mesh per square inch). Three different ratios of bees (5:25, 5:50, and 5:100) of various ages were used in the cages (see Figure 14, 15); there were 27 combinations of age groups as shown below:

Series	Food supply	Ratio	Age of bees (days)								
I	with food	5	7	14	21	7	14	21	7	14	21
	without	25	7	14	21	7	14	21	7	14	21
II	"	5									
	"	50	"			"			"		
III	"	5									
	"	100	"			"			"		

In each combination, 5 bees of the same age were put into one compartment of the cage and supplied with a 50% honey and water solution with red carmine dye added; the larger number of bees (25, 50, and 100) were put into the other compartment of the cage without any food supplied. All the cages were kept at room temperature. The honey stomachs of all the large groups of bees were weighed after 24 hours. Control bees (see Table 13 and Figures 16, 17, and 18) of various ages (also in various ratios) were kept in separate cages; for each age one group was fed and one was starved for 24 hours before dissection. Each test had 3 replicates.

In test B, only 2 age groups (7 and 21 days old) and 2 ratios (5:25, 5:100) were used (see Table 15.); the tests were confined to groups of the same age (i.e. 7:7 day old bees and 21:21 day old bees) and the tests were run for 8 days instead of 24 hours as in test A.. During the test period, the mortality of the bees and the volume of food which the bees took from the feeding tubes in a 96 hour period was recorded (see Figure 15 and Table 15). Dead bees were replaced by bees kept in extra cages and which received similar treatments.

RESULTS

In test A, dyed honey stomach contents were found in all of the bees which had had no food supplied to them except by bees on the other side of the screen; regardless of age and ratio of feeding to fed bees, in general, younger bees had more food in their honey stomachs than did the older ones after 24 hours (3 exceptions, Table 12). Seven day old bees appeared to have the most, 14 day old bees less, and 21 day old bees the least amount. The same results were found among the control bees when they had access to food (see Table 12 and 13 and Figures 16, 17 and 18).

Regardless of the different ratio of feeding to fed bees, all the combinations of ages contained between 1-10 mg. indicating that 5 bees with food could feed 100, 50, or 25 bees equally well (at least for 24 hours).

In test B as expected, and regardless of age (7 or 21 days old) there was high mortality within the first 24 hours when bees were starved (see Table 14, control).

There was low mortality among the groups of 25 bees (7 and 21 days old) when fed continuously (Table 14 and Figures 19, 20, 21, and 22). Among the groups of 100 bees the mortality level of 21 day old bees was much higher than that of the 7 day old bees (Table 14 and Figures 21 and 22).

When 25 bees were being fed by 5 bees more of the 21 day old bees died than the 7 day old ones in a given time. Among the groups of 100 bees being fed by 5 bees, the mortality of the 21 day old group was higher than that of the 7 day old group.

In test B, the amount of food (ml.) which the bees took in given times showed that less food was taken by 5 bees in the cage where the 25 or 100 bees had food supplied than by the 5 bees in the cage

where the large groups of bees did not have food supplied (see Table 15). This result indicates that food was being passed (compare A-B, E-D in Table 15) through the screen (from 5 bees to 25 or 100 bees).

When feeding 25 bees, 5 bees, 7 and 21 days old, took about the same volume of food (4.53 and 4.03 ml.) in 98 hours, but when feeding 100 bees, 5 bees of 21 days old took more (7.03 ml.) food than the 7 days old (4.60 ml.).

The amount of food passed by 5 bees to 25 bees was similar to the amount that 25 bees took when feeding themselves (Table 15, A vs C). However, when 100 bees fed themselves they took much more food than when 100 bees were fed by 5 bees (Table 15, D vs F).

DISCUSSION AND CONCLUSIONS

Bees were kept in cages divided into two compartments by wiremesh which had apertures 2.5 mm. square; the bees which only had access to food by being fed by 5 bees through the screen all had dyed honey in their honey stomachs indicating that food was being passed to them by the 5 bees in the other compartment which had access to food.

All ages of bees received food as well as gave it, but generally speaking younger bees had more food

in their honey stomachs than the older ones after they were being passed food by other bees for 24 hours. This is possibly because as Istomina-Tsvetkova (1953) and Free (1957) found , there was a general tendency for food to be passed from older bees to younger bees, or because the older bees consumed more food than the younger ones in a given time. In the control bees when fed continuously, younger bees had more food in their honey stomachs than the older ones. This was probably because older ones consumed more food in 24 hours.

Regardless of the number of bees per cage, all the combinations of ages which had no access to food retained between 1-10 mg. in their honey stomachs. When 25 bees were being fed by 5 bees, the group of 5 bees, 7 and 21 days old each took about the same volume of food in 98 hours. But when 100 bees were being fed by 5 bees, the group of 5 bees, 21 days old , took a greater amount (7.03 ml.) of food than the 7 day old bees (4.60 ml.*). This indicates that 21 day old bees received more food than the 7 day old bees when fed by the 5 bees of their own age.

The amount of food passed by 5 bees to 25 bees seems to be about the correct amount because it was similar to the amount that the 25 bees took

(* 1 ml. 50% honey solution weighed about 1200mg.)

when feeding themselves. However, it does not appear that 5 bees can supply the amount of food that 100 bees would take if they had direct access to it. It appears that during a 98 hour period 5 bees can only take between 4-7 ml. of 50% honey solution and feed on part of it and pass the rest.

When bees fed themselves, few died among the groups of 25 bees (see Figures 19 and 20) regardless of age, but among groups of 100 bees a higher mortality occurred among older bees than among the younger ones (see Figures 21 and 22), possibly due to the age factor itself.

When groups of bees (25 and 100) were being fed by 5 bees (in the groups of the same age) the mortality of 21 day old bees was higher than that of the 7 day old bees. This is possibly because the older bees require more food and/or because of their age they die of natural causes. Too, the 7 day old bees may be better "feeders". (Alpatov & Saf'yanova, 1950 found that 10 day old bees were the best feeders).

It is concluded that small numbers of bees, which have access to food, can deliver food to large number of bees, such as bees in a winter cluster or those who are producing wax or building comb (Grout, 1966). Thus food transmission assists in the division

of labour of colonies. It was also been shown that both the age of the bee (and the number) which is passing food and that of the one receiving (and the number) are important factors determining what amount of food certain bees will have in their honey stomachs.

TABLE 12 WEIGHT OF HONEY STOMACHS OF GROUPS OF BEES OF VARIOUS AGES AND NUMBERS, WHICH WERE FED BY 5 BEES FOR 24 HOURS

No. of bees without food	Replicates	Age (days) of groups of 5 bees with food								
			7			14			21	
		7*	14	21	7	14	21	7	14	21
25	I	115	152	65	62	167	48	176	54	39
	II	165	180	82	44	104	45	81	34	37
	III	118	256	151	111	59	40	130	104	31
	Total	398	588	298	217	330	133	387	192	107
	Mean	5.3	7.8	4.0	2.9	4.4	1.8	5.2	2.6	1.4
	Range	1-21	1-35	1-30	1-17	1-35	1-11	1-33	1-22	1-6
50	I	162	96	68	45	72	59	222	86	29
	II	123	130	77	55	62	45	134	199	84
	III	185	155	106	219	97	51	82	65	40
	Total	470	381	251	319	231	155	438	350	153
	Mean	6.3	5.1	3.4	4.3	3.1	2.1	5.8	4.7	2.0
	Range	1-29	1-29	1-28	1-29	1-21	1-19	1-39	1-29	1-15
100	I	169	70	157	137	78	67	63	135	36
	II	147	166	64	136	80	108	211	219	70
	III	399	73	181	186	48	58	97	61	29
	Total	715	309	402	459	206	233	371	415	135
	Mean	9.5	4.1	5.4	6.1	2.8	3.1	5.0	5.5	1.8
	Range	1-60	1-35	1-25	1-21	1-18	1-16	1-28	1-46	1-13

* Ages of groups of bees without food and being fed by the group of 5 bees

TABLE 13 WEIGHT OF HONEY STOMACHS OF GROUPS OF BEES OF VARIOUS AGES
AND NUMBERS WHEN FED CONTINUOUSLY AND STARVED FOR 24 HOURS

No. of bees in group	Replicates	Age (days) of bees					
		7		14		21	
		Without food	With food	Without food	With food	Without food	With food
25	I	53	193	29	138	26	83
	II	33	327	29	167	43	114
	III	-	149	-	98	-	47
	Total	86	669	58	403	69	244
	Mean	1.7	8.9	1.2	5.4	1.4	3.3
	Range	1-15	1-34	1-3	1-32	1-7	1-28
50	I	82	271	30	220	49	154
	II	30	289	33	181	32	107
	III	25	160	-	104	-	78
	Total	137	720	63	505	81	339
	Mean	1.8	9.6	1.3	6.7	1.6	4.5
	Range	1-48	1-36	1-5	1-46	1-12	1-26
100	I	53	554	27	132	25	192
	II	38	145	34	296	41	230
	III	29	143	-	233	-	249
	Total	120	842	61	661	66	671
	Mean	1.6	11.2	1.2	8.8	1.3	9.0
	Range	1-6	1-46	1-6	1-29	1-7	1-42

TABLE 14 TOTAL MORTALITY OF GROUPS OF BEES OF VARIOUS AGES AND NUMBERS WHICH WERE (A) STARVED, (B) FED CONTINUOUSLY, OR WERE (C) FED BY 5 BEES THROUGH A SCREEN IN 8 DAYS

Age of bees (days)	No. of bees per cage	food	Days after removal from hive							
			1	2	3	4	5	6	7	8
7	25	A	3	18	36	75	-	-	-	-
		B *	0	0	3	3	5	5	6	9
		C	0	0	3	3	4	4	4	5
	100	A	15	25	150+	300	-	-	-	-
		B **	0	5	5	5	9	13	13	15
		C	0	6	6	6	6	10	11	25
21	25	A	41	75	-	-	-	-	-	-
		B	0	2	8	8	11	16	21	21
		C	9	13	19	19	20	24	28	38
	100	A	150+	300	-	-	-	-	-	-
		B	0	9	13	18	21	42	45	57
		C	12	42	48	48	54	75	93	150+

* Total of 75 bees in 3 replicates

** Total of 300 bees in 3 replicates

TABLE 15 AMOUNT OF FOOD (ml.) TAKEN FROM THE FEEDING TUBES BY BEES, SOME OF WHICH WERE FEEDING OTHER BEES

		Ages of bees															
		7 days old								21 days old							
Replicates		A	B	C	Ma	D	E	F	Mb	A	B	C	Ma	D	E	F	Mb
I	30*	1.13	0.63	1.43	0	1.37	0.57	5.40	0	1.00	0.77	1.97	0	2.43	0.87	5.17	0
II	24	1.00	0.43	0.87	0	1.13	0.43	4.63	5	0.77	0.43	1.03	2	1.87	0.27	5.10	9
III	24	1.30	0.77	1.47	3	0.93	1.03	4.10	0	1.03	0.60	1.67	6	1.60	0.90	4.57	4
IV	20	1.10	0.43	0.93	0	1.17	0.47	2.63	0	1.23	0.50	1.10	0	1.13	0.37	2.73	5
Total	98 (hrs.)	4.53	2.26	4.70	3	4.60	2.50	16.76	5	4.03	2.30	5.77	8	7.03	2.41	17.57	18

- A Amount of food (ml.) taken by 5 bees when feeding 25 bees without access to food
 B Amount of food (ml.) taken by 5 bees when separated by a screen from 25 bees with access to food
 C Amount of food (ml.) taken by 25 bees with direct access to food
 D Amount of food (ml.) taken by 5 bees when feeding 100 bees without access to food
 E Amount of food (ml.) taken by 5 bees when separated by a screen from 100 bees with access to food
 F Amount of food (ml.) taken by 100 bees with direct access to food
 Ma Mortality of 25 bees with direct access to food
 Mb Mortality of 100 bees with direct access to food
 * Times when the amount of food (ml.) taken by bees was measured



Figure 14 Cages showing 5 bees with access to dyed food. Ratio of bees, left to right : 5:100, 5:50, 5:25. Note relative food level



Figure 15 Cages showing bees with access to dyed food. Ratio of bees, left to right : 5:25, 5:50, 5:100. Note relative food level

WEIGHT (mg.) OF POLLY STOMACHS

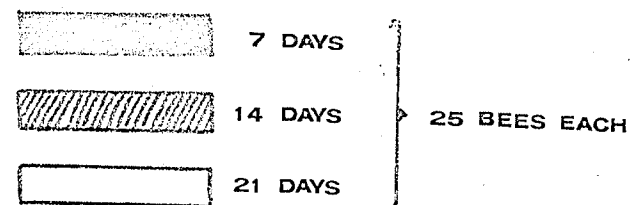
20

15

10

5

0



- A. EACH FED BY FIVE 7 DAY OLD BEES
B. " " 14 " "
C. " " 21 " "
D. F. H. BEES STARVED
E. G. I. BEES WHICH FED THEMSELVES

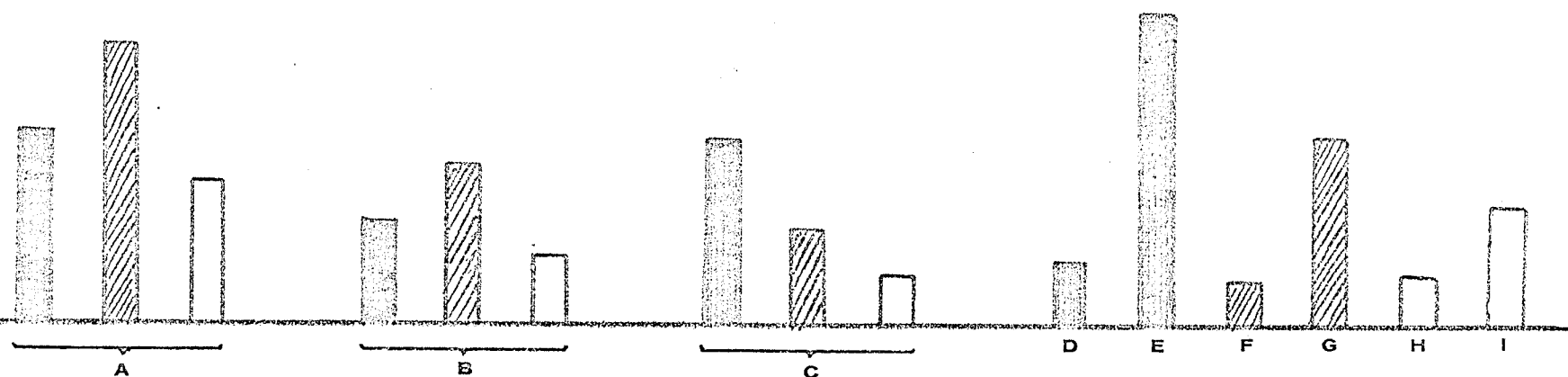


Figure 16 Weight of honey stomachs of groups of 25 bees of various ages some of which were being fed by 5 bees

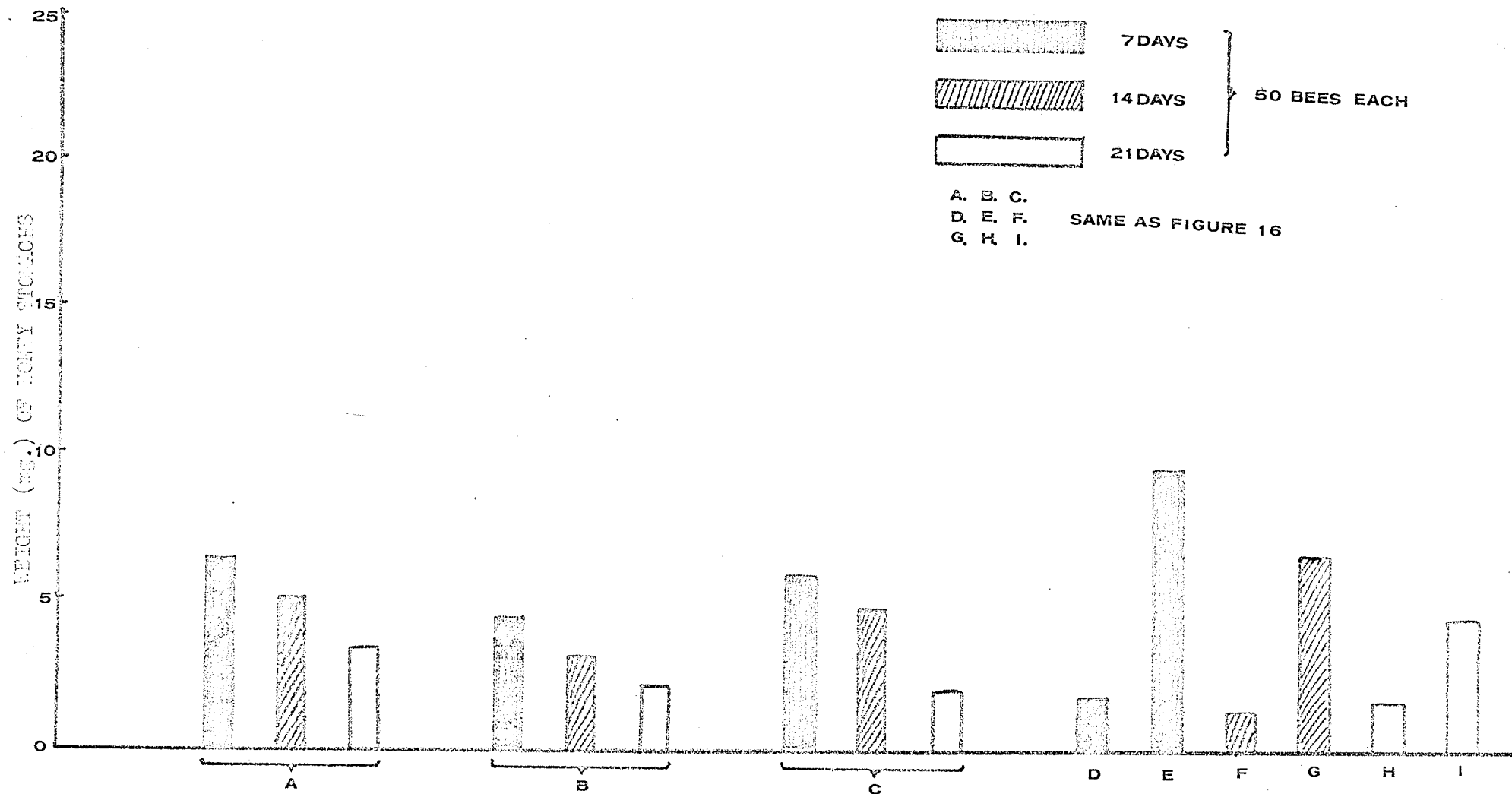


Figure 17 Weight of honey stomachs of groups of 50 bees of various ages some of which were being fed by 5 bees

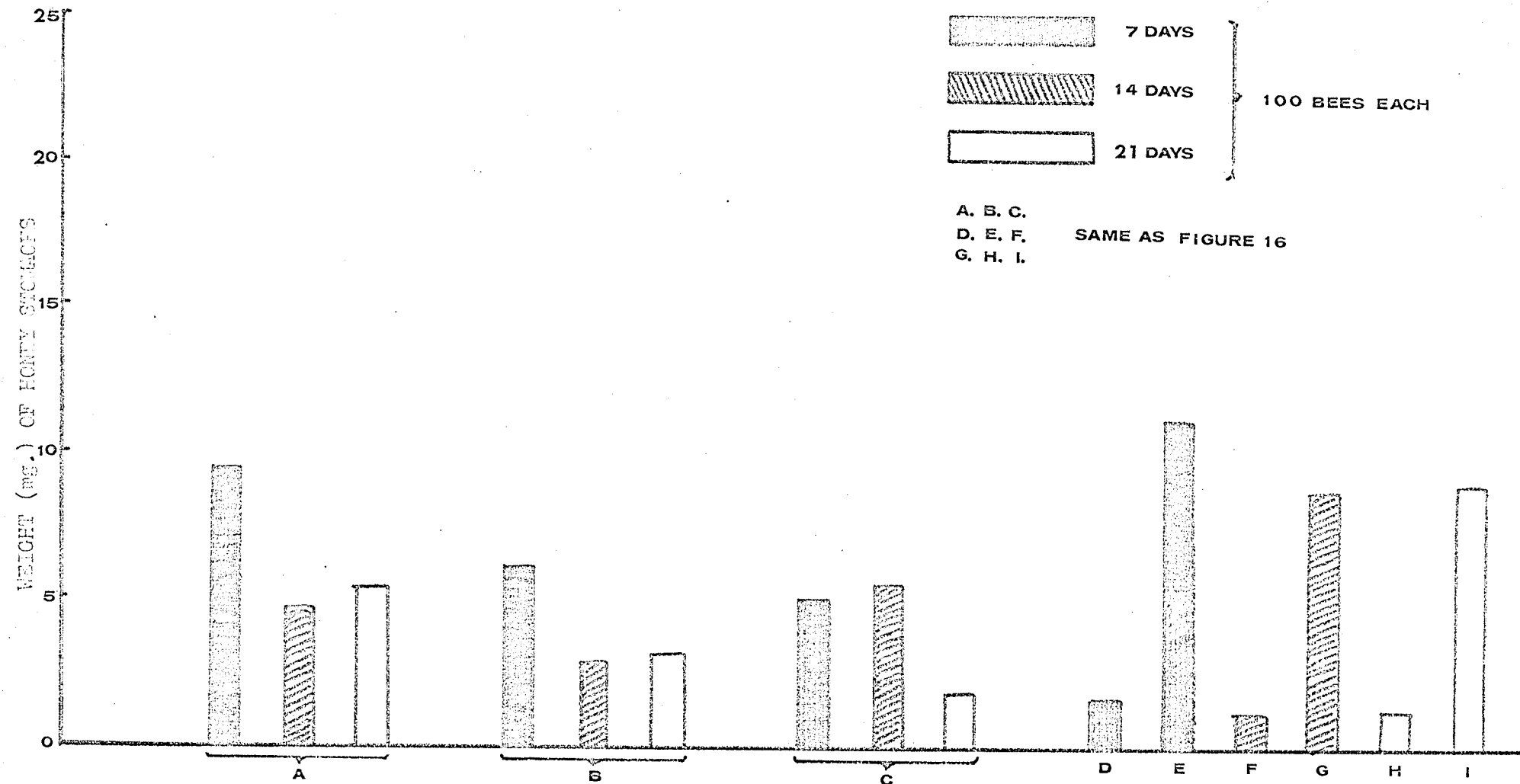


Figure 18 Weight of honey stomachs of groups of 100 bees of various ages some of which were being fed by 5 bees

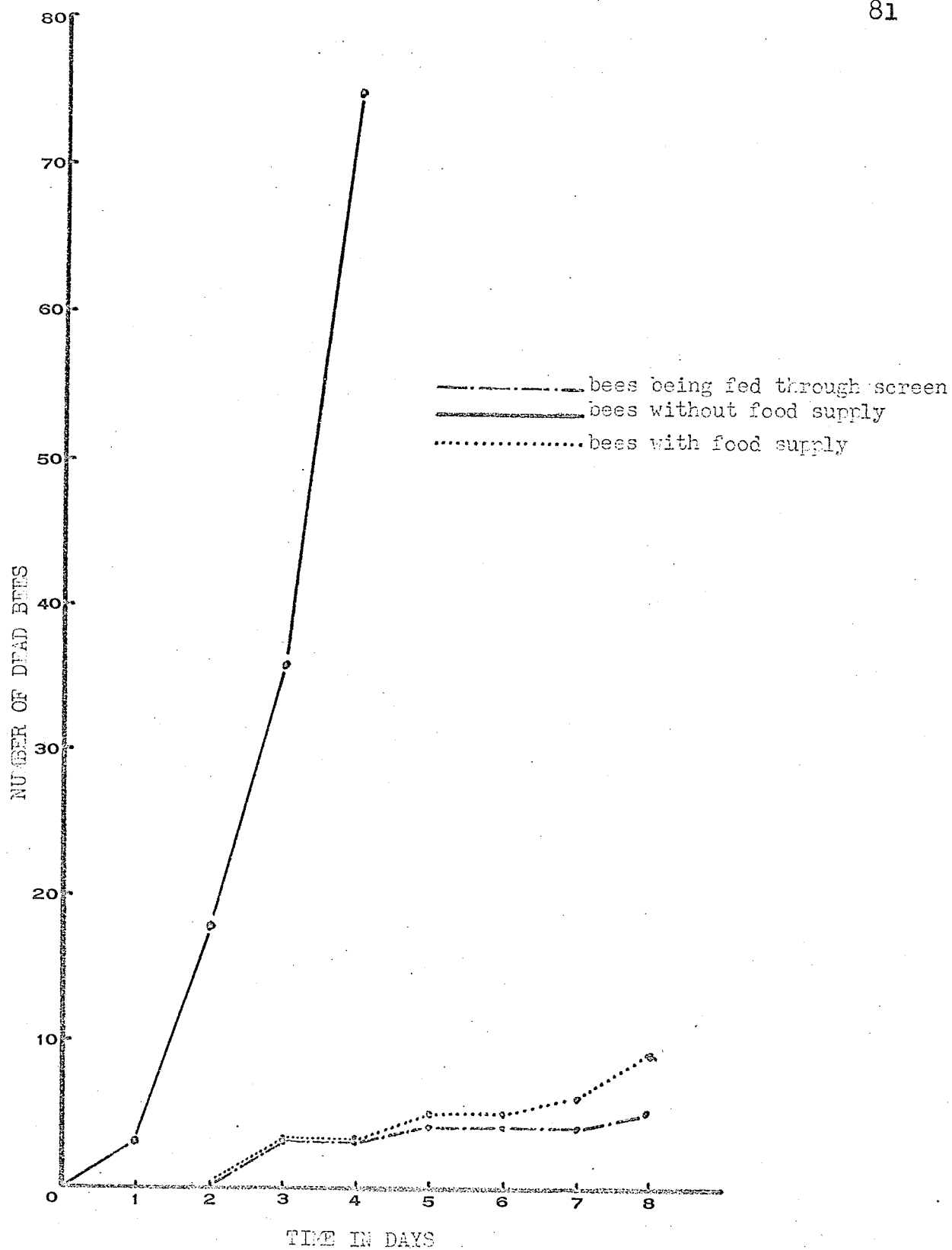


Figure 19 Total mortality of groups of 7 day old bees which were (a) starved, (b) fed continuously, or were (c) fed by 5 bees through a screen. (3 replicates each) (25 bees in each group)

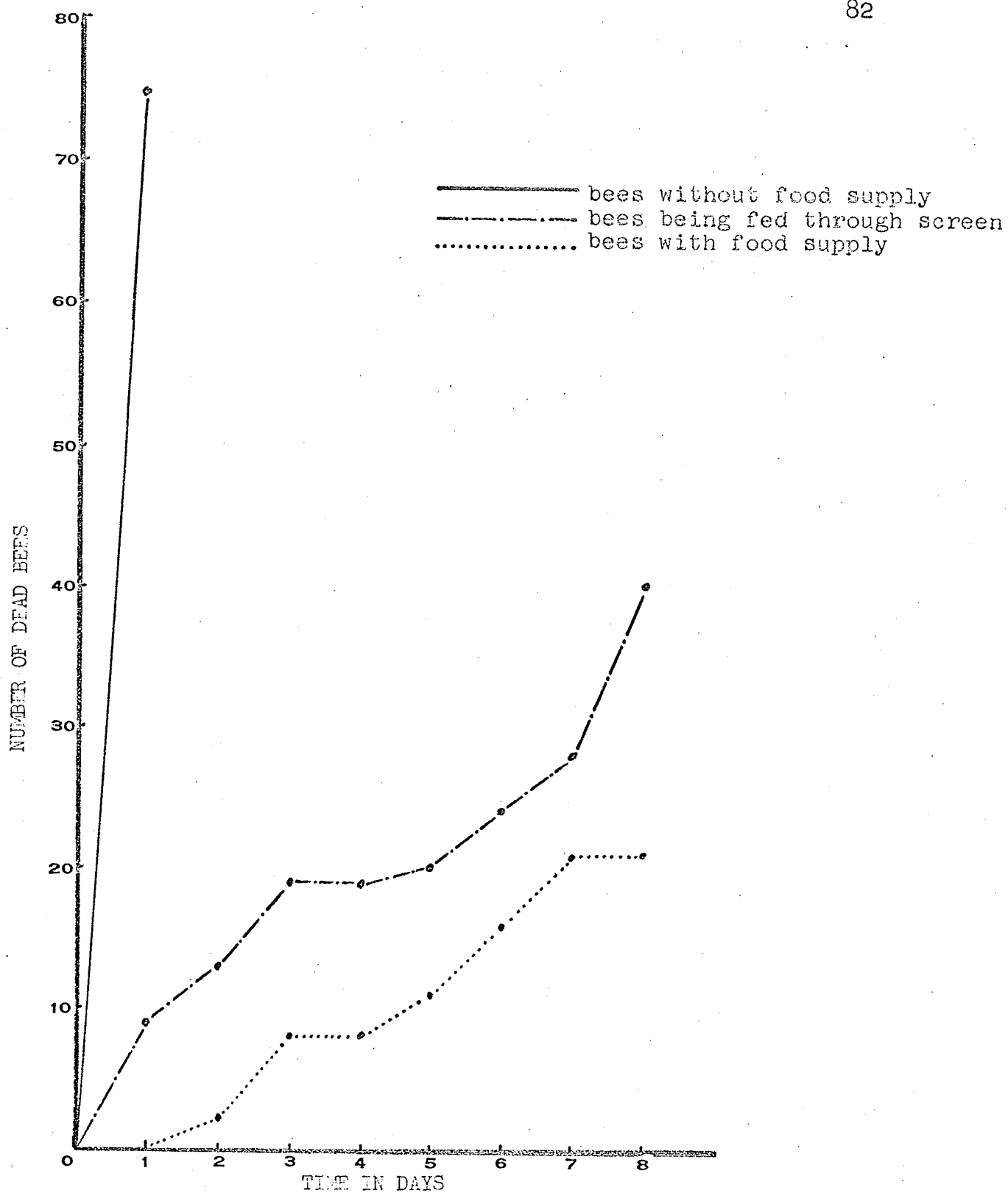


Figure 20. Total mortality of groups of 21 day old bees (25 bees per group) which were (a) starved, (b) fed continuously, or were (c) fed by 5 bees through a screen. (3 replicates each)

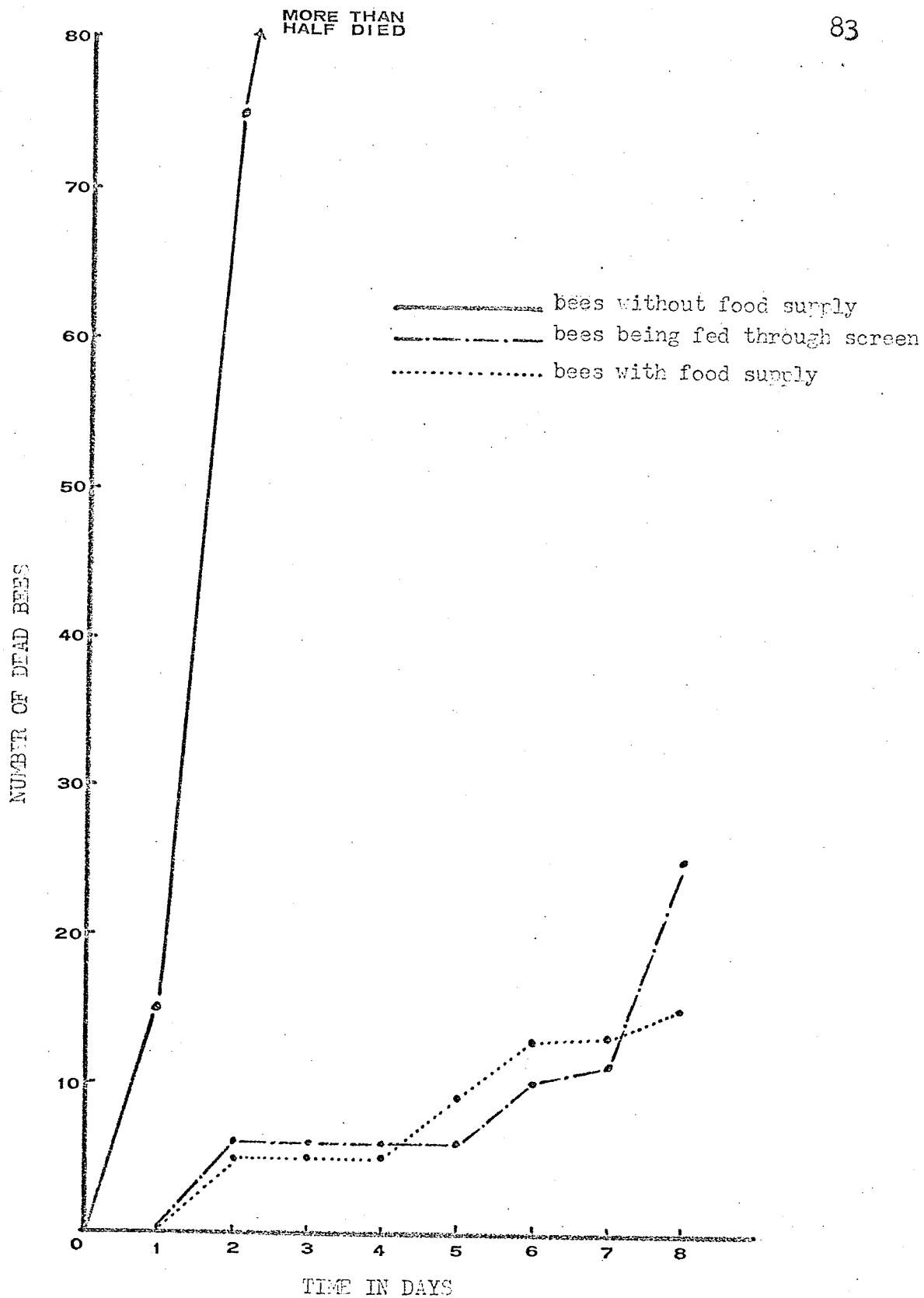


Figure 21 Total mortality of groups of 7 day old bees (100 bees per group) which were (a) starved, (b) fed continuously, or were (c) fed by 5 bees through a screen. (3 replicates each)

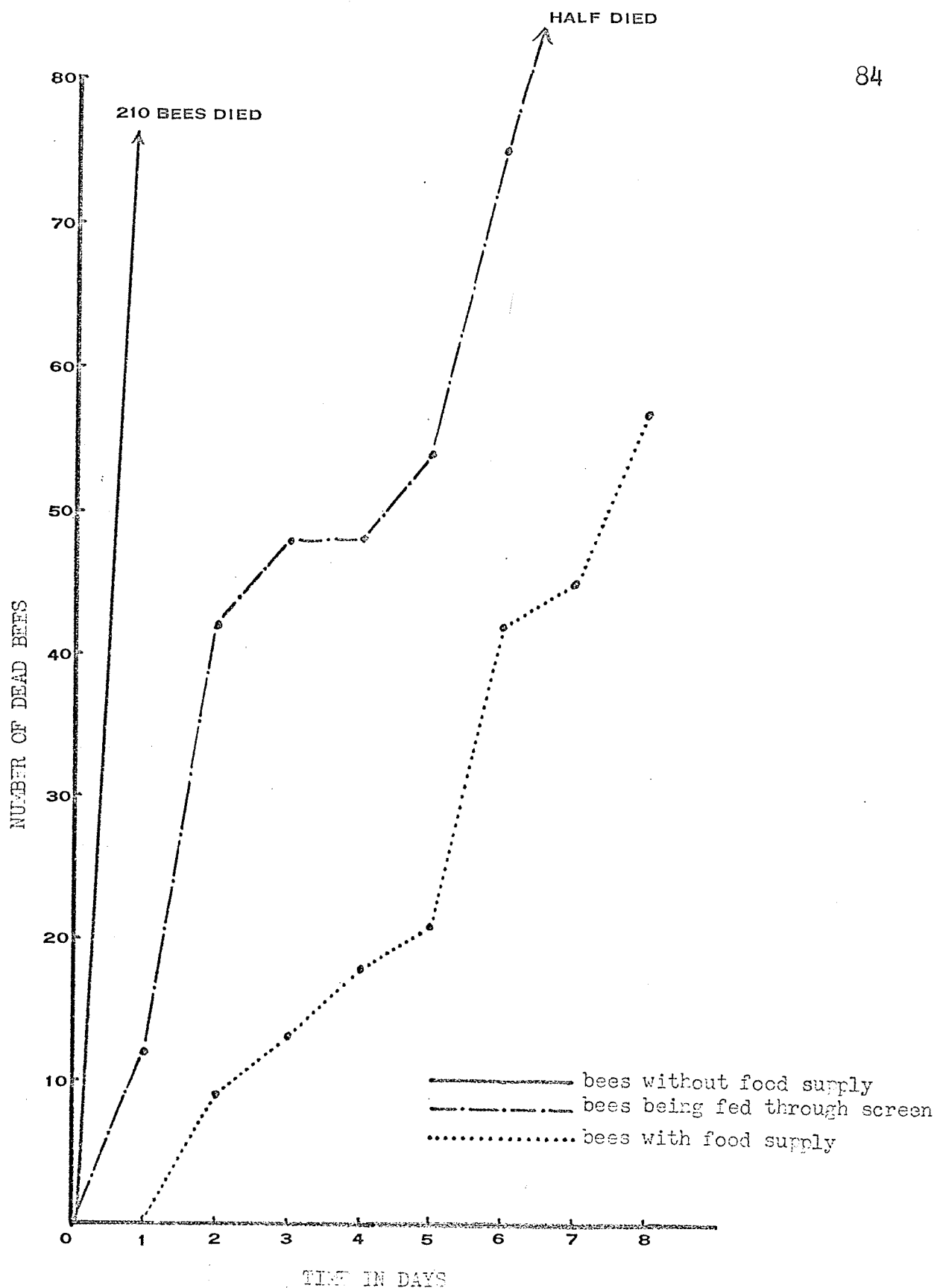


Figure 22 Total mortality of groups of 21 day old bees (100 bees per group) which were (a) starved, (b) fed continuously, or were (c) fed by 5 bees through a screen. (3 replicates each)

CHAPTER VII

EFFECT OF FORAGING ACTIVITY AND LOCATION OF BEES
WITHIN HIVES DURING SPRING AND SUMMER ON THE
WEIGHT OF HONEY STOMACHS

INTRODUCTION

Little data are available concerning seasonal effects on honey stomach weights of bees depending on their position within the hive and their foraging activities. This study was a preliminary attempt to show whether or not such effects do exist-- particularly among bees of mixed ages which were collected at three different times of the day on open and sealed cells containing honey, open and sealed cells containing brood, when leaving the hive, and when returning to the hive with nectar and/or pollen.

METHOD

Bees of mixed ages were collected at about ten day intervals from each of 3 hives which were located same distance apart on the edge of a bush; the hives faced south onto an experimental crops area on The University of Manitoba campus; these crops bloomed at various periods throughout the season of 1968.

Three times (at 900-1000, 1300-1400, and 1700-1800 hours) per day 25 bees were collected

with tweezers from honey combs (open and sealed) and from brood combs (open and sealed). At the entrance to the hive 25 bees which were leaving the hive were collected, as well as 25 pollen gatherers (with pollen loads on hind legs) and 25 nectar gatherers. Care was taken when collecting nectar gatherers not to pick the bees which were undertaking orientation or defecation flights or guarding the entrance.

When bees were removed from the hive they were immediately put into a test tube which was dipped into a dry ice and alcohol mixture (giving a temperature of -60° to $-70^{\circ}\text{C}.$) which killed them in about 1 minute; they were then kept in a thermos jug with the temperature at about $-30^{\circ}\text{C}.$ until they were brought to the laboratory ready for dissection.

Each of the 3 colonies (plus 1 extra) were checked periodically for queen losses and disease. The honey flow within this bee yard was recorded throughout the season by placing a colony of bees on a beam scale.

RESULTS

The results are shown in Table 16 and 17, Appendix A (Table 18-27), and Figure 23-29. Regardless of the time of day or time during the season, the house bees tended to have more food in their honey stomachs than the foragers; the bees on open honey comb cells had the most (range 1-106 mg.) while the bees leaving the hive had the least (range 1-49 mg.). The weight of honey stomachs can be expressed as follows: honey comb > brood comb > nectar gatherers > pollen gatherers > leaving bees. Bees on open cells had more food in their honey stomachs than those on the sealed cells and bees returning to the hive had more food than those leaving it. (see Table 18-27 in Appendix A)

When bees were collected at different times (900-1000, 1300-1400, and 1700-1800 hours) during the day, no great changes occurred in the honey stomach weights of bees leaving the hive. Nectar gatherers collected more food at 1700-1800 hours than at other times; this was also true of the honey stomach weights of pollen gatherers and the weight of honey stomachs can be expressed as followed: 1700-1800 > 1300-1400 > 900-1000 hours indicating that the bees were frequently collecting both pollen and

nectar on the same trips. Pollen loads weighed the most at 1300-1400 hours, less at 900-1000 hours, and least at 1700-1800 hours. Among the bees on honey combs or brood combs the weight of honey stomachs was lower at 1700-1800 hours than at other times of the day, but they varied somewhat in the morning (900-1000 hours) and at noon (1300-1400 hours) (see Figures 23 -28). It should be noted that a few of the nectar collectors may have, in fact, been collecting water, but for practical purpose, they have been treated as nectar collectors in this thesis.

Regardless of the time of day or season the bees leaving the hive had about the same amount of food in their honey stomachs. The honey stomach weight pattern of both nectar and pollen gatherers followed fairly well the honey flow. The peak of the honey flow occurred somewhere between August 3rd and August 20th (see Figures 26 -29).

The honey stomach weights of bees collected either from honey combs or brood combs had similar patterns throughout the season, i.e. there were two peaks for each of the groups of bees (open and sealed honey comb, open and sealed brood comb). One peak

occurred on about July 20th, and the other occurred on about August 27th. Late in the season, bees on open honey combs had more food in their honey stomachs than did any other groups.

Based on calculations of unladen bees (mean = 100.6 mg.) it was found that the bees carrying the heaviest nectar loads weighed a mean of 154.1 mg. (i.e. they were carrying 53.2% of their own weight) and those carrying the heaviest pollen loads weighed a mean of 144.3 mg. (i.e. they were carrying 43.4% of their own weight, 30.7% of which was pollen and 12.7% of which was nectar). The heaviest house bees weighed a mean of 182.1 mg. (i.e. they were carrying 80.9% of their own weight) (see Table 17).

DISCUSSION AND CONCLUSIONS

Regardless of when bees were collected during the day or season, the house bees tended to have more food in their honey stomachs than did the foragers; the bees on open honey comb cells had the most while the bees leaving the hive had the least. This is probably because the house bees required more food to perform such duties as rearing brood, producing wax and building comb than did the foragers. Also the bees collected from the open honey comb cells had probably just finished eating or were still

doing so while the bees collected when leaving the hive had probably passed most of their honey stomach contents to house bees. Food is also more easily obtained from unsealed cells.

Bees had more food in their honey stomachs when collected from open brood cells than from sealed cells, probably because the larvae in open cells required much feeding. Free (1960) and Furgala and Boch (1961) found that house bees were more attracted to open brood than sealed brood.

Bees which were leaving the hive at different times (900-1000, 1300-1400, 1700-1800 hours) during the day, had low honey stomach weights, probably because the experimental plots not only had much forage available but it was close at hand; according to Istomina-Tsvetkova (1958) the amount of food which foragers retain in their honey stomachs, after passing food onto house bees, is determined by the length of their next flight. Because the bees in these studies were probably foraging in the same close area they probably retained about the same amount of food in their honey stomachs.

Bees collected more pollen at 1300-1400 hr., and more nectar at 1700-1800 hr. probably because

these were the times when the plants were secreting nectar and presenting pollen in the foraging area. Chauvin (1963) found that pollen collection was more related to daily temperatures than to other factors. Pollen gatherers appeared to collect nectar as well as pollen. Free (1967) and Sekiguchi and Sakagami (1966) found that individual bees quickly changed from collecting nectar to collecting pollen and vice versa according to their colony's needs. Some of the pollen gatherers in these experiments may have been in the process of switching from pollen gathering to nectar gathering (or vice versa), or some bees may have been collecting nectar and were covered accidentally with pollen and hence packed it into their corbiculae. The pattern of both pollen and nectar collection followed fairly well the honey flow.

There was no special pattern of honey stomach weights of bees on honey combs or brood combs (except that it was slightly lower at 1700-1800 hours) at different times of the day. Probably because the bees were working indoors, their duties were not seriously affected by the time of day. The honey stomach weights of the bees collected from both honey combs and brood combs had similar patterns throughout the season; there were two peaks, one about July 20th and the other about August 27th. The reason for this is not clear.

It is concluded that bees on open honey combs had the most food, while bees leaving the hive had the least. This fact can be used to obtain bees with high and low amounts of food in their honey stomachs for experimental purposes. It is also concluded that the weight of honey stomachs of bees is partly affected by the times of day and season when they are collected as well as their location in the hive and probably the kinds of duties they are performing.

TABLE 16

MEAN WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF BEES
TAKEN FROM VARIOUS PARTS OF A HIVE THROUGHOUT THE SEASON

Times when bees collected								
900 - 1000								
Bees collected on:								
Dates	Brood comb		Honey comb		Returning to Hive			
	open cells	sealed cells	open cells	sealed cells	Leav- ing Hive	with Nectar only	with both Nectar Pollen	
22 May	14.1*	14.1	18.1	18.1	-	10.7	2.6	12.5
31 May	12.2	12.2	15.4	15.4	6.5	9.8	3.7	14.1
18 June	17.8	16.3	35.1	-	7.0	12.2	3.2	16.9
27 June	25.3	14.8	27.1	-	9.1	11.6	3.4	18.2
19 July	15.2	14.2	36.6	24.5	2.6	12.8	6.9	13.0
25 July	25.5	33.2	37.4	27.0	5.6	23.2	9.1	16.1
8 Aug.	21.3	17.7	32.3	31.6	4.4	21.6	10.3	18.9
14 Aug.	25.5	14.3	36.4	20.6	3.6	19.9	6.0	15.4
27 Aug.	33.9	33.1	32.8	31.6	4.3	15.2	3.7	11.1
10 Sept.	34.9	39.4	68.3	29.4	3.4	13.6	3.6	14.5

* Mean of 75 bees

TABLE 16 (Continued)

Times when bees collected								
1300 - 1400								
Bees collected on:								
Dates	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
22 May	14.1	14.1	17.1	17.1	-	-	3.2	10.6
31 May	6.0	6.0	9.4	9.4	4.6	10.0	4.8	15.0
18 June	9.5	8.7	20.0	7.0	4.1	6.9	4.4	10.8
27 June	4.4	9.2	23.8	20.9	2.4	11.9	6.6	7.7
19 July	24.7	32.8	46.9	33.0	4.7	19.5	12.0	16.8
25 July	29.9	24.8	34.2	25.8	6.1	20.4	13.6	19.6
8 Aug.	23.6	16.2	28.0	17.8	4.4	22.6	13.1	14.6
14 Aug.	27.5	16.3	25.4	15.5	4.4	25.6	10.7	19.2
27 Aug.	30.6	40.2	35.5	28.3	4.4	11.5	8.6	13.1
10 Sept.	26.0	20.6	47.6	14.2	4.7	16.0	9.4	15.8

TABLE 16 (Continued)

Times when bees collected								
1700 - 1800								
Bees collected on:								
Dates	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
22 May	10.4	10.4	17.1	17.1	-	-	3.2	9.6
31 May	8.5	8.5	15.3	15.3	-	11.0	5.3	10.1
18 June	7.4	10.6	15.3	8.0	2.7	10.9	3.8	7.2
27 June	9.1	7.1	14.6	9.7	1.9	11.5	7.7	5.2
19 July	21.5	22.6	39.0	21.9	4.3	22.0	16.4	15.9
25 July	35.9	25.2	31.8	29.5	10.0	29.8	16.5	18.4
8 Aug.	-	-	-	rain storm	-	-	-	-
14 Aug.	13.8	12.9	31.5	13.1	5.9	13.5	10.7	13.7
27 Aug.	19.6	24.9	39.4	22.9	4.2	19.3	9.8	7.5
10 Sept.	16.5	13.8	38.6	15.7	4.7	11.5	8.2	7.9

TABLE 17 WEIGHT (mg.) OF 75 BEES WITH THE HEAVIEST
HONEY STOMACHS AND POLLEN LOADS

	Nectar gatherers	Pollen gatherers		House bees	
	Honey stomachs	Honey stomachs	Pollen loads	Honey stomachs	Unladen wt.
Total wt.	4012	958	2316	6113	7544
Mean	53.5	12.8	30.9	81.5	100.6
S. D.	6.1	8.5	2.4	5.9	8.3
Range	45-69	1-38	28-44	74-99	79-118

S.D. Standard deviation

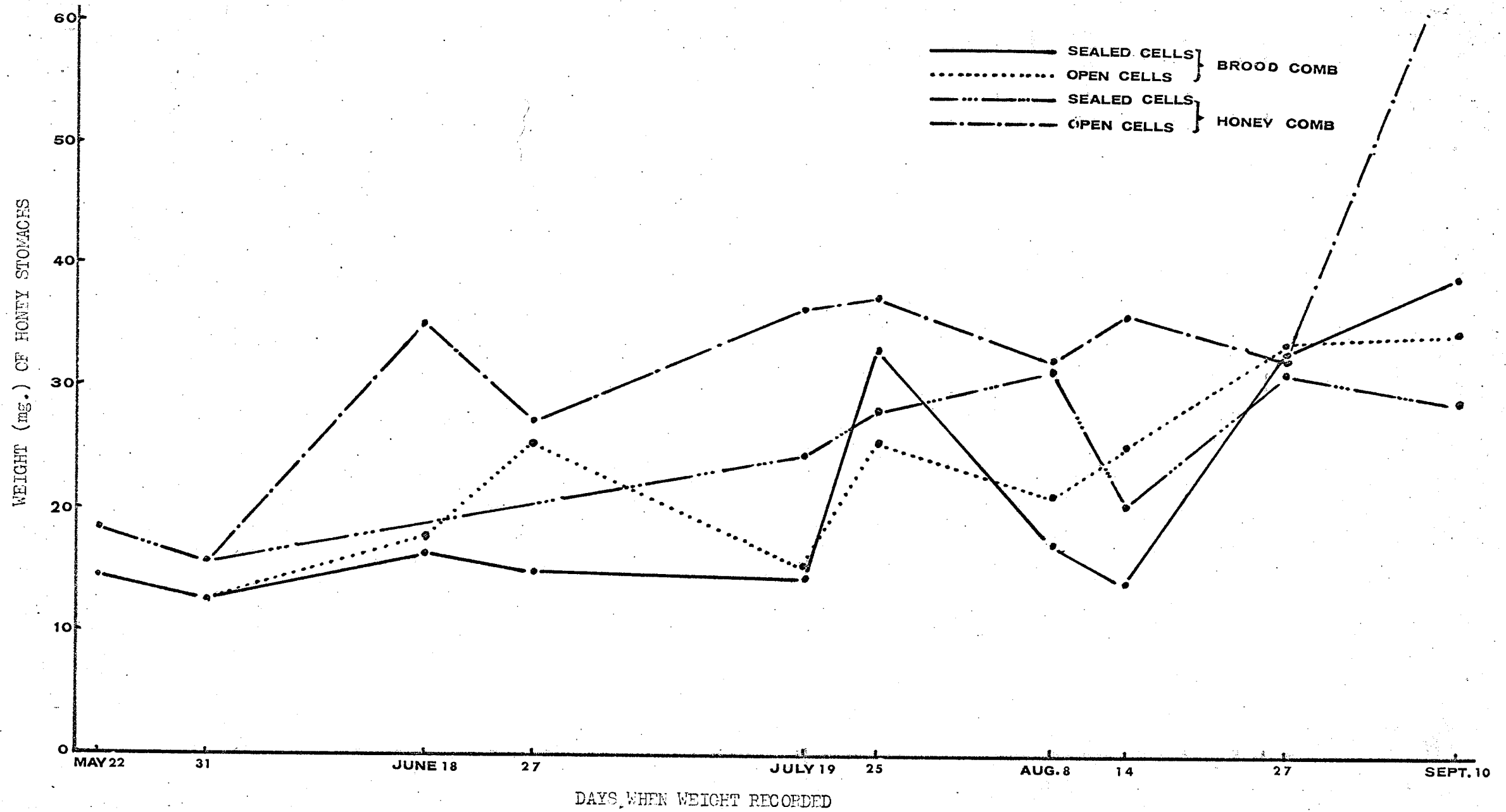


Figure 23 Weight of honey stomachs of bees collected on open and sealed honey and brood cells at 900-1000 hours throughout the 1968 season

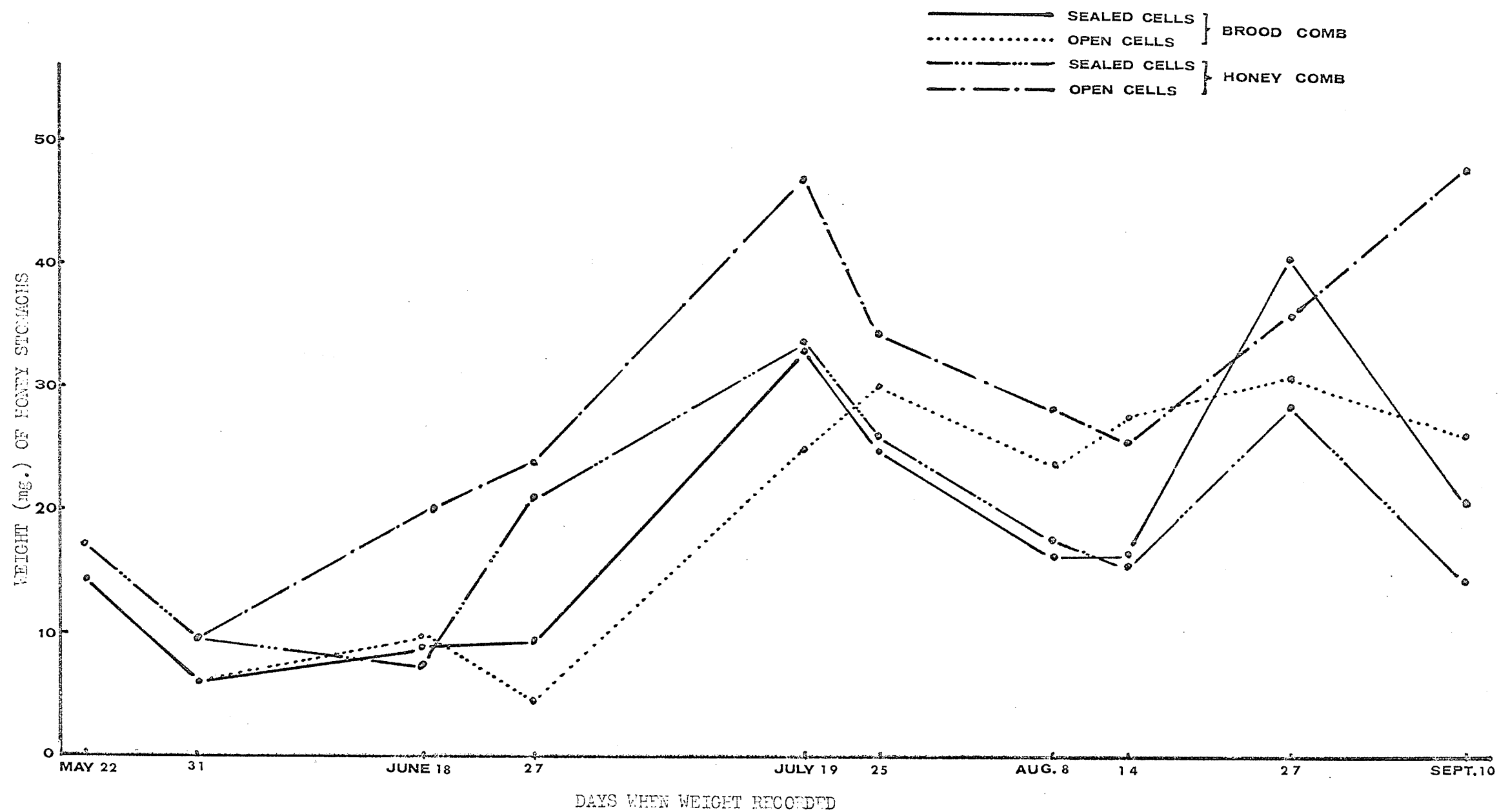


Figure 24 Weight of honey stomachs of bees collected on open and sealed honey

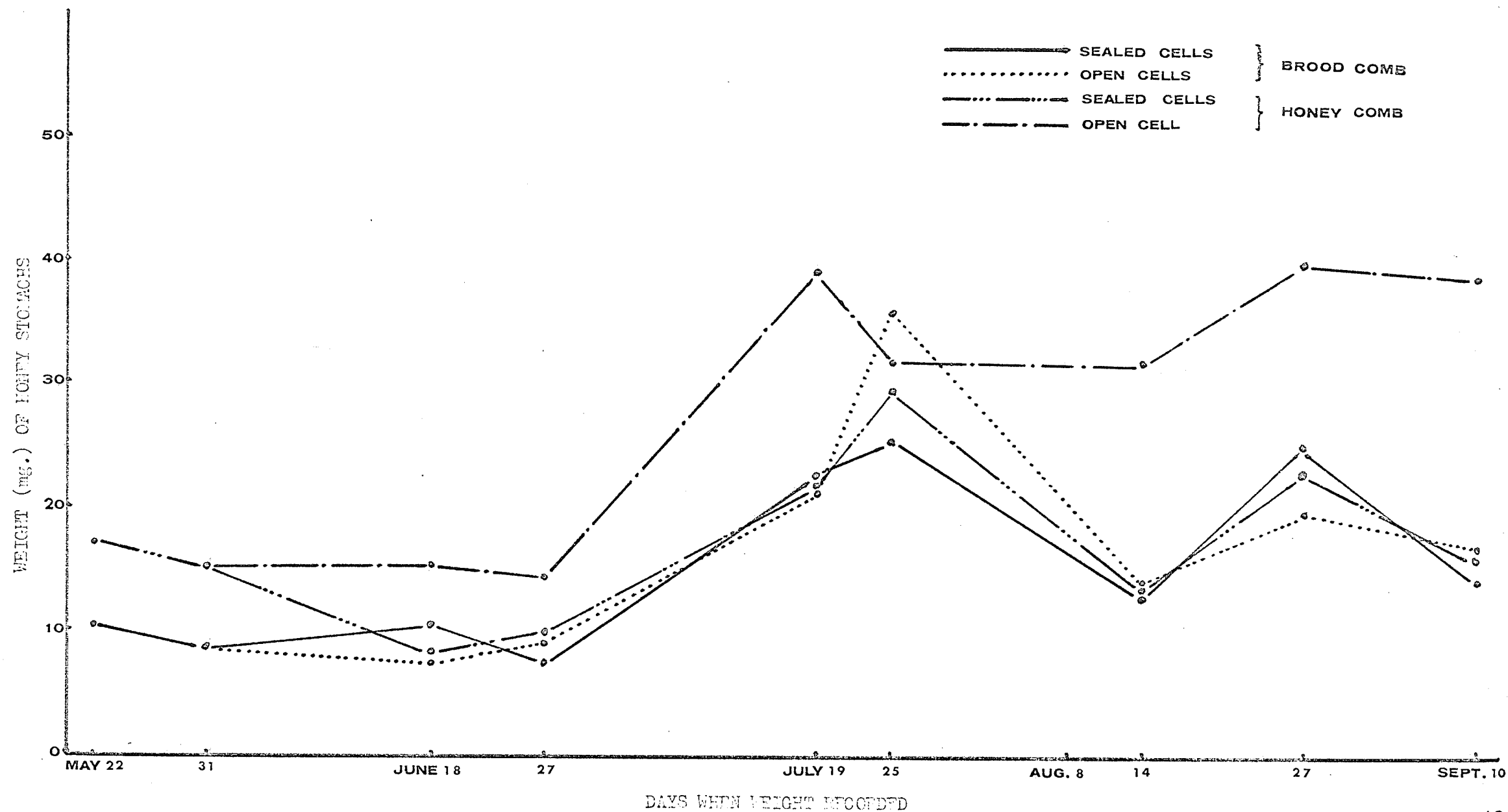


Figure 25 Weight of honey stomachs of bees collected on open and sealed honey and brood cells at 1700-1800 hours throughout the 1968 season

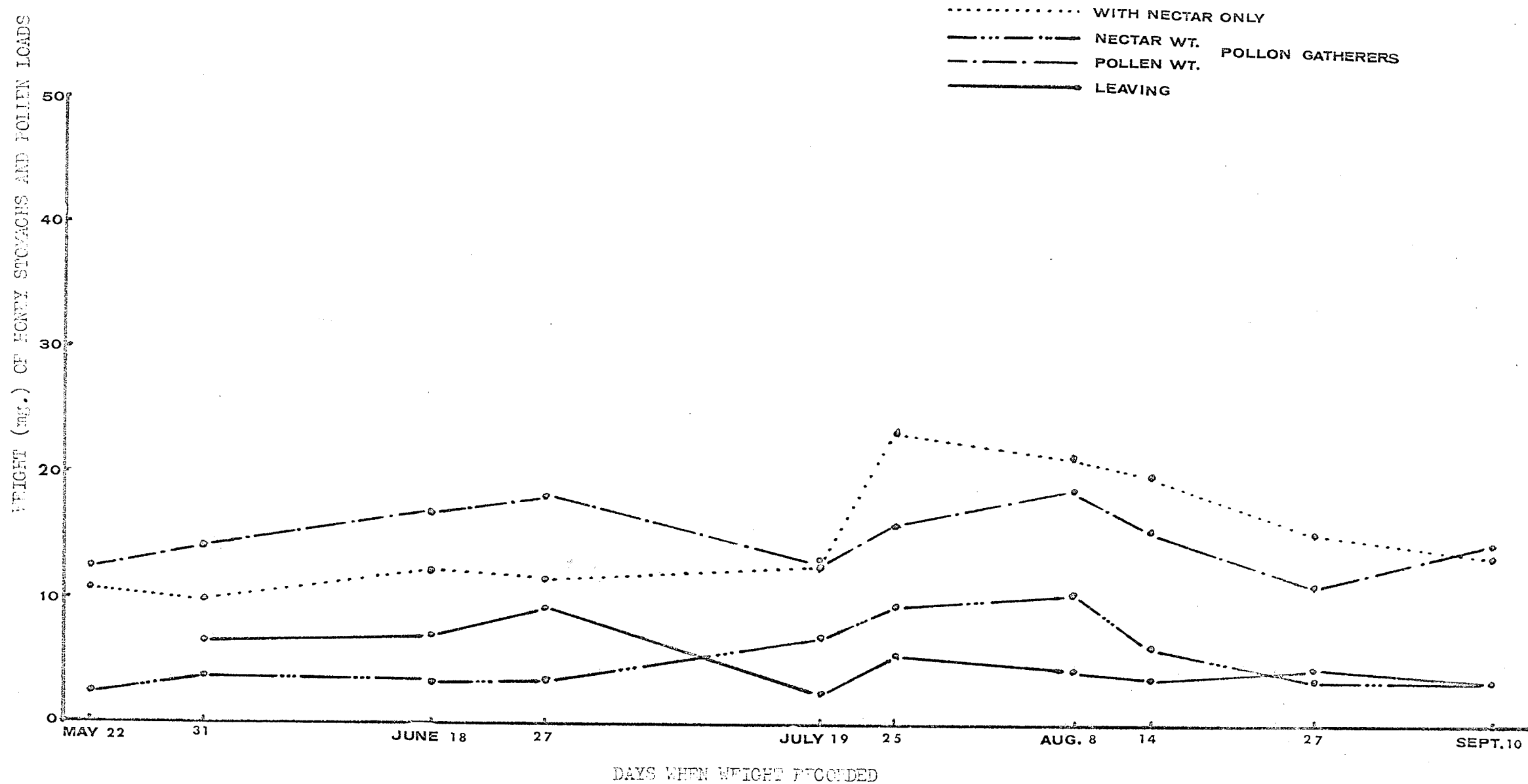


Figure 26 Weight of honey stomachs and pollen loads of bees collected when leaving or returning to the hive at 900-1000 hours throughout the 1968 season

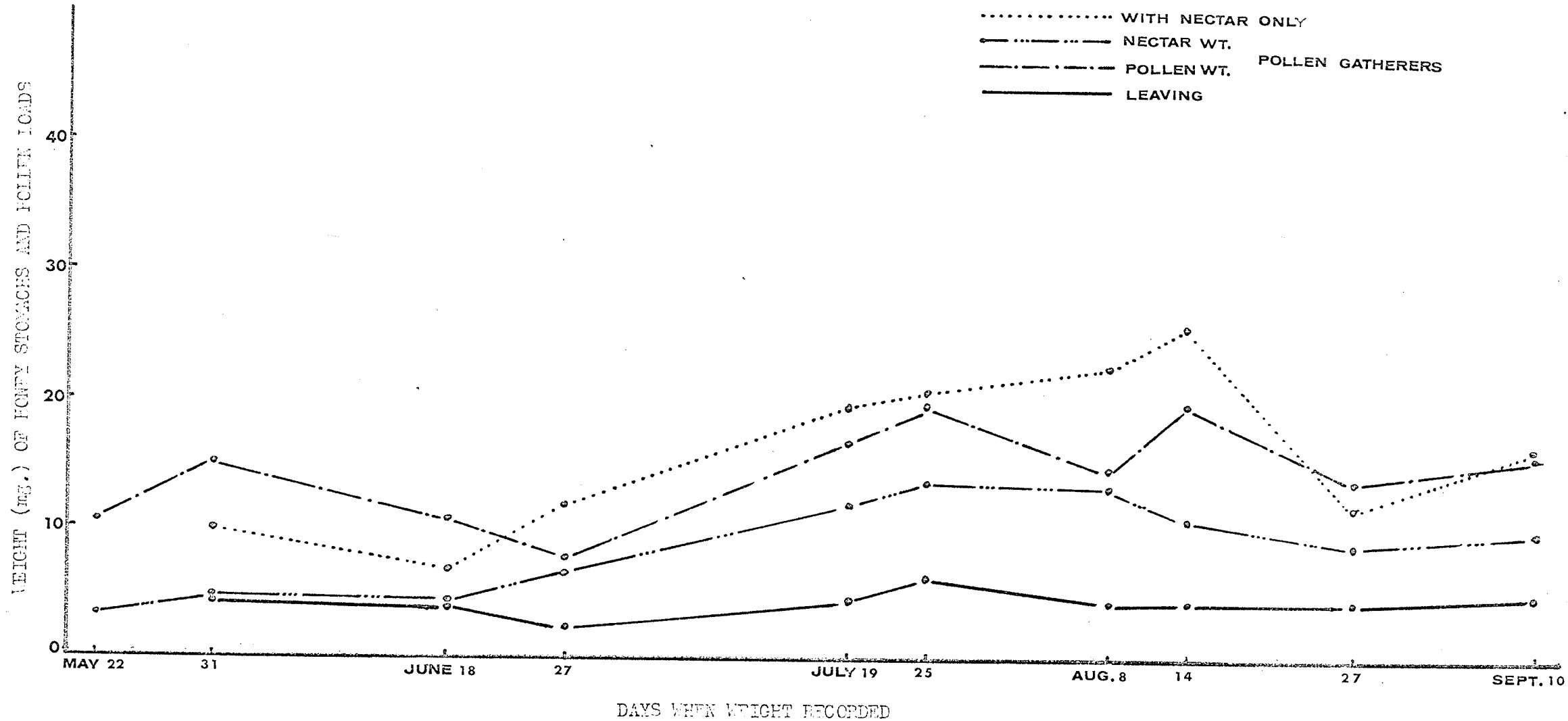


Figure 27 Weight of honey stomachs and pollen loads of bees collected when leaving and returning to hive at 1300-1400 hours throughout the 1968 season

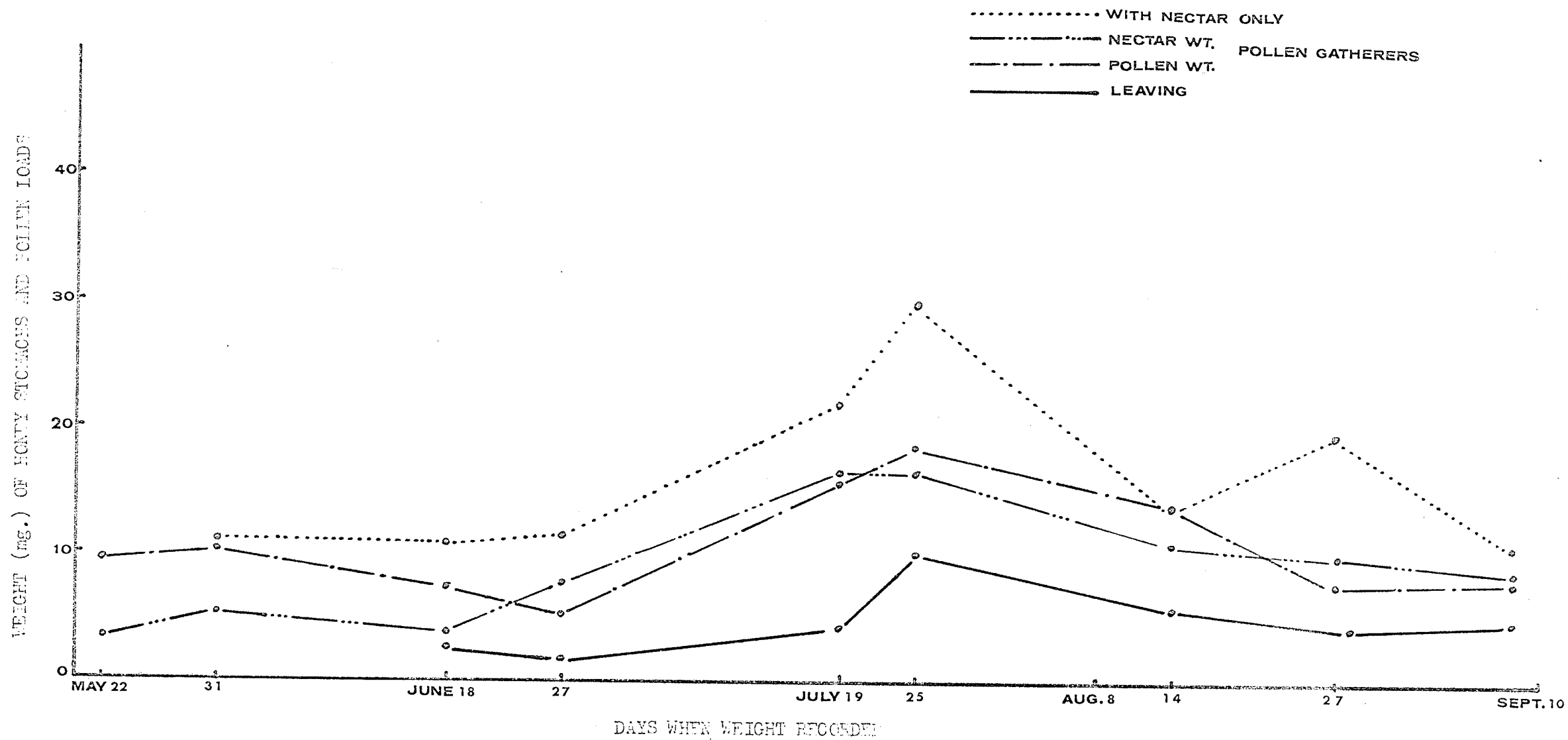


Figure 28 Weight of honey stomachs and pollen loads of bees collected when leaving and returning to hive at 1700-1800 hours throughout the 1968 season

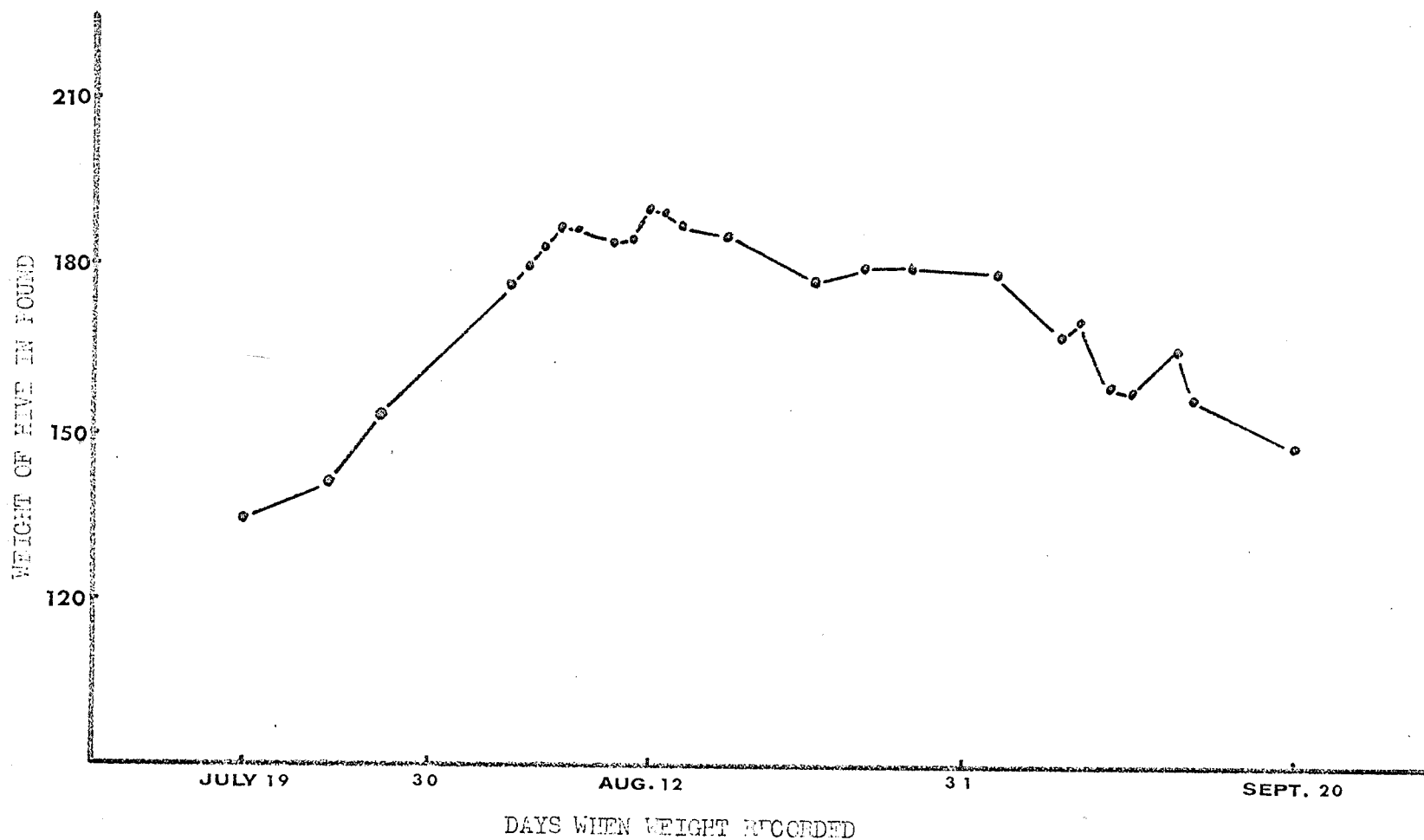


Figure 29 Honey flow chart for hives kept on The University of Manitoba campus (1968)

GENERAL SUMMARY

Various factors were studied to ascertain their effects on the weights of honey stomachs of worker honey bees.

CHAPTER III

Five methods, cyanide gas, carbon dioxide gas, freezer temperatures (-20° to -30°C.), dry ice (-60° to -70°C.), and liquid nitrogen (-195°C.) were used to kill bees quickly in an attempt to prevent the regurgitation of food from the honey stomach or its passage backwards to the midgut. Liquid nitrogen was found to be suitable for laboratory studies and dry ice for field studies. Methods for removing honey stomachs from bees were devised.

CHAPTER IV

Groups of bees 2, 7, 14, and 21 days old were removed from a hive and either starved or fed continuously, or first starved for various time periods and then fed for 0.5 hours. When removed from the hive the older bees usually had more food in their honey stomachs and subsequently had higher mortality rates in most tests than the younger bees.

The weights of the honey stomachs of bees of all ages tended to decrease at the same rate when

the bees were starved; this was also true when the bees were fed continuously for two hours; after this time the results were variable. In this latter test the younger bees had less food in their honey stomachs, at any given time, than the older ones. When the various groups of bees were starved for different time periods and then fed for 0.5 hours the honey stomach weight patterns varied according to age.

It is concluded that age, and the length of the feeding and/or starvation periods affect the amount of food found in the honey stomachs of bees at specific times.

CHAPTER V

Experiments were done with groups of bees of various ages (2, 7, 14, and 21 days old) supplied with high (65%) or low (15%) concentration honey solutions; these were fed continuously or for various time periods followed by various periods of starvation. After being starved and then fed, bees of all ages had more of the higher concentration food in their honey stomachs (after allowing for the difference in weight between the 65% and 15% food) than of the lower one. The honey stomach weights increased greatly during the first 0.5 or 1.0 hour of feeding and then decreased thereafter

even when food was available.

When fed continuously on 15% foods the honey stomach weights of bees of all ages tended to decrease with time whereas those of most age groups, fed on the 65% foods, varied within a narrow range (except for those of the 21 day old bees, which decreased).

It is concluded that the sugar concentration of the bees' food and their previous experience (i.e. fed or starved) affects the honey stomach weights of bees of various ages.

CHAPTER VI

Groups of 5 bees (7, 14, or 21 days old) were supplied with food and allowed to feed groups of 25, 50, or 100 bees, (7, 14, or 21 days old) through a screen for various time periods. After 24 hours, regardless of the age of the 5 bees with access to the food or the number of bees they were feeding, the 7 day old bees had the heaviest honey stomachs and the 21 day old bees had the lightest ones.

More food was passed by the 5 bees of both ages to the 100 bees than to the 25 bees and the groups of 100, 21 day old bees took more food than did the 100, 7 day old ones over 8 days. Regardless of the number of bees being fed, it

appears that in a 100 hour period, groups of 5 bees (7 and 21 days old) can only ingest and/or feed 4 and 7 ml. of a 50% honey solution.

It is concluded that the age and number of bees being fed in relation to the age and number of bees doing the feeding is an important factor affecting the honey stomach weights of bees.

CHAPTER VII

Groups of bees were collected on given days from hives at 900-1000, 1300-1400, and 1700-1800 hours throughout the spring and summer season. They were collected on open and sealed honey comb cells, on open and sealed brood cells, when leaving the hive, and when returning to it with loads of nectar and/or pollen; their honey stomachs and/or pollen loads were then weighed.

Regardless of time of day or season the gradation of honey stomach weights can be expressed generally as follows: honey comb > brood comb > nectar gatherers > pollen gatherers > leaving hive. Bees on open cells had heavier honey stomachs than those on sealed ones and bees returning to the hive (pollen and nectar gatherers) had heavier honey stomachs than those leaving it. The heaviest loads of nectar and pollen were collected at 1700-1800 and 1300-1400 hours

respectively. The honey stomach weight patterns of both nectar and pollen gatherers followed closely the honey flows. The honey stomach weights of bees on honey and brood combs varied considerably throughout the day but they had patterns similar to each other throughout the season with two peaks occurring, one in July and one in August.

It is concluded that the weight of honey stomachs of bees is affected by the time of day and season when they are foraging, as well as by their location in the hive at these times.

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APPENDIX A

TABLE 18. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
22nd May, 1968.

		Times when bees collected:					
		900 - 1000 hrs.					
Hive		Bees collected on:					
Number		Brood comb		Honey comb		Returning to Hive	
		open cells	sealed cells	open cells	sealed cells	Leav- ing Hive only	with Nectar with both Nectar Pollen
	Total	295		269		-	215 47 -
I*	Mean	11.8		10.8		-	8.6 1.9 -
	Range	1-40		1-25		-	2-19 1-7 -
	Total	392		454		-	289 80 -
II	Mean	15.7		18.2		-	11.6 3.2 -
	Range	1-48		1-44		-	1-26 1-14 -
	Total	372		637		-	298 67 313
III	Mean	14.9		25.5		-	11.9 2.7 12.5
	Range	1-59		13-52		-	1-27 1-11 5-22
	Total	1059		1360		-	802 194 313
**	Mean	14.1		18.1		-	10.7 2.6 12.5
	Range	1-59		1-52		-	1-27 1-14 5-22

* 25 bees per sample

** Total of 75 bees

TABLE 18 (Continued)

Times when bees collected:							
1300 - 1400 hrs.							
Bees collected on:							
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive	
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen
Total	473		631		-	-	72 217
I* Mean	18.9		25.2		-	-	2.9 8.7
Range	1-54		2-53		-	-	1-14 4-13
Total	283		335		-	-	86 299
II Mean	11.3		13.4		-	-	3.4 12.0
Range	1-60		1-41		-	-	1-8 3-20
Total	298		317		-	-	82 278
III Mean	11.9		12.7		-	-	3.3 11.1
Range	1-38		2-30		-	-	1-19 6-19
Total	1054		1283		-	-	240 794
** Mean	14.1		17.1		-	-	3.2 10.6
Range	1-60		1-53		-	-	1-19 3-20

* 25 bees per sample

** Total of 75 bees

TABLE 18 (Continued)

Times when bees collected:							
1700 - 1800 hrs.							
Bees collected on:							
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive	
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen
I* Total	334		232		-	-	59 223
I* Mean	13.4		9.3		-	-	2.4 8.9
I* Range	1-55		1-46		-	-	1-8 2-17
II Total	206		551		-	-	78 189/18 bees
II Mean	8.2		22.0		-	-	4.3 10.9
II Range	1-25		1-60		-	-	1-15 2-20
III Total	239		497		-	-	- -
III Mean	9.6		19.9		-	-	- -
III Range	1-36		1-55		-	-	- -
** Total	779		1280		-	-	137 412/43 bees
** Mean	10.4		17.1		-	-	3.2 9.6
** Range	1-55		1-60		-	-	1-15 2-20

* 25 bees per sample

** Total of 75 bees

TABLE 19. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS
OF BEES TAKEN FROM VARIOUS PARTS OF A HIVE
ON 31st MAY, 1968.

		Times when bees collected:					
		900 - 1000					
		Bees collected on:					
Hive Number		Brood comb		Honey comb		Returning to Hive	
		open cells	sealed cells	open cells	sealed cells	Leav- ing Hive	with Nectar only with both Nectar Pollen
I*	Total	287		590		163	205 124 402
	Mean	11.5		23.6		6.5	8.2 5.0 16.1
	Range	1-48		2-64		1-19	1-20 1-31 4-30
II	Total	216		340		184	254 93 382
	Mean	8.6		13.6		7.4	10.2 3.7 15.3
	Range	1-35		1-39		1-25	1-26 1-19 4-23
III	Total	412		225		143	273 57 270
	Mean	16.5		9		5.7	10.9 2.3 10.8
	Range	1-41		1-35		1-19	2-36 1-10 3-20
**	Total	915		1155		490	732 274 1054
	Mean	12.2		15.4		6.5	9.8 3.7 14.1
	Range	1-48		1-64		1-25	1-36 1-31 3-30

* 25 bees per sample

** Total of 75 bees

TABLE 19(Continued)

Times when bees collected:							
1300 - 1400							
Bees collected on:							
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive	
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen
I* Total	136		233		97	218	165
I* Mean	5.4		9.3		3.9	8.7	6.6
I* Range	1-36		1-36		1-28	1-25	1-26
II Total	136		326		114	205	105
II Mean	5.4		13.0		4.6	8.2	4.2
II Range	1-42		1-46		1-24	1-26	1-19
III Total	178		145		136	330	92
III Mean	7.1		5.8		5.4	13.2	3.7
III Range	1-32		1-29		1-31	1-36	1-24
** Total	450		704		347	753	362
** Mean	6.0		9.4		4.6	10.0	4.8
** Range	1-42		1-46		1-31	1-36	1-26

* 25 bees per sample

** Total of 75 bees

TABLE 19 (Continued)

Times when bees collected:							
1700 - 1800							
Bees collected on:							
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive	
	open cells	sealed cells	open cells	sealed cells		Nectar only	with both Nectar Pollen
I*	Total	187	181		-	260	138 226/22 bees
	Mean	7.5	7.2		-	10.4	6.3 10.3
	Range	1-14	1-26		-	1-36	1-26 2-25
II	Total	178	589		-	274	90 207/21 bees
	Mean	7.1	23.6		-	11.0	4.3 9.9
	Range	1-45	1-62		-	1-50	1-20 2-22
III	Total	273	376		-	294	- -
	Mean	10.9	15.1		-	11.7	- -
	Range	1-35	1-35		-	3-28	- -
**	Total	638	1146		-	828	228 433/43 bees
	Mean	8.5	15.3		-	11.0	5.3 10.1
	Range	1-45	1-62		-	1-50	1-26 2-25

* 25 bees per sample

** Total of 75 bees

TABLE 20. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
18th JUNE, 1968.

Times when bees collected:								
900 - 1000								
Bees collected on:								
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I* Total	333	234	1012	-	147	288	75	304
I* Mean	13.3	9.4	40.5	-	5.9	11.5	3.0	12.2
I* Range	1-44	1-38	2-70	-	1-23	1-33	1-14	4-24
II Total	283	244	798	-	201	333	109	496
II Mean	11.3	9.8	31.9	-	8.0	13.3	4.4	19.8
II Range	1-53	1-46	4-61	-	1-22	2-42	1-19	10-30
III Total	720	742	825	223	177	292	52	467
III Mean	28.8	29.7	33.0	8.9	7.1	11.7	2.1	18.7
III Range	2-57	1-68	11-52	1-39	1-24	1-53	1-7	10-32
** Total	1336	1220	2635	223	525	913	236	1267
** Mean	17.8	16.3	35.1	8.9	7.0	12.2	3.2	16.9
** Range	1-57	1-68	2-70	1-39	1-24	1-53	1-19	4-32

* 25 bees per sample

** Total of 75 bees

TABLE 20 (Continued)

		Times when bees collected:							
		1300 - 1400							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	70	151	374	-	68	166	73	219
	Mean	2.8	6.0	15.0	-	2.7	6.6	2.9	8.8
	Range	1-9	1-30	2-39	-	1-9	1-38	1-11	2-19
II	Total	220	166	403	-	159	232	121	355
	Mean	8.8	6.6	16.1	-	6.4	9.3	4.8	14.2
	Range	1-47	1-20	2-62	-	1-48	1-31	1-24	7-29
III	Total	423	336	722	175	77	117	136	238
	Mean	16.9	13.4	28.9	7	3.1	4.7	5.4	9.5
	Range	1-38	1-51	7-57	1-29	1-12	1-17	1-15	2-20
**	Total	713	653	1499	175	304	515	330	812
	Mean	9.5	8.7	20.0	7	4.1	6.9	4.4	10.8
	Range	1-47	1-51	2-62	1-29	1-48	1-38	1-24	2-29

* 25 bees per sample

** Total of 75 bees

TABLE 20 (Continued)

Times when bees collected:									
1700 - 1800									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I* Total	113	147	427	-	74	259	77	140	
I* Mean	4.5	5.9	17.1	-	3.0	10.4	3.1	5.6	
I* Range	1-26	1-24	1-55	-	1-10	1-26	1-15	1-20	
II Total	116	124	247	-	64	182	144	258	
II Mean	4.6	5.0	9.9	-	2.6	7.3	5.8	10.3	
II Range	1-21	1-41	1-36	-	1-12	1-55	1-24	1-28	
III Total	322	520	476	201	64	376	67	142	
III Mean	12.9	20.8	19.0	8.0	2.6	15.0	2.7	5.6	
III Range	1-54	1-57	1-36	1-44	1-14	1-69	1-10	1-10	
** Total	551	791	1150	201	202	817	288	540	
** Mean	7.4	10.6	15.3	8.0	2.7	10.9	3.8	7.2	
** Range	1-54	1-57	1-55	1-44	1-14	1-69	1-24	1-28	

* 25 bees per sample

** Total of 75 bees

TABLE 21. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
27th JUNE, 1968.

		Times when bees collected:							
		900 - 1000							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	733	393	246	-	114	227	33	414
	Mean	29.3	15.7	9.8	-	4.6	9.1	1.3	16.6
	Range	1-63	1-44	1-47	-	1-15	1-30	1-3	4-32
II	Total	315	456	750	-	354	203	119	443
	Mean	12.6	18.2	30.0	-	14.2	8.1	4.8	17.7
	Range	1-50	1-60	5-61	-	1-46	1-23	1-12	4-34
III	Total	849	259	1038	1007	213	441	104	507
	Mean	34.0	10.4	41.5	40.3	8.5	17.6	4.2	20.3
	Range	1-72	1-60	21-65	3-70	1-24	1-43	1-15	13-37
**	Total	1897	1108	2034	1007	681	871	256	1364
	Mean	25.3	14.8	27.1	40.3	9.1	11.6	3.4	18.2
	Range	1-72	1-60	1-65	3-70	1-46	1-43	1-15	4-37

* 25 bees per sample

** Total of 75 bees

TABLE 21 (Continued)

Times when bees collected:									
1300 - 1400									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar	with both Pollen	
I*	Total	96	122	286	-	49	334	246	114
	Mean	3.8	4.9	11.4	-	2.0	13.4	9.9	4.6
	Range	1-30	1-20	1-37	-	1-7	1-37	1-24	1-10
II	Total	138	182	756	-	75	203	180	176
	Mean	5.5	7.3	30.2	-	3.0	8.1	7.2	7.0
	Range	1-29	1-24	1-65	-	1-20	1-28	1-20	2-16
III	Total	92	387	744	523	57	353	70	284
	Mean	3.7	15.5	29.8	20.9	2.3	14.1	2.8	11.4
	Range	1-23	1-57	3-55	1-60	1-10	1-50	1-9	5-21
**	Total	326	691	1786	523	181	890	496	574
	Mean	4.4	9.2	23.8	20.9	2.4	11.9	6.6	7.7
	Range	1-30	1-57	1-65	1-60	1-20	1-50	1-24	1-21

* 25 bees per sample

** Total of 75 bees

TABLE 21 (Continued)

Times when bees collected:								
1700 - 1800								
Bees collected on:								
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I* Total	375	117	299	-	60	342	164	135
I* Mean	15.0	4.7	12.0	-	2.4	13.7	6.6	5.4
I* Range	1-33	1-22	1-27	-	1-13	1-38	1-16	2-11
II Total	100	200	401	-	54	232	223	120
II Mean	4.0	8.0	16.0	-	2.2	9.3	8.9	4.8
II Range	1-21	1-57	1-35	-	1-8	1-22	1-23	2-13
III Total	205	216	398	242	29	288	44/6hrs.	35/6
III Mean	8.2	8.6	15.9	9.7	1.2	11.5	7.6	5.8
III Range	1-42	1-32	1-38	1-34	1-3	1-21	1-19	2-12
** Total	680	533	1098	242	143	862	431	290
** Mean	9.1	7.1	14.6	9.7	1.9	11.5	7.7	5.2
** Range	1-42	1-57	1-38	1-34	1-13	1-38	1-23	2-13

* 25 bees per sample

** Total of 75 bees

TABLE 22. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
19th JULY, 1968.

Times when bees collected:									
900 - 1000									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	298	467	513	150	56	251	123	253
	Mean	11.9	18.7	20.5	6.0	2.2	10.0	4.9	10.1
	Range	1-47	1-69	1-63	1-18	1-7	1-26	1-17	2-29
II	Total	509	478	1264	-	70	515	261	288
	Mean	20.4	19.1	50.6	-	2.8	20.6	10.4	11.5
	Range	2-82	2-65	10-67	-	1-7	1-54	1-29	2-24
III	Total	336	116	965	1077	71	191	134	437
	Mean	13.4	4.6	38.6	43.1	2.8	7.6	5.4	17.5
	Range	1-59	1-35	2-70	6-64	1-17	1-23	1-14	6-31
**	Total	1143	1061	2742	1227	197	957	518	978
	Mean	15.2	14.2	36.6	24.5	2.6	12.8	6.9	13.0
	Range	1-82	1-69	1-70	1-64	1-17	1-54	1-29	2-31

* 25 bees per sample

** Total of 75 bees

TABLE 22 (Continued)

Times when bees collected:									
1300 - 1400									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	580	546	1145	485	99	351	122	250
	Mean	23.2	21.8	45.8	19.4	4.0	14.0	4.9	10.0
	Range	1-79	1-68	2-72	2-64	1-11	1-30	1-30	4-22
II	Total	702	769	1285	1417	121	658	520	484
	Mean	28.1	30.8	51.4	56.7	4.8	26.3	20.8	19.4
	Range	2-72	4-70	28-69	30-72	1-31	2-55	2-51	6-35
III	Total	568	1146	1-86	569	131	454	257	528
	Mean	22.7	45.8	43.4	22.8	5.2	18.2	10.3	21.1
	Range	1-78	2-74	12-71	1-64	1-17	3-44	1-30	10-29
**	Total	1850	2461	3516	2471	351	1463	899	1262
	Mean	2417	3218	4619	33.0	4.7	19.5	12.0	16.8
	Range	1-79	1-74	2-72	1-72	1-31	1-55	1-31	4-35

* 25 bees per sample

** Total of 75 bees

TABLE 22 (Continued)

Times when bees collected:									
1700 - 1800									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	372	355	599	542	98	517	313	228
	Mean	14.9	14.2	24.0	21.7	3.9	20.7	12.5	9.1
	Range	1-52	2-62	2-68	1-69	1-20	6-35	1-29	2-17
II	Total	882	608	1263	715	90	475	448	494
	Mean	35.3	24.3	50.5	28.6	3.6	19.0	17.9	19.8
	Range	6-64	2-63	34-79	4-61	1-16	6-37	10-33	8-44
III	Total	355	731	1060	382	133	655	470	467
	Mean	14.2	29.2	42.4	15.3	5.3	26.2	18.8	18.7
	Range	2-69	7-65	2-73	1-73	1-22	6-51	1-32	11-30
**	Total	1609	1694	2922	1639	321	1647	1231	1189
	Mean	21.5	22.6	39.0	21.9	4.3	22.0	16.4	15.9
	Range	1-69	2-65	2-79	1-73	1-22	6-51	1-33	2-44

* 25 bees per sample

** Total of 75 bees

TABLE 23. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
25th JULY, 1968.

Times when bees collected:									
900 - 1000									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	759	334	549	416	97	265	213	201
	Mean	30.4	13.4	22.0	16.4	3.9	10.6	8.5	8.0
	Range	1-75	1-73	1-74	1-73	1-10	1-42	1-43	1-18
II	Total	404	847	738	765	110	590	185	452
	Mean	16.2	33.9	29.5	30.6	4.4	23.6	7.4	18.1
	Range	1-63	1-73	1-65	1-65	1-17	1-55	1-22	10-28
III	Total	748	1309	1519	845	211	883	287	556
	Mean	29.9	52.4	60.8	33.8	8.4	35.3	11.5	22.2
	Range	2-74	5-81	34-75	1-73	1-40	8-65	1-33	12-32
**	Total	1911	2490	2806	2026	418	1738	685	1209
	Mean	25.5	33.2	37.4	27.0	5.6	23.2	9.1	16.1
	Range	1-75	1-81	1-75	1-73	1-40	1-65	1-43	1-32

* 25 bees per sample

** Total of 75 bees

TABLE 23 (Continued)

Times when bees collected:									
1300 - 1400									
Bees collected on:									
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	498	398	772	406	143	344	301	225
	Mean	19.9	15.9	30.9	16.2	5.7	13.8	12.0	9.0
	Range	1-80	1-70	1-73	1-62	1-42	1-39	1-25	1-23
II	Total	729	212	741	719	132	499	264	635
	Mean	29.2	8.5	29.6	28.8	5.3	20.0	10.6	25.4
	Range	2-75	1-49	1-78	2-73	1-16	1-59	1-29	18-33
III	Total	1015	1253	1-51	806	185	684	453	613
	Mean	40.6	50.1	42.0	32.2	7.4	27.4	18.1	24.5
	Range	2-84	16-75	2-85	1-63	1-31	6-46	2-34	14-32
**	Total	2242	1863	2564	1931	460	1527	1018	1473
	Mean	29.9	24.8	34.2	25.8	6.1	20.4	13.6	19.6
	Range	1-84	1-75	1-85	1-73	1-42	1-59	1-34	1-33

* 25 bees per sample

** Total of 75 bees

TABLE 23 (Continued)

Times when bees collected:									
1700 - 1800									
Bees collected on:									
Hive Number	Brood open cells	comb sealed cells	Honey open cells	comb sealed cells	Leav- ing Hive	Returning to Hive			
						with Nectar only	with both Nectar	Pollen	
I* Total	888	1063	401	540	314	342	293	212	
I* Mean	35.5	42.5	16.0	21.6	12.6	13.7	11.7	8.5	
I* Range	1-79	6-82	1-63	1-71	1-49	2-40	1-40	1-22	
II Total	515	391	744	659	230	648	543	644	
II Mean	2016	15.6	29.8	26.4	9.2	25.9	21.7	25.8	
II Range	1-58	1-49	5-65	1-75	1-37	1-53	1-35	10-34	
III Total	1288	432	1242	1010	209	1241	399	523	
III Mean	51.5	17.3	49.7	40.4	8.4	49.6	16.0	21.3	
III Range	10-79	1-76	3-92	1-75	1-40	18-67	2-36	9-28	
** Total	2691	1886	2387	2209	753	2231	1235	1379	
** Mean	35.9	25.2	31.8	29.5	10.0	29.8	16.5	18.4	
** Range	1-79	1-82	1-92	1-75	1-49	1-67	1-40	1-34	

* 25 bees per sample

** Total of 75 bees

TABLE 24. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON 8th AUGUST, 1968.

Times when bees collected:								
900 - 1000								
Bees collected on:								
Hive Number	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I* Total	175	303	851	405	79	299	244	404
I* Mean	7.0	12.1	34.0	16.2	3.2	12.0	9.8	16.2
I* Range	1-34	1-46	1-65	1-61	1-15	1-40	1-24	3-3-
II Total	398	264	669	395	148	479	152	459
II Mean	15.9	10.6	26.8	15.8	5.9	19.2	6.1	18.4
II Range	1-67	1-55	1-57	1-54	1-44	1-45	1-16	9-28
III Total	1022	758	900	1573	99	844	375	554
III Mean	40.9	30.3	36.0	62.9	4.0	33.8	15.0	22.2
III Range	2-74	1-77	15-61	44-78	1-17	14-55	2-38	6-32
** Total	1595	1325	2420	2373	326	1622	771	1417
** Mean	21.3	17.7	32.3	31.6	4.4	21.6	10.3	18.9
** Range	1-74	1-77	1-65	1-78	1-44	1-55	1-38	3-32

* 25 bees per sample

** Total-75 bees

TABLE 24 (Continued)

Hive Number		Times when bees collected:							
		1300 - 1400							
		Bees collected on:							
		Brood comb open cells	sealed cells	Honey comb open cells	sealed cells	Leav- ing Hive	Returning to Hive with Nectar only	with both Nectar Pollen	
I*	Total	243	306	499	397	114	272	212	233
	Mean	9.7	12.2	20.0	15.9	4.6	10.9	8.5	9.3
	Range	1-44	1-55	3-46	1-69	1-17	1-27	1-24	2-20
II	Total	342	215	773	536	120	488	202	404
	Mean	13.7	8.6	30.9	21.4	4.8	19.5	8.1	16.2
	Range	1-62	1-35	2-60	2-67	1-26	4-35	1-20	6-21
III	Total	1184	691	826	405	96	933	507	456
	Mean	47.4	27.6	33.0	16.2	3.8	37.3	22.7	18.2
	Range	21-73	1-66	2-78	1-67	1-13	3-59	7-42	5-30
**	Total	1769	1212	2098	1338	330	1693	981	1-93
	Mean	23.6	16.2	28.0	17.8	4.4	22.6	13.1	14.6
	Range	1-73	1-66	2-78	1-69	1-26	1-59	1-42	2-30

* 25 bees per sample

** Total of 75 bees

NOTE: Due to rainstorm no bees were collected between
1700 - 1800 hours.

TABLE 25. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
14th AUGUST, 1968.

		Times when bees collected:							
		900 - 1000							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	492	264	922	449	44	410	148	284
	Mean	19.7	10.6	36.9	18.0	1.8	16.4	5.9	11.4
	Range	1-58	1-63	9-69	1-61	1-4	1-39	1-25	4-24
II	Total	233	277	847	219	143	538	165	391
	Mean	9.3	11.1	33.9	8.8	5.7	21.5	6.6	15.6
	Range	1-39	1-41	1-55	1-38	1-21	1-56	1-19	8-25
III	Total	1189	528	961	877	79	543	140	476
	Mean	47.6	21.1	38.4	35.1	3.2	21.7	5.6	19.0
	Range	7-83	1-74	15-65	12-71	1-7	5-53	1-12	12-28
**	Total	1914	1069	2730	1545	266	1491	453	1151
	Mean	25.5	14.3	36.4	20.6	3.6	19.9	6.0	15.4
	Range	1-83	1-74	1-69	1-71	1-21	1-56	1-25	4-28'

* 25 bees per sample

** Total of 75 bees

TABLE 25 (Continued)

		Times when bees collected: 1300 - 1400							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	515	176	327	597	62	391	158	326
	Mean	20.6	7.0	13.1	23.9	2.5	15.6	6.3	13.0
	Range	3-48	1-42	3-27	6-56	1-5	2-47	1-35	6-20
II	Total	445	307	664	389	135	671	286	522
	Mean	17.8	12.3	26.6	15.6	5.4	26.8	11.4	20.9
	Range	1-80	1-67	4-82	2-51	1-23	8-56	1-32	10-30
III	Total	1104	737	915	476	136	856	357	590
	Mean	44.2	29.5	36.6	19.0	5.4	34.2	14.3	23.6
	Range	13-77	3-76	7-63	2-53	1-20	11-55	1-40	12-36
**	Total	2064	1220	1906	1462	333	1918	801	1438
	Mean	27.5	16.3	25.4	15.5	4.4	25.6	10.7	19.2
	Range	1-80	1-76	3-82	2-56	1-23	2-56	1-40	6-36

* 25 bees per sample

** Total of 75 bees

TABLE 25 (Continued)

Times when bees collected:								
1700 - 1800								
Hive Number	Bees collected on:							
	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	217	216	821	182	118	350	243
	Mean	8.7	8.6	32.8	7.3	4.7	14.0	9.7
	Range	1-43	1-50	1-79	1-53	1-21	2-51	2-28
II	Total	556	461	445	511	170	352	236
	Mean	22.2	18.4	17.8	20.4	6.8	14.1	9.4
	Range	1-64	1-71	3-50	2-49	1-17	2-30	2-19
III	Total	265	291	1093	288	155	311	320
	Mean	10.6	11.6	43.7	11.5	6.2	12.4	12.8
	Range	1-46	1-45	4-72	1-48	1-20	2-32	4-25
**	Total	1038	968	2359	981	443	1-13	799
	Mean	13.8	12.9	31.5	13.1	5.9	13.5	10.7
	Range	1-64	1-71	1-79	1-53	1-21	2-51	2-28

* 25 bees per sample

** Total of 75 bees

TABLE 26. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
27th AUGUST, 1968.

Times when bees collected:								
900 - 1000								
Hive Number	Bees collected on:							
	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I* Total	734	398	989	771	77	458	101	336
I* Mean	29.4	15.9	39.6	30.8	3.1	18.3	4.0	13.4
I* Range	2-61	1-53	6-59	3-62	1-10	1-61	1-28	9-22
II Total	397	760	826	947	145	455	124	336
II Mean	15.9	30.4	33.0	37.9	5.8	18.2	5.0	13.4
II Range	1-80	1-78	8-82	2-76	1-12	4-29	1-15	6-29
III Total	1411	1327	643	655	101	229	50	159
III Mean	56.4	53.1	25.7	26.2	4.0	9.2	2.0	6.4
III Range	31-82	29-76	3-67	3-57	1-13	1-25	1-5	3-13
** Total	2542	2485	2458	2373	323	1142	275	831
** Mean	33.9	33.1	32.8	31.6	4.3	15.2	3.7	11.1
** Range	1-82	1-78	3-82	2-76	1-13	1-61	1-28	3-29

* 25 bees per sample

** Total of 75 bees

TABLE 26 (Continued)

		Times when bees collected							
		1300 - 1400							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	851	771	808	666	113	239	153	239
	Mean	34.0	30.8	32.3	26.6	4.5	9.6	6.1	9.6
	Range	1-77	1-78	3-77	1-66	1-31	1-50	1-26	3-20
II	Total	405	1031	973	710	77	276	246	387
	Mean	16.2	41.2	38.9	28.4	3.1	11.0	9.8	15.5
	Range	1-66	1-87	9-75	1-69	1-14	1-42	1-20	7-34
III	Total	1-42	121-	882	745	138	344	242	353
	Mean	41.7	48.4	35.3	29.8	5.5	13.8	9.7	14.1
	Range	1-97	7-79	5-79	1-74	1-28	1-35	2-22	8-21
**	Total	2298	3012	2663	2121	328	859	641	979
	Mean	30.6	40.2	35.5	28.3	4.4	11.5	8.6	13.1
	Range	1-97	1-87	3-79	1-74	1-31	1-50	1-26	3-34

* 25 bees per sample

** Total of 75 bees

TABLE 26 (Continued)

Hive Number	Times when bees collected								
	1700 - 1800								
	Bees collected on:					Returning to Hive			
	Brood comb open cells	sealed cells	Honey comb open cells	sealed cells	Leav- ing Hive	with Nectar only	with both Nectar Pollen		
I*	Total	434	469	600	991	91	472	234	196
	Mean	17.4	18.8	24.0	39.6	3.6	18.9	9.4	7.8
	Range	1-56	1-65	2-65	14-75	1-13	1-63	1-24	2-16
II	Total	381	823	1225	419	145	443	249	207
	Mean	15.2	32.9	49.0	16.8	5.8	17.7	10.0	8.3
	Range	1-40	1-74	2-89	1-48	1-18	3-34	1-24	3-18
III	Total	658	574	1128	310	77	535	254	157
	Mean	26.3	23.0	45.1	12.4	3.1	21.4	10.2	6.3
	Range	2-64	1-74	4-91	1-44	1-16	10-43	1-31	2-12
**	Total	1473	1866	2953	1720	313	1450	737	560
	Mean	19.6	24.9	39.4	22.9	4.2	19.3	9.8	7.5
	Range	1-64	1-74	2-91	1-75	1-18	1-63	1-31	2-18

* 25 bees per sample

** Total of 75 bees

TABLE 27. WEIGHT OF HONEY STOMACHS AND POLLEN LOADS OF
BEES TAKEN FROM VARIOUS PARTS OF A HIVE ON
10th SEPTEMBER, 1968.

		Times when bees collected							
		900 - 1000							
		Bees collected on:							
Hive Number		Brood comb		Honey comb		Leav- ing Hive	Returning to Hive		
		open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen	
I*	Total	824	826	1630	320	81	252	69	315
	Mean	33.0	33.0	65.2	12.8	3.2	10.1	2.8	12.6
	Range	2-74	1-72	27-99	1-76	1-15	1-31	1-7	6-22
II	Total	861	1026	1532	568	69	398	75	406
	Mean	34.4	41.0	61.3	22.7	2.8	15.9	3.0	16.2
	Range	2-77	3-79	38-90	1-56	1-9	2-28	1-10	7-24
III	Total	935	1106	1623	1320	107	368	122	368
	Mean	37.4	44.2	64.9	52.8	4.3	14.7	4.9	14.7
	Range	2-76	15-71	39-95	8-90	1-23	1-43	1-13	10-24
**	Total	2620	2958	4785	2208	257	1018	266	1089
	Mean	34.9	39.4	68.3	29.4	3.4	13.6	3.6	14.5
	Range	2-77	1-79	27-99	1-90	1-23	1-43	1-13	6-24

* 25 bees per sample

** Total of 75 bees

TABLE 27 (Continued)

Times when bees collected									
1300 - 1400									
Hive Number	Bees collected on:								
	Brood comb		Honey comb		Leav- ing Hive	Returning to Hive			
	open cells	sealed cells	open cells	sealed cells		with Nectar only	with both Nectar Pollen		
I*	Total	769	660	1518	305	110	362	168	367
	Mean	30.8	26.4	60.7	12.2	4.4	14.5	6.7	14.7
	Range	1-87	2-82	29-97	1-69	1-17	3-35	1-20	8-32
II	Total	427	410	974	345	116	387	209	384
	Mean	17.1	16.4	39.0	13.8	4.6	15.5	8.4	15.4
	Range	1-56	1-67	6-70	1-28	1-19	2-28	1-19	6-29
III	Total	751	476	1075	417	129	447	324	430
	Mean	30.0	19.0	43.0	16.7	5.1	17.9	13.0	17.2
	Range	2-76	1-69	8-106	1-85	1-26	9-37	4-26	11-24
**	Total	1947	1546	3567	1067	355	1196	701	1181
	Mean	26.0	20.6	47.6	14.2	4.7	16.0	9.4	15.8
	Range	1-87	1-82	6-106	1-85	1-26	2-37	1-26	6-32

* 25 bees per sample

** Total of 75 bees

TABLE 27 (Continued)

		Times when bees collected							
		1700 - 1800							
Hive Number		Bees collected on:					Returning to Hive		
		Brood open cells	comb sealed cells	Honey open cells	comb sealed cells	Leav- ing Hive	with Nectar only	with both Nectar Pollen	
I*	Total	502	204	901	441	114	246	218	197
	Mean	20.1	8.2	36.0	17.6	4.6	9.8	8.7	7.9
	Range	1-80	1-27	9-73	2-71	1-13	1-36	3-17	2-18
II	Total	324	488	1-28	342	122	327	192	199
	Mean	13.0	19.5	41.1	13.7	4.9	13.1	7.7	8.0
	Range	1-63	3-65	5-89	1-33	1-22	2-40	2-24	2-16
III	Total	-	-	-	-	-	-	-	-
	Mean	-	-	-	-	-	-	-	-
	Range	-	-	-	-	-	-	-	-
**	Total	826	692	1929	783	236	573	410	396
	Mean	16.5	13.8	38.6	15.7	4.7	11.5	8.2	7.9
	Range	1-80	1-65	5-89	1-71	1-22	1-40	2-24	2-18

* 25 bees per sample

** Total of 75 bees