THE COLLECTION OF FOOD BY THE HONEYBEE DURING THE BROOD-REARING PERIOD

by

CLELL [redacted] WISECUP

B. S., Kansas State Agricultural College, 1926

A THESIS

submitted in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

KANSAS STATE AGRICULTURAL COLLEGE

1928

TABLE OF CONTENTS

INTRODUCTION

The constituents of the food of honeybee larvae, as of animals in general, consists of mixtures of carbohydrates, proteins, fats, mineral salts, water, and presumably vitamines, according to Bertholf (1927). Parker (1926) quotes Table I from Von Planta, 1889, to show the composition of larval foods.

The only materials normally brought into the hive are nectar (which is transformed into honey), pollen and water. Obviously this larval food is not merely a mixture of honey and pollen, but consists in great part of glandular secretions of the adult bees.

The food of the adult honeybee likewise consists only of pollen and nectar. Pollen is the principal source of protein in the bees' diet. Pollen, or its derivatives stored in the body, is an essential element in the food of all bees in the hive, both young and adult at all times, since the workers are able to produce the glandular proteid food only from the pollen which they themselves have eaten (Snodgrass, 1925).

Quoting again from Parker (1926), we find chemical analyses of pollen grains as given in Table II.

"A lack of pollen causes a cessation or a slackening of brood rearing, while pollen coming to the hive acts as a stimulus to brood rearing. When there is a plentiful supply of pollen in the hive and other conditions are favorable, brood rearing progresses rapidly" (Parker, 1926). Parker also found that substitutes for pollen, such as rye, wheat, oats, pea meal, corn, buckwheat ground fine, and Mellin's food, are not beneficial. Larvae fed these foods were found to die just after the period of mass feeding.

The other food constituent brought to the hive by honeybees is nectar. Strictly speaking, nectar is a sugar (sucrose) gathered from flowers by bees (Root, 1923). It is thickened and transformed by them into honey. An analysis of honeys as given by Brown and Young (1908), in Table III, shows that it contains the remainder of the constituents necessary for the life processes of the bee.

Thus, the carbohydrates are supplied from the nectar sources, and from physiological and chemical knowledge it is known that the fats are synthesized from the carbohydrates within the body of the insect.

Pollen represents the male element of reproduction in seed plants. The pollen grains are very minute and are produced in small sacs on the tip of the stamen, commonly called the anthers. When ripe, the breaking of the sac sets the grains free in great abundance.

Pollination is the fertilization of the blossoms of a plant resulting in the development of seed. The activities of the bee in securing pollen has been known to be perhaps the greatest factor in fertilizing plants. The work of Hutson (1926) recognizes that honeybees and bumblebees are the most important insect pollenizers in southern New Jersey.

The secretion of nectar is at once one of the most remarkable and baffling functions of plant life. Foliage leaves are factories in which are made the carbohydrates, foods required for the growth of plants. But in nectar secretion the plant parts with the food that it has just manufactured. It was C. Konrad Sprengel, a German rector, who in 1793 first stated the opinion that nectaries are for the purpose of furnishing a sweet substance intended to attract insects in the fertilization of plants (Cook, 1923).

Snodgrass (1925) describes in detail the method by which the nectar is taken up through the labium and into the honey sac. Casteel (1912) describes the method of gathering pollen; as does Lineburg (1926) and Parker (1926). In general, the pollen is loosened from the flower by biting, clawing or merely brushing the body against the anthers. When a considerable amount of pollen is attached to the various parts of the body it is brushed together by the action of the three pairs of legs and finally deposited upon the pollen combs of the third pair of legs, whence it is packed in the corbiculae or pollen baskets.

The method of coming into proper contact with the pollen to be collected is classified by Parker according to the type of flower or floral arrangement:

a. Open type (Silver maple).

The worker bites the anthers with its mandibles and pulls them toward its body with the front legs while it runs rapidly over the flowers, all the while packing the pollen in the pollen baskets. This type comprises dandelion, elm, boxelder, cherry, hard maple, pear, apple, strawberry, buckeye, rose, bass wood, aster, spiraea, and honey locust.

b. Tubular type (Honeysuckles).

The bee alights on the corolla and inserts the probascis into the tube for nectar. Pollen collecting is usually incidental, and the quantity of pollen gathered is small. The pollen collected adheres to the mouth parts or to the fore legs. Flowers in this group are: Japanese barberry, lilac, snowberry and Russian olive.

c. Closed type (Clovers).

The bee alights on the wing of the flower and separates the keel from the wings by forcing the fore legs between them on either side. Pollen is gathered on the fore legs and mouth parts and packed while bee is flying from one flower to another. In the larger flowers the body is wedged into the opening. Flowers in this group are: redbud, Siberian pea tree, clovers, black locust.

d. Spike or catking type (Willows).

The bee alights at base or lower part of flower group, runs up the catkin a short distance, then flys away to pack what pollen has been gathered, then returns for more. It may not actually alight on catkin, but merely brushes the anthers. Flowers of this group are: poplars, pines, giant ragweed, corn, walnuts, oaks.

The number of trips made by a bee has been noted by observers and experimenters to vary from four to 110 trips per day. The most recent and outstanding work on this has been done by Park (1928), who finds that the time required for gathering a load of nectar varies greatly, but under favorable conditions one hour is ample time for a nectar-carrier to make a round trip, averaging ten trips per day. The time required for a pollen-carrier to make a round trip varies greatly, but when gathering from corn under favorable conditions, trips were completed in a quarter of an hour or less on the average.

Parker (1926) found that 25 per cent of bees observed collected pollen only, 17 per cent gathered both pollen and nectar on the same trip, and 58 per cent collected nectar alone.

The flows of nectar which are of value for surplus honey crop production are those which come after the colonies are strong, but earlier honey-flows are of great value in providing stores and in furnishing a stimulus to breeding (Phillips, 1926). For each locality it is, therefore, most desirable that the plants which furnish nectar and pollen be known and that the usual time of blossoming be learned.

Eastern Kansas lies in the Central Lowlands and the western two-thirds is a part of the Great Plains. Merrill (1922) lists the following as honey plants of Kansas: alfalfa, white sweet clover, yellow sweet clover, white clover, heartsease, alsike clover, dandelion, basswood, goldenrod, Spanish needle, fruit bloom, soft maple, elm, box elder, and perhaps persimmon, aster, black locust and sumac.

Manhattan, Kansas is located on the eastern edge of the Great Plains region.

PURPOSE

It is a known fact that the ecological conditions of different localities induce differences in plants producing pollen and nectar, affecting the availability of the pollen and nectar to the honeybees. The beekeeping literature abounds with statements as to the availability of certain plants in certain localities.

Definite information concerning the blooming season, availability to the honeybees, and the relative importance of the various honey plants at Manhattan, Kansas, was lacking, so the present study was undertaken.

Dr. R. L. Parker had terminated a similar seasonal study at Ames, Iowa in 1924. At his suggestion the problem was undertaken in the spring of 1927. At that time the aims of the problem were two fold; viz:

1. To secure a chronological sequence of blooming dates of the food plants of honeybees for this locality.

2. To determine which food, pollen or nectar or both, is secured by the honeybee from each species of plant, and the relative amount of such food.

Due to pressing commercial interests the problem was not carried through the summer of 1927, but was again taken up in the spring of 1928. By this time it was realized that observation alone might be misleading, as bees were apparently attracted to certain plants but were securing little or no pollen or nectar from such species. Accordingly, a third object was undertaken:

3. To determine the average weights of pollen and nectar loads gathered by the bees.

It is with pleasure that the writer acknowledges the assistance of Dr. R. L. Parker in planning and carrying out this problem.

MATERIAL AND METHODS

The campus of the Kansas State Agricultural College at Manhattan, Kansas, constitutes a very good arboretum, as far as an apiculturist is concerned. Not only are practically all native trees, shrubs and herbs growing on the campus, but many exotic and introduced species are found here.

The tulip tree, indigenous to the Appalachian Mountains is found here in full vigor and beauty; the basswood or American linden grows on the campus to be a stately tree, though naturally confined to a more humid, northeastern climatic zone; the tamarisk, used extensively by landscape gardeners, commands the attention because of its widespread use on the campus here; these are a few of the introduced honey plants which can be studied in an unnatural habitat.

These facts have an important bearing on the results of this problem. While such an abundance of plants give an observer more material with which to work, it gives results not in keeping with the limited flora of the average central Kansas locality.

During the spring of 1927 the only method of procedure was by means of observation. On herbs, shrubs and low trees the bees were watched at work by getting as close to them as possible. When the bees were working in tall trees, field glasses were brought into use, resulting in very close observation of the movements of the individual bees.

Records were kept of the activities of the bees on each species of plant observed. These observations lasted as a rule from two to five minutes.

A method of determining the substance within the proventriculus of the honeybee is given by Parker (1926, p. 14). The contents of the honey sac may be identified as being either honey or nectar by absorbing them on filter paper. The bee is dissected, pulling the abdomen apart from the thorax at the propodeum. The honey sac is punctured allowing its contents to spread upon a piece of filter paper. The outline of the liquid on the filter paper is indicated by a pencil line while it is still moist. After drying, honey leaves a transparent spot, which upon further drying becomes hard; while the nectar spots vary in degree of transparency from almost none to about half that of honey, depending upon the influence of weather upon the density of nectar.

Capturing and dissecting representative bees suggested the possibility of weighing the loads carried by the bees. It could easily be seen that the loads varied not only according to the plant visited but also according to the time of day and other ecological conditions, which factors influenced the availability of the pollen and nectar to the bees.

In securing weights the bees were captured and killed in cyanide bottles, then transferred to vials labeled as to plant from which taken, date, and time of day. Each vial contained from three to fifteen bees, the number varying with the number of bees that could be captured. The vial and contents were then weighed on the analytical balances, and weight recorded. All pollen collected upon the pollen basket or corbicula was then removed and the vial and bees again weighed. The difference in weights gave the weight of the pollen removed from the entire number of bees.

The bees were then dissected to determine contents of the honey sac. To do this the thorax of the insect was grasped by the left hand and the abdomen caught by a blunt pair of forceps held in the right hand. A short, sharp pull separated the abdomen and thorax at the propodeum, only the alimentary tract remaining intact. Thus, the proventriculus or honey sac was disclosed without rupturing it. The honey sac is then ruptured on a piece of filter paper and treated as stated above. Park (1923) has a method which does not necessitate the killing of the insect, but as live bees are troublesome to handle and would cause complications in weighing, this was thought to be the better method.

The vial and dismembered bees are then weighed the third time and this weight subtracted from the second weight giving the total weight of nectar. Proper entries were made, giving these different weights and the number of bees, so that the average weight of both pollen and nectar could be calculated.

The fact that representative bees were usually just out of reach on the shrubs and were totally inaccessible on tall trees led to the devising of the "bee catcher" shown in figure 1. The idea was that of the author, who took it to Professor E. V. Floyd of the Physics Department of K/S.A.C. for amplification of the idea into a reality. Professor Floyd suggested several improvements and contributed much of his time to the manufacture of the instrument. Though it was not finished until near the end of the experiment it performed very credibly, and holds great promise for future work of this nature.

OBSERVATIONS

Lovell (in A B C and X Y Z of Bee Culture; Root, 1923) defines a honey plant as one which secretes nectar, accessible to honeybees, in quantities sufficiently large to be of practical importance to beekeepers.

A complete list of the plants in this locality on which bees were observed at work is given in Table IV. The food plants of the bee are placed in three classes depending on whether they supply pollen, nectar, or both pollen and nectar.

The first object of this problem was to compile a chronological sequence of the blooming dates of food plants of honeybees for this locality. This is given in figure 2. This sequence has been derived as follows: The first and last observations made in 1927 and in 1928 were graphically set down, below which was set the limits of bloom as noted by F. F. Crevecoeur (unpublished) at Onaga, Kansas, which location is about 50 miles north and east of Manhattan, Kansas. The limits of blooming as noted for 1927 and 1928 at Manhattan were compared with the limits of several years observation by Crevecoeur, and the average derived as given in figure 2. Certain individual plants here given will be reviewed under the heading discussion.

A total of 372 observations were made and recorded as to the type of food available to bees from different plants, but only 346 records were kept on the number of bees observed on each plant at the time of observation. Table V gives a tabular review of the number of bees observed. Below the number of observations made and the number of bees observed are given the percentage per hour of the total involved. Figure 3 presents Table V graphically.

The number of hourly observations increased rapidly until nearly noon, then dropped off more slowly, the sudden break at 12:00 noon being due to the lunch hour. If observations had been carried on normally curve A would have continued directly from 12 noon to 1:00 p. m., and likewise curve B would have followed the same general course. It is noticed that curve B, the per cent of the total number of bees per hour, follows almost exactly the per cent of total number of observations. This is explained when it is noted by Table IV how nearly all hourly averages of bees noted per observation coincided with the average of the total.

Table VI is taken directly from the field records, giving the record of what the bees were doing at each observation. Table V is the totals of Table VI. From this table was derived figure 4. The number of bees securing nectar or both pollen and nectar increased very rapidly during the afternoon (the sudden break in the curve at noon due to lack of observations being made). Chiefly noticeable is the manner in which the curves for pollen and nectar together and nectar only approach each other, while that for pollen only tends to drag behind, maintains its peak from 10:30 a. m. to 1:30 p. m., and then drops almost completely off by 2:00 p. m. This is in accord with the findings of Parker (1926) at Ames, Iowa.

Table VII is the record for ten plants which bloom from early March until the middle part of April, viz. soft maple, white elm, slippery elm, cornelian cherry, apricot, plum, pear, Japanese quince, box elder and apple. Figure 5 is derived from Table VII. The prominent part played by the pollen producing plants is to be noticed here. The curve for the number of bees securing pollen alone far exceeds that for nectar alone or that for pollen and nectar. When it is considered that when both pollen and nectar are collected from the same flower that usually only sufficient nectar is obtained to moisten the pollen, the importance of these early plants as producers of pollen for brood rearing can be realized.

The most outstanding fact from Table VIII and figure 6 is the small amount of pollen alone gathered from the following plants: honeysuckles, dandelion, redbud, Missouri currant, strawberry, Ohio buckeye, horse chestnut, barberry, flowering maple and hawthornes. This may be due to the fact that more varieties of plants are in bloom so that the flowers must offer nectar as an inducement for insect visitors. The sudden rush of bees for the field as soon as the temperature rises is indicated by the rapid rise from 8:00 a. m. to 9:00 a. m. reaching the peak between 10:00 a. m. and 11:00 a. m. The descent throughout the afternoon is slow, dropping off abruptly about 4:00 p. m. when the sun gets low and the temperature drops.

Table IX and figure 7 presents the observations made on six plants preceding the main honey flow from May 13 to June 13. These plants were tulip tree, tamarisk, white clover, yellow sweet clover, persimmon and basswood. The early rush of bees was due almost exclusively to the basswood nectar flow, which quickly fell off and was then taken up by the flow from yellow sweet clover about 10:00 a. m. The late afternoon rise was due to the basswood again becoming attractive to bees as the evening became cooler.

The second phase of the problem, the weighing of the loads secured by the bees, arose from the necessity of knowing for certain whether the bees were securing nectar, or whether they were merely searching for it as they loaded themselves with pollen. Observations on maple trees were of necessity made through field glasses, so that it was difficult to determine whether the bees were securing any nectar.

At the time the soft maples come into bloom no other pollen producing plants are in bloom in this locality. Thus, a splendid opportunity was at hand to capture the bees as they returned to the hive, loaded with whatever they had collected. Bees with average size pollen loads were usually captured, although some extremely large and small loads were taken in an endeavor to determine which bees, if any, were bringing in nectar with the pollen. Observations among the blossoms had determined that every bee was gathering pollen, but it was not a certainty that nectar was being gathered.

Results of these weights are given in Table X, presented graphically in figure 8. The morning of March 10, 1928, was cloudy, but the sun came out warm about noon, sending the temperature up to 66° F. at 12:30 p. m., and increasing to 74.5° F. by late afternoon. This was the best day that the bees had in which to gather pollen, and the most was made of the opportunity. The last bees coming in at 6:00 p. m. carried the largest loads of pollen, which might tend to indicate that pollen is made more available by continued warmth.

The average pollen load for these 213 bees was thus found to be .01193 grams. The lightest loads brought in averaged .00727 grams for 11 bees, a deviation of .00466 grams lighter than the average. The heaviest average load was .0200 for 18 bees, brought in at 11:30 a. m. on March 11, 1928. This exceeded the average by .00907 grams. No doubt this great difference in weight of load can be traced directly to the weather conditions, affecting not only the availability of the pollen but also the actions of the bees in flying.

The average load contained in the honey sac was found to be .00276 grams, ranging from .00379 grams to .00112 grams for different hours of the day. In order to show that very little, if any, nectar was being collected the spots on the filter paper made by the contents of the ruptured honey sacs were measured and tabulated according to whether they gave the appearance of honey or nectar; Table XI. There were 102 bees with material in the proventiculus, while 111 or 52.12% of the total came back to the hive with large loads of pollen and empty honey stomachs.

Of the 102 loaded bees, 68 gave evidence of having some honey in the stomach, while 34 carried some substance similar to nectar or very thin honey; that is, 31.92% of the bees carrying pollen, or 66.66% of those having material in the proventriculus returned to the hive with some honey. Only 15.96% of the total, or 33.33% of those having weight in honey sac, returned with material resembling nectar.

The honey carried by the 69 bees composed a bulk sufficient to spread over 986 square millimeters of filter paper, while the so-called nectar spots covered only 258 square millimeters. This gives an average of 14.5 square millimeters per bee, carrying honey, and only 7.58 square millimeters per bee carrying nectar. The honey spots constituted 79.26% of the area covered, while the lighter spots comprised 20.74% of the area. Thus, it is safe to say that two-thirds of the bees involved carried four-fifths of the material in question as honey while one-third of the bees carried only one-fifth of the material. It is a common observation that the nectar, being much thinner, will be absorbed by the filter paper faster and will make a large spot in comparison with the same volume of honey. It would appear from the foregoing that the amount of nectar carried would be very negligible.

Table XII gives the weights of pollen and nectar loads from all bees weighed, the number of bees carrying each load, and the total number of bees at each weighing. We find that 515 bees or 67.85% of those weighed carried an average of .01072 grams of pollen per load; and 244 bees or 32.15% carried an average of .006425 grams of nectar. Figures 9 and 10 present these tables graphically.

DISCUSSION

Maple

Pollett (1920) quotes a report from Iowa of a scale hive showing a gain of one to two pounds daily from soft maple, inferring that this gain is from nectar. My observations during both 1927 and 1928 would lead to the belief that pollen alone was collected but the actual examination and weighing of bees shows that no nectar was secured from soft maple in this locality during 1928. This increase in hive weight, however, could be accredited to the pollen brought in by the bees. Brood rearing at that season could not consume a fraction of the pollen brought in, so it would be stored. At the average load of .0119 gram, with 75 bees arriving per minute (a very low estimate on bright warm days), it would require 8.47 hours to bring one pound of pollen into the hive.

In an effort to determine the number of bees gathering from soft maple an isolated tree was closely observed during the afternoon of March 9, 1928. This tree was about one-fifth in full bloom, well protected by surrounding trees and standing in the full sunlight. The day was cooler and more windy than was comfortable and not as many bees were flying as did normally in the afternoon.

Table XIII presents the results for that series of observations. The thermometer was placed in the tree about five feet above ground, in the shade. Temperature readings were taken immediately after counting the bees for each observation. From this table it is seen that the bees cease flying freely when the temperature drops to 70° F. or below on a cloudy day.

Elms

While blooming profusely in 1927, the days were so cool and rainy that there was no opportunity for the bees to gather pollen from the elm trees. In 1928 the American elm came into bloom during the latter part of the soft maple bloom, and as the weather was very good for several days, sufficient pollen for brood rearing was easily accessible from both American and slippery elm.

Early Honey Plants

The pussy willows planted as ornaments and those along the streams were extensively worked for both pollen and nectar. Golden willow and forsythia had only a few honey bee visitors. On March 25, 1928, the apricots presented a riot of color, and the bees made good use of the time they had before a frost cut short the bloom.

Honeysuckles were extensively worked for both pollen and nectar in 1927, but the severe freeze in 1928 stopped them, as it did for the fruit bloom. Pears were almost past their peak and apple blossoms were just opening when they were cut short. The Japanese quince, however, blossomed steadily, seemingly being able to withstand the cold. Box elder blossomed normally, but the redbud and following plants were held back from a week to ten days later than in 1927. Fruit bloom was heavy in 1927, but there were only a few scattered days which were suitable for the flight activities of the bees. Despite the inclement weather apple, pear and cherry blossoms were well fertilized, as shown by the heavy set of fruit that season.

Dandelion

The common dandelion is reported to be a more important honey plant fifty miles east of Manhattan than it is in this locality. The college campus, the city park and vacant lots in the city are quite yellow with bloom early in April, but the countryside and hills are relatively free.

Though a few early blooms were noticed in late March, it was not until the first week in April that the bees were noted at work very intensively on the dandelions. In the early spring the blossoms were found to remain closed until about 7:00 or 8:00 a. m., depending upon the weather, and then usually closing up again shortly after noon time. As the season advanced they opened earlier and remained open throughout the entire day.

Redbud

The hill sides along water courses were found to be covered with a surprisingly large number of the redbud trees. This tree, one of the legumes, was found to be a highly available source of pollen and nectar, and can be considered an important source of brood-rearing food.

Tamarisk

This shrub or small tree is used quite extensively throughout the central portion of the state in landscape planting. The five genera and about 90-100 species of the family Tamaricaceae are mainly distributed in the Mediterranean region and in Central Asia (Wiegand in Standard Cyclopedia of Horticulture, L. H. Bailey, 1914). By means of small leaves, sunken stomata, water-storing tissue, and other contrivances, the members of this family are adapted for life in the dry regions in which they live. In its native habitat, foliage-glands excrete an excess of absorbed mineral matter, and this very hygroscopic excretion accumulates on the surface of the plant.

Careful observation of the bees on the tamarisk plants in this locality showed that the bees were securing a liquid from the flowers, presumably nectar, and were not attracted to the foliage. The hygroscopic excretion mentioned by Wiegand either does not exist in this habitat or else it is not attractive to the honeybee. Because of its drough resistance, its long period of bloom, and the large amounts of pollen and nectar secured from it by the bees, it holds promise of becoming an important early honey plant.

White Clover

The main source of surplus honey in the northern and eastern states, white clover is useful only in the early spring in this locality as an aid to brood-rearing. The cool, humid weather of May and early June induce a great mass of blossoms, but the following hot, dry, summer weather precludes any possibility of the bees securing a surplus from this plant.

Yellow Sweet Clover

Coming into bloom about a month before the white species of Melilotus, the yellow sweet clover tides the bees of central Kansas over their most critical period. At this stage of brood-rearing the winter stores are usually exhausted and but for the nectar secured from this plant the bees would be severely weakened for the main honey flow from the white sweet clover.

Table III does not cover the entire list of plant species known to bloom in this locality, but merely lists those plants from which records were made when the bees were found gathering food from them.

CONCLUSIONS

1. On the average, the earliest pollen for brood-rearing is available from soft maple about March 6.

2. Important brood-rearing honey plants of this locality are:

   a. Soft maple for early pollen.

   b. Fruit bloom, Japanese quince and dandelion for early pollen and nectar.

   c. Honeysuckle for pollen and nectar soon after fruit bloom.

   d. White clover and yellow sweet clover for pollen and nectar just preceding the main honey flow.

   These plants are important because of their abundance and because of their availability to the honeybee.

3. The early honey plants are more important as sources of pollen than for hectar secretion.

4. Of the total number of bees observed, 48.95% collected both pollen and nectar, 32.92% collected only nectar and 18.13% collected only pollen. Bees gathering pollen utilize the nectar from the same species of plants for moistening the pollen loads whenever any nectar is available.

5. The average weight of pollen load collected by the bees was .01072 grams for 515 bees taken on 16 plant species. The greatest load was .03607 grams from an unknown species of rose.

The average nectar load was .006425 grams for 244 bees taken on 18 plant species. The greatest load was .0424 grams for honeysuckle.

6. With available food plants of honeybees present, weather conditions are the determining factors in the gathering of food by the honeybee. Proper conditions for plant growth are often unfavorable for the flight activities of the bees.

LITERATURE CITED

Bailey, Liberty Hyde
1914. Standary cyclopedia of horticulture, Vol. 1, 55. Macmillan Co., New York.

Bertholf, L. M.
1927. The utilization of carbohydrates as food by honeybee larvae. Jour. Agr. Research, Vol. 35, No. 5, 420-452, 11 figs.

Browne, C. A. and W. J. Young
1908. Chemical analysis and composition of American honeys. U.S.D.A. Bur. Chem. Bul. 110, 93 pp., 6 plates, 1 fig.

Casteel, D. B.
1912. Behavior of the honeybee in pollen collecting. U.S.D.A. Bur. Ent. Bul. 121, 33 pp., 9 figs.

Cook, William S.
1923. Structure of some nectar glands of Iowa honey plants. Iowa Acad. Sci. Proc., Vol. XXX, pp. 301-329, 10 plates.

Hutson, Ray
1926. Relation of the honeybee to fruit pollination in New Jersey. N. J. Agr. Exp. Sta. Bul. 434, pp. 1-23, 3 figs.

Lineburg, Bruce
1926. Pollen collecting by the honeybee. American bee jour. 66, pp. 66-67, 5 figs.

Lovell, John H.
1926. Honey plants of North America. A. I. Root Co., Medina, Ohio.

Merrill, J. H.
1922. Honey plants of Kansas. Amer. bee jour., 1922, pp. 7-10.

Park, O. W.
1928. Time factors in relation to the acquisition of food by the honeybee. Iowa Agr. Exp. Sta. Research Bul. 108, pp. 184-225, 13 figs.

Parker, Ralph L.
1923. Some pollens gathered by bees. Amer. bee jour., 1923, pp. 16-19, 2 figs.

1926. The collection and utilization of pollen by the honeybee. Cornell Agr. Exp. Sta. Memoir 98, 55 pp., 16 figs.

Pellett, Frank C.
1920. American honey plants. Amer. bee jour., Hamilton, Ill.

Phillips, E. F.
1926. Beekeeping. Macmillan Co., New York.

Root, A. I. and E. R. Root
1923. A B C and X Y Z of Bee Culture. A. I. Root Co., Medina, Ohio.

Snodgrass, R. E.
1925. Anatomy and physiology of the honeybee. McGraw-Hill, New York.

TABLE I

Composition of Larval Foods (VonPlanta, 1889)

Nature of dried substance	Queens	Drones: Under 4 days	Drones: Over 4 days	Workers: Under 4 days	Workers: Over 4 days
Nitrogenous products	45.15	55.91	31.67	53.38	27.87
Fat	13.55	11.09	4.74	8.38	3.69
Sugar	20.39	9.57	38.49	18.09	44.93

TABLE II

Analysis of Pollen Grains

Plant	Authority	Protein %	Fat %	Ash %	Starch %	Sugars %
Hazel	Von Planta (1885)	30.06	4.20	3.81	5.26	14.7
Pine	Von Planta (1886)	16.58	10.56	3.30	7.06	11.24
Sugar Beet	Stift (1901)	16.28	5.47	7.13		[illegible].27
Rye	Heyl (1917)	40.00	3.00	26.00		
Corn	And and Kulp (1922)	4.53	1.43	3.46	11.07	21.68

TABLE III

Analyses of Honey (Brown and Young, 1908)

Substance	Dandelion	White Sweet Clover
Water	14.54	17.49
Invert sugar	76.84	76.20
Sucrose	3.12	2.24
Ash	.16	.12
Dextrin	1.23	.45
Undetermined	4.11	3.50

TABLE IV

Classification of Plants According to the

Food Collected by Bees

A. Pollen

Acer negundo L.	Box elder
Acer saccharinum L.	White or silver maple
Aquilegia vulgaris L.	Columbine
Castalia tuberosa Gr.	Water lily
Cornus sp.	Dogwood
Quercus Robur L.	English oak
Rosa canina L.	Dog rose
Rosa sp.	Wild rose
Ulmus americana L.	American elm
Ulmus fulva Michx.	Slippery elm

TABLE IV (Cont'd)

B. Nectar

Aesculus glabra Willd.	Ohio buckeye
Gleditsia triacanthos L.	Honey locust
Gymnocladus dioica Koch.	Kentucky coffee tree
Ligustrium japonicum Thunb.	California privet
Narcissus sp.	Garden narcissus
Prunus persicae S. & Z.	Peach
Rhamnus sp.	Buckthorn
Ribes aureum Prush	Missouri currant
Staphylea trifolia L.	American bladder nut
Veronica spicata L.	Veronica

C. Pollen and Nectar

Acer ginnala	Flowering maple
Aesculus hippocastanum L.	Horse-chestnut
Berberis vulgaris L.	Common barberry
Catalpa bignonioides Walt	Catalpa
Cercis canadensis L.	American redbud
Chaenomeles lagenaria	Japanese quince
Colutea arborescans	Pea tree
Cornus mas	Cornelium cherry
Crataegus sp.	Hawthorn
Diospyros virginiana L.	Persimmon
Elaeagnus augustiofolia	Russian olive
Forsythia suspensa Vahl.	Forsythia
Fragaria chiloensis Duch.	Strawberry
Gaillardia sp.	Gaillardia
Ilex verticillata Gray	Bittersweet
Lonicera spp.	Honeysuckles
Liriodendron tulipifera L.	Tulip tree
Melilotus officinalis Lam.	Yellow Sweet Clover
Philadelphus coronarius L.	Mock orange
Prunus armeniaca L.	Apricot
Prunus cerasus L.	Cultivated cherry
Prunus serotina Ehrh.	Wild Black Cherry
Pyrus communis L.	Pear
Pyrus malus L.	Apple
Rhus cotinus L.	Smoke tree
Robina pseudo acacia L.	Black locust
Rubus occidentalis L.	Raspberry
Salix cordata Muhl.	Pussy willow
Salix sp.	Golden willow
Syringa vulgaris L.	Lilac

TABLE IV (Cont'd)

Tamarix gallica L.	Tamarisk
Taraxacum erythrospermum	Andrz. Dandelion
Tilia heterophylla Vent.	White basswood
Trifolium repens L.	White clover

TABLE V

Totals of Observations and Bees

Hour a. m.	7-8	8-9	9-10	10-11	11-12	12-1	Total
Obs.	16	17	45	50	87	20	
% Total	4.62	4.91	12.42	14.45	25.14	5.78	
Bees	134	191	377	418	742	100	
% Total	4.82	6.44	12.72	14.10	25.03	3.37	
Bee/Obs.	8.37	11.23	8.70	8.36	8.52	5.00	
Hour p. m.	1-2	2-3	3-4	4-5	5-6	6-7	
Obs.	36	24	19	17	10	7	346
% Total	10.40	6.93	5.49	4.91	2.89	2.02	
Bees	326	264	181	119	88	24	2964
% Total	10.99	8.91	6.10	4.01	2.97	.81	
Bee/Obs.	9.05	11.00	9.52	7	8.8	11.58	8.56
							Ave.

TABLE VI

Total of Field Observations

Hour	PN	N	P	Total
7-8	65	60	9	134
8-9	108	57	26	191
9-10	206	88	83	377
10-11	219	87	112	418
11-12	406	238	98	742
12-1	59	28	13	100
1-2	94	116	116	326
2-3	105	103	56	264
3-4	50	120	11	181
4-5	77	29	13	119
5-6	53	35		88
6-7	9	15		24
778				
	1451	976	537	2964

TABLE VII

Record of Ten Early Honey Plants

Hour	PN	N	P	Total
7-8	8	0	0	8
8-9	5	0	0	5
9-10	22	12	46	80
10-11	35		68	103
11-12	122	27	185	334
12-1	2	5	13	20
1-2	0	0	87	87
2-3	0	0	54	54
3-4	0	0	8	8
4-5	43		13	56
5-6		6		6
	236	40	474	750

TABLE VIII

Record of Ten Middle Season Honey Plants

Hour	PN	N	P	Total
7-8	5	0	0	5
8-9	25	17	0	42
9-10	109	24	27	160
10-11	92	56	19	167
11-12	66	59	17	142
12-1	22	16	0	38
1-2	25	60	8	93
2-3	27	59	2	88
3-4	17	81	3	101
4-5	4	12	0	16
	392	384	76	852

TABLE IX

Record of Six Late Season Honey Plants

Hour	P[illegible]	[illegible]	P	Total
6-7	20	0		20
7-8	42	70		112
8-9	48	30		78
9-10	50	6	3	59
10-11	76	57		133
11-12	114	83		197
12-1	30	7		37
1-2	54	26		80
2-3	55	0		55
3-4	17	36		53
4-5	32	12		44
5-6	53	20		73
6-7	9			9
	600	347	3	950

TABLE X

Record of Weights From Soft Maples

Date	Time	Wt. P	Wt. P per bee	No. bees	Wt. contents of honey sac	Wt. honey sac/bee
3- 7-28	1:50 p.m.	.1258	.01258	10	.0201	.00201
3- 7-28	3:05 p.m.	.0890	.00890	10	.0376	.00376
3- 7-28	4:00 p.m.	.1300	.00866	15	.0409	.00272
3- 8-28	3:30 p.m.	.0800	.00727	11	.0502	.00376
3-10-28	11:30 a.m.	.2089	.01228	17	.0191	.00112
3-10-28	1:00 p.m.	.1781	.01047	17	.0219	.00128
3-10-28	2:00 p.m.	.1846	.01025	18	.0249	.00138
3-10-28	3:00 p.m.	.2276	.01338	17	.0245	.00144
3-10-28	4:00 p.m.	.1481	.00987	15	.0400	.00266
3-10-28	5:00 p.m.	.1759	.01034	17	.1155	.00679
3-10-28	6:00 p.m.	.2774	.0162	17	.0530	.00311
3-11-28	10:30 a.m.	.1166	.00728	16	.0417	.00260
3-11-28	11:30 a.m.	.3600	.0200	18	.0372	.00206
3-12-28	9:00 a.m.	.2390	.01598	15	.0627	.00418
		.01193	Ave.	213	.00276	Ave.

TABLE XI

Results of Filter Paper Tests From Soft Maple

Date	Time	No. bees	Honey area, sq. mm.	No. bees	Nectar area, sq. mm.
3- 7-28	1:50 p.m.			3	17
3- 7-28	3:05 p.m.	2	41	2	12
3- 7-28	4:00 p.m.	4	75	3	20
3- 8-28	3:30 p.m.	8	151	3	24
3-10-28	11:30 a.m.	2	30	1	5
3-10-28	1:00 p.m.	8	121		
3-10-28	2:00 p.m.	4	42	2	10
3-10-28	3:10 p.m.	5	44	1	6
3-10-28	4:00 p.m.	2	20	2	11
3-10-28	5:00 p.m.	9	126	2	10
3-10-28	6:00 p.m.	14	173	2	7
3-11-28	10:30 a.m.	2	41	5	37
3-11-28	11:30 a.m.	2	25	3	19
3-12-28	9:00 a.m.	6	97	5	29
		68	986	34	258
		Ave.	14.5	Ave.	7.58

TABLE XII

Pollen and Nectar Loads

Plant	Wt. P	No. bees	Ave. Wt. P	Wt. N.	No. bees	Ave. Wt. N	To-tal
Maple	3.5631	214	.01665				240
Honeysuckle	.0512	10	.00512	.2650	16	.01656	16
Dandelion	.2688	27	.00995	.0936	18	.0052	27
Japanese quince	.0872	13	.0067	.0646	12	.00538	13
Redbud	.0587	11	.00533	.0713	9	.00792	15
Cherry	.0087	4	.00217	.0163	8	.00203	10
Apple	.0996	12	.0083	.0651	11	.00591	12
Crab apple				.0125	4	.00312	7
Currant				.0291	5	.00582	5
Pea tree				.0212	2	.0106	8
Tamarisk	.2623	46	.005702	.2538	46	.00551	64
White Clover	.1548	28	.00528	.0578	18	.00321	32
Ky. Coffee tree				.0120	1	.0120	3
Yellow Sweet Clover	.4588	98	.00466	.2136	45	.00474	111
Russian Olive	.0250	4	.00625	.0173	3	.00576	6
Persimmon	.1286	23	.00559	.0479	4	.01197	24
Dog Brier Rose	.0183	4	.00457				4
Rose #2	.0154	3	.00513				3
Rose	.2525	7	.03607				7
Veronica				.0166	2	.0083	8
Basswood	.0727	11	.0066	.1914	28	.0068	59
White Sweet Clover				.1186	12	.00988	19
	5.5257	515		1.5677	244		703
	Ave.		.01072	Ave.		.006425	

TABLE XIII

Observations on Soft Maple

Time p.m.	No. bees	Temp., Degrees F.	Remarks
1:10	9	74	Wind fitful; from south.
1:15	12	75	More windy.
1:20	13	75	Most bees on west side of tree.
1:25	9	75	7 of these on west side.
1:30	9	75.5	4 of these on west side.
1:35	6	75.5	Wind increasing.
1:40	11	75.5	
2:10	6	70	Windy and cooler.
2:15	5		Cloudy.
2:20	11	74	Wind stronger; fitful.
2:30	8	69	Cloudy; most bees on north out of wind.
2:40	8	69	Semi-cloudy; wind fitful.
2:50	6	69.5	Semi-cloudy; wind fitful.
3:00	5	69.5	Semi-cloudy; wind fitful.
3:20	5	66	More cloudy.
3:30	4	66	More cloudy.
3:40	5	66	Not so much wind.
3:50	4	65	More cloudy; wind fitful; bees restless.

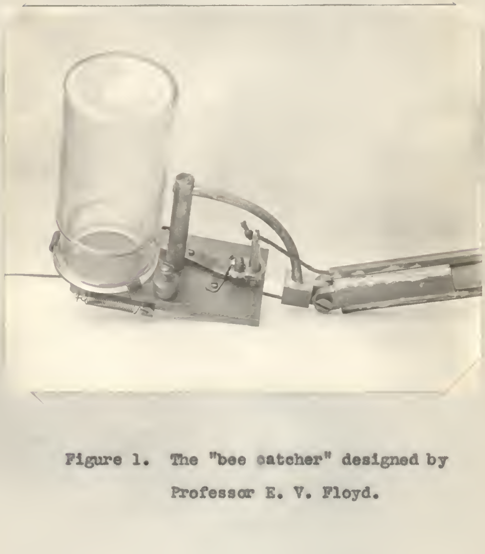

Figure 1. The "bee catcher" designed by
Professor E. V. Floyd.

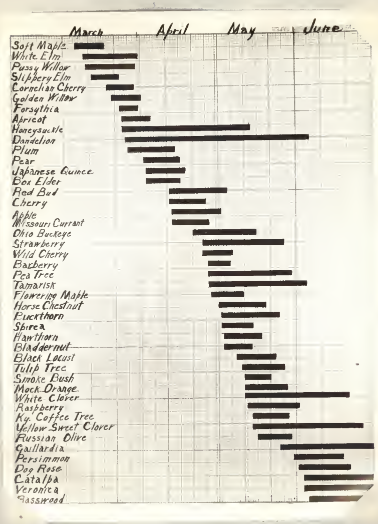

Figure 2. Blooming sequence of brood-rearing honey plants at Manhattan, Kansas, for 1927-28.

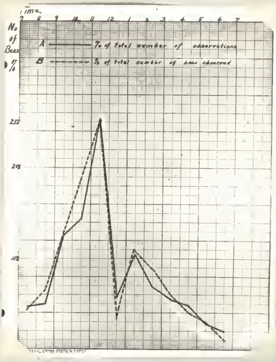

Figure 3. Summary of observations and bees observed (by per cent).

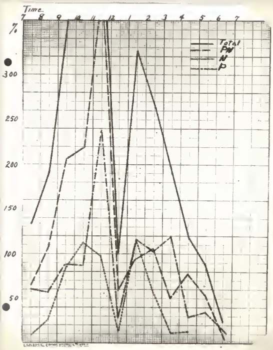

Figure 4. Summary of field records (by actual number of bees).

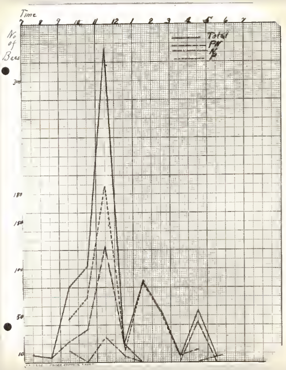

Figure 5. Number of bees visiting ten early season honey plants per hour.

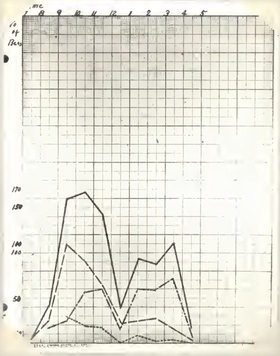

Figure 6. Number of bees visiting ten middle season honey plants per hour.

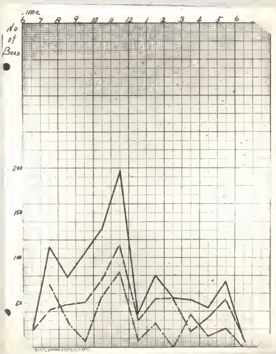

Figure 7. Number of bees visiting six late season honey plants per hour.

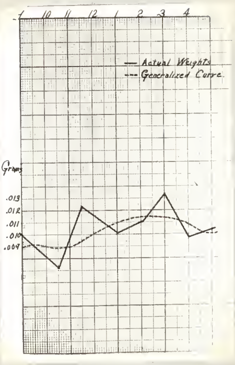

Figure 8. Record of weights from soft maple

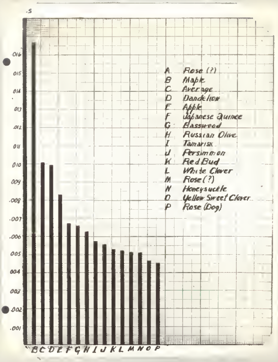

Figure 9. Weights of pollen.

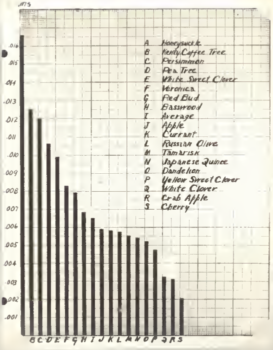

Figure 10. Weights of nectar
