MAJOR POLLEN SOURCES IN THE MANHATTAN, KANSAS AREA AND THE INFLUENCE OF WEATHER FACTORS UPON POLLEN COLLECTION BY HONEYBEES IN 1954

by

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INTRODUCTION

The study of the pollen grains has interested research workers in various fields of science. Much work has been done on the relationship to the medical field, beekeeping, botany and honeybee nutrition. Pollen grains are the powdery substance produced by the anthers of flowers. At the time of dehiscence of the anthers this powdery substance is transferred in different ways to the female organs of the flowers, carrying the gametes necessary in the reproduction process.

The relation of pollen grains to the field of apiculture comes through its vital importance to the bees as a larval food and for the young nurse bees. These pollen grains are collected and carried to the hive in the form of pellets where they are stored adjacent to the brood nest. They provide the protein and vitamins which are utilized for building the body tissues. They also contain carbohydrates, fats and minerals which are of less importance if they are compared with the proteins. Carbohydrates are supplied by the honey; fats can not be utilized by the bees.

It has been proved that the importance of this substance is great in relation to brood rearing. Brood rearing completely ceases in the absence of pollen. Adequate pollen stores are essential in the hive at all times, but it has been found that fresh pollen brought into a colony provides a direct stimulus to brood rearing.

For a beekeeper who is working for either honey production or selling bees, strong colonies with large populations are needed, and this depends to a large extent upon this nitrogenous substance if all proper beekeeping management is provided.

Betts (1928) stated that much aid can be gained by constructing pollen species curves for a number of districts. Such curves give some information about the factors that make a locality a good or poor beekeeping district. Information regarding pollen is now available from several sources but still the study of pollen sources in the different districts favorable for the beekeeping industry must be worked out in more detail.

This study is an attempt to find the important pollen sources in the Manhattan, Kansas, area during the active season and the influence of the weather factors upon pollen collection. The plants in the area surrounding the Kansas Agricultural Experiment Station apiary provide a good source of pollen and nectar for the bees. Some plants in this area are more attractive to the bees, while others, although they also can be considered as good sources, they are less valuable economically because either they furnish small quantities of pollen or they blossom when other plants are in bloom which are more attractive to the bees, or their blooming periods are subjected to unfavorable weather. It is important for a beekeeper located in a certain area to become acquainted with the important pollen sources which will provide his bees with this highly nutritional substance. He must know also the relative importance of these different sources during the different seasons.

The knowledge of the periods of availability of the different pollen sources are also needed to establish its relation to successful management of the bees. It is important to construct a pollen chart for this region in order to recognize the period when there is a gap in pollen production so that it can be overcome by furnishing stored pollen to the colonies to continue brood rearing without interruption.

The identification of the pollen collected by the bees in a certain period helps also in determining the sources of nectar gathered by the bees. The study of the relative quantities of pollen collected from the different sources and the constancy of the bees in visiting certain plants helps in the use of bees in pollination. The knowledge of the weather factors and their influence on pollen collection is of great importance in determining the quantities of pollen the bees can gather from the different sources during their blooming periods.

REVIEW OF LITERATURE

When the plants begin their bloom in the spring bees will be seen visiting the flowers gathering pollen or nectar and even in the latter case some pollen may be attached to their bodies. Parker (1922) noticed that from some flowers the bees gather only pollen, others collect only nectar, and still others may collect nectar and pollen. Parker (1926) described the manner of gathering pollen from different plants according to the type of flowers or floral arrangement. His classification was based upon four main types. He classified the flowers as open type, tubular, closed and spike or catkin type.

After a bee becomes dusted with dry pollen and leaves the flower on her way to the hive a complicated quick moving action of the legs can be observed. This is the packing process. This process has been described by Casteel (1912), Parker (1926), and Hodges (1952).

The pollen-collecting honeybees in returning to the hives attract the scientists' attention by the different colors of pollen loads which they are carrying when there is a considerable number of plants in bloom at any one time.

The color of these pollen loads differs to some extent from the dry pollen occurring directly from the anthers. Parker (1922) noted that pollen gathered by bees at various times during the blooming period of certain plants showed different colors and that the microscopical examination proved that these respective pollens were pure. Reiter (1947) stated that a large percentage of the color change in pollen when packed by the bee is due to the change in surface texture of the pollen masses, the addition of moisture, absorption of light waves by the honey used in packing the pollen, dilution of water soluble pigments and the addition of foreign matter. The color change caused a decrease in brilliancy.

The causes of the color variations has been studied also by Hodges (1949 and 1952). She came to the conclusion that the color variations are brought about by the following points: (1) the condition of the pollen when gathered, whether it is exposed to the weather factors at a time of unfavorable condition for the flight of bees, or it is collected immediately after it is released from the anthers; (2) the amount of moisture used by the bees in making the loads; (3) the color and nature of the moistening material used by the bees; and (4) the inclusion of adulterants such as dust, soot, or fungus spores present on the flower at the time of collection. She also constructed a color chart of the pollen loads of bees working on certain plants showing the different gradations of color of these pollen loads. In some instances bees were caught on the alighting board and their loads identified under the microscope. The color of the pollen loads was taken as a partial basis for identification either by direct observation at the hive or in sorting the loads taken from pollen traps. The pollen loads were examined microscopically and identified to species. This color sorting of pollen loads also has been done by Parker (1922), Betts (1935), Percival (1947), Synge (1947), Vansell and Todd (1949), and Todd and Bretherick (1942). The study of the color of pollen loads in relation to identification has been carried further by Hodges (1952).

The importance of pollen as a source of protein, minerals and special biological products in the honey bee diet and its part in the determination of the brood rearing cycle has been studied by many workers. Parker (1926) noted that brood rearing is limited to that portion of the year when pollen is available in the field and that feeding substitutes stimulates the queen to lay eggs and the nurse bees to feed the young larvae, but development is not completed. Farrar (1934) stated that an abundant fall pollen reserve promotes brood rearing during the winter and results in very populous, early spring colonies. The importance of pollen to brood rearing encouraged many workers in recent years to use pollen traps during the summer months to collect surplus pollen brought in by the bees and then feed the pollen in the following spring to stimulate brood rearing when there is a shortage of pollen.

The study of the pollen cycle and the availability of the pollen during the active season and the different plants which furnish pollen has been studied also by many workers. Parker (1926) in studying the pollen cycle and the availability of the pollen at Ames, Iowa, based his work on field observation and catching bees collecting pollen from certain plants. Betts (1928) made a systematic study of the plants worked for pollen at Camberly, England by Percival (1947) followed the same procedure in catching bees on their return to the hives and identifying the pollens they were collecting. Many other sources regarding the information about the important pollen plants in a region are based upon field observations. Synge (1947) used in her experiment pollen traps in two hives at Rothamstead Experiment Station. She analyzed the daily collection of the pollen and identified it to species for obtaining a quantitative as well as qualitative estimation of the pollen gathered by colonies of honey bees. Todd and Bishop (1940) studied the seasonal distribution of pollen collection in four locations in California. The complete season trapping ranged from about 13.5 to 18.0 kg. per colony. Eckert (1942) used several pollen traps for determining the quantities of pollen required by a colony. He stated that a normal colony of honey bees may collect as much as 122.24 pounds of pollen in a single season at Davis, California. He also identified the various types of pollen collected to determine the relative importance of each plant as a pollen source.

Weather is a complicated factor which has a great influence on flight activity of the bees, colony strength and plant growth and bloom. Lundie (1925) stated that the lowest temperature at which flight began was 50° F., and that a threatening storm or a strong wind reduced the flight of the bees and that during hot days flight activity also decreased. Parker (1926) noted that the availability of pollen is influenced by relative humidity and temperature. Todd and Bishop (1940) stated that the quantity of pollen collected by a colony was influenced by weather factors and colony strength; that peaks in the quantities of pollen gathered were correlated with the blooming of good sources, and did not occur during the peak of the colony population. They noted that the dehiscence of anthers was affected by atmospheric conditions; that the activity in pollen gathering and the quantity of pollen collected were influenced by cold, rain, or cloudiness. Vansell (1942) noted that bees seldom leave the hives if the temperature was below 50° F.; that the wind greatly reduced the field bee activity; that bees did not fly out in large numbers when it was cloudy, and that even a temporary shadow from a thick cloud caused partly loaded field bees to return quickly to the hive. Percival (1947) stated that the weather conditions affect the flying activity of the bees which in turn affect the pollen collection. She noted that in warm calm weather with or without sunshine, the pollen collection was comparatively high; that the opening of the flowers were accelerated by the sun as well as the flight activity of the bees. The approach of a heavy cloud bank made the bees return quickly from the field; that rain absolutely stopped pollen collections and after a rain collection began very quickly. She also concluded (in 1950) that pollen presentation depends upon weather conditions and that the time of pollen presentation is a constant specific character and varies in the different plant species. Synge (1947) stated that the main pollen flow from any plant occurred when a rise in the temperature followed a cold period and that the flow may not continue with the same intensity until the temperature drops. She also noted that the relation between pollen gathering and temperature was probably due as much to the increase in flowering as to the greater activity of the bees, both being caused by a rise in the temperature. She concluded that if the bad weather prevailed during the flowering period of a plant, it will probably depress flowering as well as bee activity and will result in the collection of little or no pollen from a plant which may potentially be a heavy pollen yielder. She also stated that there is a definite time of the day when pollen from a particular plant species is available. Parks (1925) reported that bees gathered pollen and nectar at temperatures as low as 42° F.

Eckert constructed a pollen trap for determining the plants on which bees were working. Farrar (1934) improved the trap for collecting pollen for feeding. The trap consisted of two parallel strips of metal each having two rows of 3/16 inch holes mounted 2 inches apart. The trap was placed at the hive entrance so that an entering bee must pass through two holes where the pollen will be scraped from her legs and fall into a tray below. Todd and Bishop (1940) improved the trap and used 5 mesh to the inch hardware cloth instead of the sheet metal and the strips were placed 5/8 inch apart so that the holes in the front strip were opposite the crosswire in the rear strip to force the bees to make a turn in passing through. Schaefer and Farrar (1946) improved the trap again and used it for collection of pollen for feeding. Synge (1947) used a similar trap in her work. Maurizio (1949) used a pollen trap made of celluloid with a single row of circular holes each hole having four radial slots on its lower half through which the bee would normally draw her legs.

Many investigators have been engaged in the study and identification of pollen grains. Wodehouse (1935) devoted his study mainly to pollens which cause hayfever. He also studied the morphology and the taxonomy of pollen grains. Erdtman (1943, 1952) studied the morphology in relation to plant taxonomy and pollen found in peat and coal. Parker (1922) studied the morphology of different pollen grains collected by the bees at Ames, Iowa. Allen (1936) devoted his study to the pollen grains of the European bee plants. Maurizio (1949) dealt with the methods of removing pollen grains from honey and preparing them for microscopical examination. Hodges (1952) in her recent book made excellent detailed drawings and color charts of the pollen loads which she collected from the bees.

METHODS AND TECHNIQUE

Trapping the Pollen

The colony used for this experiment was an overwintered colony in a Dadant hive. Trapping began at the beginning of the soft maple and the elm bloom, on March 6, 1954 and ended on October 12, 1954. The principle used in this trap was the same as used by Schaefer and Farrar (1946), and Eckert (1947). The bees in entering the hive have to pass through a 5 mesh to the inch grid which scrapes off their pollen loads. The bees in entering the hive through this trap have to pass through only one grid instead of two. The reason for the use of one grid was to lessen the effect of the trap in the food economy of the hive. The trap consisted of a wooden box similar in width and length to the Dadant hive, the depth of the box equaling 5 3/4 inches. The wooden box is divided into two halves, the back half is used as a ventilating space with fly screen covering the slots on three sides. The top of this part which will face the bottom of the brood chamber is also provided with fly screen extending from the edge of the hardware cloth to the rear as shown in Plate I. The hardware cloth is bent and fixed at the end of the front half taking the following shape:  . The horizontal part of it faces the bottom of the brood chamber. Extending from the front edge of the hardware cloth to the front of the trap is a piece of sheet metal covering the top of this front half which faces the bottom of the brood chamber. The front part of the trap is also divided into two halves, the bottom half provides a space for the tray in which the pollen loads fall. This space is separated by a thin board fixed in a slopping position leading to the hardware cloth grid. The board protects the tray from the upper part which is the flight entrance of the bees. The pollen loads drop on the lower hardware cloth and then to the pollen tray. The trap is placed on top of the bottom board and beneath the brood chamber. The bees in passing through the passage over the tray will enter the brood chamber after passing through the hardware cloth which scrapes off their pollen loads.

Analysis of Pollen

The daily collection of pollen loads was weighed and a representative sample was taken for further examination. The weight of this sample was a proportion of the total weight of the pollen collected. On days when the weight of pollen collected was 20 grams or less, the whole sample was taken for further examination. In case the weight ranged between 20 to 100 grams, a 1/5 was taken, if the weight was more than 100 grams, 1/25 of the whole pollen collection was taken for further examination. The sample of the pollen loads taken was then sorted, separating the different colors by using an aspirator. Texture, size and shape of the loads were also of some help in sorting. The homogenous loads were weighed and multiplied by the proportion taken. A representative sample of each type of pollen load was mounted on slides and examined microscopically for identification.

Preparing the Pollen for Microscopical Examination

The method used for preparing permanent slides was a modification of the method used by Wodehouse (1935). A small part of the pollen load was placed on the slide and a drop of 95 per cent alcohol was added. The whole mass was stirred with a dissecting needle to obtain good distribution. A second and third drop of alcohol was added for washing out the oily resinous substances which were wiped away by a piece of filter paper.

A drop of basic fucsin soluble in 95 per cent alcohol with a saturation of 0.125 per cent was added to the whole mass and then stirred with a needle. The excess stain was washed away by adding a few drops of 95 per cent alcohol to the mass. The excess stain and alcohol was absorbed by filter paper. This process was repeated several times until the excess stain was completely removed. The slide with the pollen was allowed to dry, a drop of xylol was added to the mass for clearing, then a drop of the mounting media (Permount) was added and covered with a cover glass. The previous method caused some shrinking of the pollen grains and in some cases it caused rupturing of the grains. To avoid these conditions and for immediate examination, the method used by Owczarzak (1952) was followed. After washing out the oily resinous substances, obtaining a good distribution of the pollen on the slide, allowing it to dry partly, then hot drops of glycerine jelly stained with methyl green and phloxine was added and covered by a cover glass. The immediate examination of the slides prepared by the second method gave good results, but after leaving the preparations for a few weeks the entine pollen grains were more deeply stained due to absorbing more stain.

Identification of the Pollen Loads

During the blooming of the different plants slides were prepared from pollen taken from the flowers of these plants for

PLATE I

Fig. 1

Fig. 2

comparison with the slides prepared from the loads collected in the trap. In some cases identification was made by collecting bees which were gathering pollen from plants. The loads from their legs were used in preparing slides for comparison with slides made from pollen from the same flowers. Not being familiar with the plants in this region and because of interference of class work with making more extensive field observations, it was necessary to limit efforts toward seeking the plants on which the bees were working. This resulted, to some extent, upon the drawings and the descriptions noted in the references for pollen grains of the plants distributed in this area.

RESULTS

From the data represented in Table 1 giving the weights of pollen collected from the different plants through the active season and the periods of pollen collection from these sources, and Fig. 1, also, showing the periods of pollen collection, in the spring of 1954 there was a succession of blooming of plants which furnished good quantities of pollen. These sources can be divided into major and minor sources. Although some of the minor sources included under this heading furnish quantities of pollen, their distribution in this area was not in large enough numbers to provide good quantities of pollen. Most of the plants which furnished pollen in the spring were shrubs or shade trees. Pollen collection from these plants were greatly influenced by

Table 1. Weights of pollen collected from different plants through the 1954 active season and the periods in which pollen was collected.

	Plant name	Quantities in grams	% of total season	Time of pollen collection 1954
1	*Acer saccharinum* L., (soft maple)	649.4	6.1	March 6 - April 4
2	*Ulmus americana* L., (white elm)	130.04	1.2	March 6 - April 7
3		32.62	0.3	March 11 - April 5
4	*Taraxacum officinalis* Weber.(dandelion)	123.76	1.1	March 11 - May 11
5		0.15	0.001	March 21 - March 22
*6	*Prunus angustifolia* Marsh. (wild plum)	35.95	0.3	March 25 - April 4
7	*Salix discolor* Muhl. (pussy willow)	17.15	0.16	March 26 - April 6
8		1.55	0.01	April 2 - April 6
9	*Acer negundo* L. (boxelder)	344.25	3.27	April 6 - April 18
10	*Populus* sp. (cottonwood)	41.50	0.39	April 6 - April 9
#11	*Chaenomeles laginaria* (Jap. quince)	26.0	0.24	April 6 - April 8
12	*Cercis canadensis* L. (redbud)	186.35	1.77	April 10 - April 16
13		24.5	0.23	April 11 - April 14
*14	*Pyrus* sp. (Hoppa crab)	49.0	0.46	April 15 - April 19
*15	*Salix* sp. (willow)	156.72	1.49	April 17 - April 25
#16	*Lonicera tartarica* L. (honeysuckle)	290.78	2.76	April 19 - May 14
17		25.0	0.23	April 20
18		12.3	0.11	April 20 - April 24
*19	*Forsythia* sp. (forsythia	14.25	0.13	April 22 - April 23
20	*Aesculus hippocastanum* L. (horse chestnut)	52.0	0.49	April 23 - May 11
21		2.25	0.02	April 23 - May 5
22	*Spiraea vanhouttei* Zabel (spiraea)	219.95	2.09	April 24 - May 13
23	*Robina pseudoacacia* L. (black locust)	570.98	5.43	April 26 - May 12
#24	*Pyrus malus* L., (apple)	35.10	0.33	April 29 - May 8
25		184.55	1.75	May 4 - May 15
#26	*Eloeagnus angustifolia* L. (Russian olive)	26.55	0.25	May 4 - May 12
27		1.65	0.01	May 4 - May 8
28		25.65	0.24	May 4 - May 20
#29	*Gleditsia triacanthos* L. (honey locust)	767.25	7.3	May 13 - May 29
30		29.35	0.27	May 20 - May 26

Table 1. (Concluded)

	Plant name	Quantities in grams	% of total season	Time of pollen collection 1954
31	<u>Melilotus officinalis</u> Lam. and <u>M. alba</u> Desf. (sweet clover)	793.21	7.54	May 22 - June 27
32		2.0	0.019	May 23 - May 28
#33	<u>Rhus glabra</u> L. (Sumac)	1.55	0.014	May 28 - June 2
#34	<u>Diospyros virginiana</u> L. (persimmon)	39.78	0.37	June 2 - June 17
35		6.85	0.065	June 2 - June 14
36	<u>Trifolium repens</u> L. (white clover)	22.34	0.21	June 9 - June 20
37		3.72	0.03	June 13 - June 23
38	<u>Medicago sativa</u> L. (alfalfa)	175.75	1.67	June 25 - August 13
39	<u>Zea mays</u> L. (Indian corn)	1517.56	14.44	July 4 - August 18
*40	<u>Persicaria</u> sp. (smartweed)	12.49	0.118	July 5 - August 11
41	<u>Portulaca</u> sp. (Portulaca)	1.45	0.013	July 26 - August 11
42		162.67	1.54	August 1 - August 11
43		9.40	0.08	August 1 - August 11
44	<u>Polygonum</u> sp. (smart weed)	2484.82	23.64	August 13 - October 12
45	<u>Sorghum vulgare</u> Pers. (sorghum)	354.45	3.37	August 19-September 8
46		16.75	0.15	August 23-September 1
47	<u>Helianthis</u> sp. (sunflower)	698.20	6.64	August 23 - October 12
48		6.50	0.061	September 12-September 14
49		122.8	1.16	September 15-October 12
	Total weights of pollen loads	10,508.84		
	Total weights of pollen dust	536.24		
	Grand total	11,045.08		

* Identified with the help of Dr. Roger P. Wodehouse.
# Identified with the help of Dr. Ralph L. Parker and his file of pollen slides.

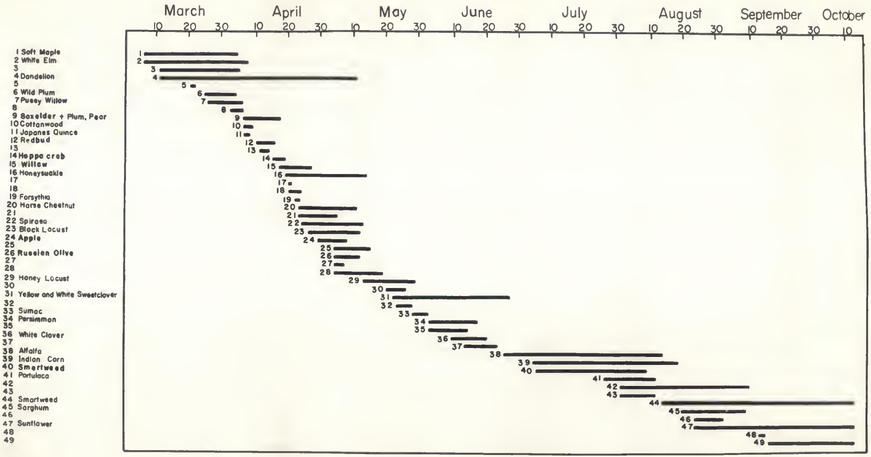

Fig.1 Periods of pollen collection from different plants, March 6 to October 12, 1954

weather factors which will be discussed later.

The results obtained in this work were based mainly upon sorting the pollen loads into the different colors, followed by a microscopical examination. Pollen loads in some instances from different sources were of a similar color which made it very difficult in separating and in securing an exact dividing line to determine the quantity exactly obtained from each source each day. In these cases the estimation of the weight of the different kinds of pollen gathered in any one day was calculated according to the percentage of each kind of pollen present in the microscopical sample. The same difficulty was met in the microscopical examination in determining the different plant species as there is a similarity in the shape, dimentions, type of sculpturing on the pollen grains of very closely related plants species which made it impossible to identify the pollen further than the plant family or genus. In the following discussion where closely related species could not be distinguished, the entire discussion is given under the heading of the most abundant source. The description of some of the pollen grains follow the description given by some of the scientists working in this field.

Spring Pollen Sources

Acer saccharinum L., Soft Maple. This plant is of great importance to the bees. It blooms early in the spring and furnishes large quantities of pollen. Brood rearing begins early in the spring and colonies are in great need of pollen which can be obtained from this plant to help in increasing the population within the colonies for the first major nectar flow. Bees were observed gathering pollen from this plant in the middle of February. The availability of pollen extended from the middle of February to April 4. Pollen collection by honeybees from this plant depends upon favorable weather conditions. On a warm day, March 10, 1954, the quantity of pollen trapped from this plant was 217.65 grams. The total quantity of pollen trapped from the plant during the early spring was 649.4 grams. Wodehouse (1942) described the pollen of this plant as spheroidal with three furrows tapering to sharp ends near the poles. The pollen grains are without germ pores; the exine is scarcely or not at all striate; grains range in size from 33.8 to 41.5 microns (Plate II, Fig. 1).

Ulmus americana L., White Elm. Due to similarity in color and morphology of the pollen grains of elms, difficulty has been encountered in the determination of what species of elm furnished the majority of the pollen. The account given herein pertains to white elm which is the most widely distributed species in the area. White elm can be considered as a good source of pollen in the early spring yet it has been observed that the bees continue working on the soft maple more than the white elm. The blooming period of this plant extended from March 6 to April 7. The color of the pollen loads from this plant has nearly the same color of the loads from the soft maple which was yellow fading to pale green which makes it very difficult to depend on color for separation. The estimation of the weight was calculated according to the percentage of each kind of pollen present in the microscopical sample. The quantity of pollen collected on a warm sunny day, March 10, was 11.45 grams. The pollen trapped from this plant through its blooming period was 130.04 grams. The activity of the bees on working on this plant was also subjected to weather conditions. Only warm sunny days were favorable for good flight and for pollen collection.

Wodehouse (1935) described the pollen grains of this plant as distinctly flattened, averaging 37.2 by 29.6 microns without furrows, germ pores three to seven, most commonly five-arranged around the equator of the grain, texture of the exine smooth when the grains are full of starch (Plate II, Fig. 2).

Taraxacum officinale Weber, Dandelion. This plant grows as a weed in this area, its importance to beekeeping can be determined by its abundance in any region. It has a long blooming period and the collection of pollen from this plant began March 11 and continued to May 11. In the early period of its bloom the activity of the bees working on this plant was subjected to the weather factors which determine the daily quantities of pollen which can be gathered from it. The total weight of pollen trapped from this plant during the blooming season was 123.76 grams. Pollen loads from this plant were orange in color. Wodehouse (1942) described the pollen grains as spheroidal with three bulging germ pores, 24-27.5 microns in diameter. The pattern of the ridge consists of 15 lacunae. Three of these lacunae surround the pores and communicate through broad gaps while six more lacunae, three in each hemisphere, are meridionally opposite them. Alternating with these latter are six more lacunae, the three of one polar hemisphere separated from the three of the other by a crest which reaches from poral lacuna to poral lacuna along the equator of the grain. Many of the grains of this plant vary in size (Plate II, Fig. 4).

Acer negundo L., Boxelder. This plant is abundant in this area and is a good source of pollen. Collection of pollen from this plant began April 6 and extended through April 18. The beginning of its bloom came at the end of the blooming period of the soft maple and the elms. Other plants blooming in this area during its bloom were comparatively insignificant which allowed the bees to concentrate their work on this plant. During the latter part of the blooming period of this plant many plants belonging to the family Rosaceae, especially plum and pear trees, began to bloom. The great similarity of the color of the loads which was yellow fading to pale green made it very difficult to separate each kind, yet it can be considered that the majority of the pollen loads was collected from boxelder as it grows abundantly in this area. The quantity collected was 344.25 grams.

Wodehouse's (1942) description for the grains was similar to other grains belonging to the maple family, the exine coarsely granular, grains measured 28.5 microns in diameter (Plate II, Fig. 3).

EXPLANATION OF PLATE II

Fig. 1. Pollen grains of *Acer saccharinum* L., magnified 645 times.

Fig. 2. Pollen grains of *Ulmus americana* L., magnified 645 times.

Fig. 3. Pollen grains of *Acer negundo* L., magnified 645 times.

Fig. 4. Pollen grains of *Taraxacum officianalis* Weber., magnified 645 times.

Fig. 5. Pollen grains of *Cercis canadensis* L., magnified 645 times.

Fig. 6. Pollen grains of *Salix* sp. magnified 645 times.

PLATE II

Fig. 1

Fig. 2

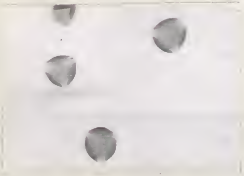

Fig. 3

Fig. 4

Fig. 5

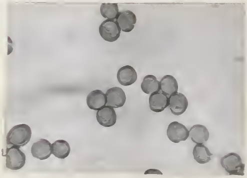

Fig. 6

Cercis canadensis L., Redbud. This plant was a good source of pollen. The plants were commonly found on hillsides and along borders of streams. The quantity of pollen obtained from this plant depends upon its abundance in the area. Although the period of availability of pollen from this plant was short, April 10 to 16, yet the quantity of pollen collected was comparatively good. The total weight of pollen trapped was 186.35 grams. The color of the loads was light brown.

Pollen grains were shperoidal or slightly angular in outline with three germ pores, exine finely granular, diameter of the grains 17.5 to 21 microns (Plate II, Fig. 5).

Salix sp. Willow. Three species of willow are recorded as growing in this region. Salix discolor Muhl., (pussy willow) blooms early in the spring. Pollen was collected from March 26 to April 6, color of the loads was yellow, the quantity collected was small, 17.15 grams due to the small number of plants in this area. The other two species which bloom later are Salix longifolia Muhl., (sand bar willow) and Salix amygdaloides Anders., (peach-leaved willow). Bees worked on these trees from April 17 to 25. The color of the loads of both the species is yellow fading to brown, pollen grains are also similar in shape and sculpturing which made it difficult to determine exactly on what species the bees worked. The total quantity of pollen trapped was 156.72 grams.

Erdtman (1943) described the grains as spheroidal, possessing long tapering furrows without germ pores, exine finely reticulate. Diameter of the pollen grains when examined formed to be 17.5 microns (Plate II, Fig. 6).

Lonicera sp. Honeysuckle. Many species of this genera were distributed in this area especially, Lonicera tartarica L., (tartarian honeysuckle) which is used as an ornamental shrub. Collection of pollen from this plant was from April 19 through May 14. It furnished a good quantity of pollen through the late part of the spring. The total quantity of pollen trapped was 290.78 grams. The color of the loads was yellow orange. Pollen grains were spheroidal or slightly angular in outline with three germ pores, exine thick and spiny, diameter 49-52.5 microns (Plate III, Fig. 1).

Spiraea vanhouttei, Zabel, Spiraea. This plant is abundant in this area as it is used as an ornamental shrub. It also furnished good quantities of pollen through the late part of the spring. Bees began working on this plant on April 24 and continued through May 13. The total quantity of pollen trapped was 219.95 grams. Pollen loads were of yellow green color.

Wodehouse (1942) described the grains of the spiraea as rounded, triangular in outline with three furrows and three germ pores, exine only faintly or not at all striate. Diameter of the grains examined found to be 14 microns (Plate III, Fig. 2).

Robinia pseudoacacia L., Black Locust. This plant is abundant in this area and is considered to be an important source of pollen. Bees work with much activity on the blossoms of this plant in the early morning. Availability of pollen from this plant was for a short time, extending from April 26 to

May 16. The quantity of pollen trapped was 570.98 grams. The color of the loads was yellow.

Pollen grains were spheroidal or slightly angular in outline with three furrows and three germ pores, exine rather thick distinctly granular, diameter 28-31.5 microns (Plate III, Fig. 3).

Gleditsia triacanthos L., Honey Locust. This tree is of great importance as a pollen source in the late part of the spring as it is commonly found in this area. Bees began working on this plant from May 13 to 29. The total quantity of pollen trapped was 767.25 grams. Color of the loads was yellow fading to brown.

Pollen grains were similar to the black locust, spheroidal or slightly angular in outline with three furrows and three germ pores exine rather thick, distinctly granular, diameter 28-35 microns (Plate III, Fig. 4).

The remaining plants were of minor importance in the spring period in this area although it is known that they are of importance as a pollen source in other localities. Their limited economical value from the standpoint of furnishing pollen was due to the fact they are not abundant near the apiary or that their blooming period was short and subjected to unfavorable weather factors which lessened the activity of the bees in pollen collection, or that there were other competitive plants in bloom which attracted the bees for pollen. Among this group were the plants belonging to the family Rosaceae which include a wide variety of plants which bloom nearly at the same time or during successive periods. The blooming of fruit trees overlapped and the similarity of the color of the pollen loads and the morphology of the pollen grains made it very difficult to determine exactly from what species came the majority of the pollen. Fruit trees which were recorded during this period were *Prunus angustifolia* Marsh (wild plum), *Chaenomeles lagenaria* (Japanese quince), *Pyrus* sp. (Hoppa crab), and *Pyrus malus* L. (apple). Other plants recorded in this period which were also of minor importance were *Populus* sp. (cottonwood), *Forsythia* sp., *Aesculus hippocastanum* L. (horse chestnut), and *Eloeagnus angustifolia* L. (Russian olive). Data on quantities of pollen trapped from these plants and periods of pollen collection were recorded in Table 1.

Summer Pollen Sources

The number of the pollen plants in the summer period (Table 1) was less than the spring period. The majority of the pollen collected came from few plants which had a long blooming period. Most of these plants were also the major nectar-producing plants, so the constancy of the bees in working on them was great and no other plants compete with them in attracting the bees. Weather factors also had a great influence on the plants in this period. Hot, dry weather which prevailed during certain periods in the season as well as low soil moisture retarded the growth and the blooming of the plants and, consequently, the quantities of pollen collected decreased as shown in Fig. 2, which represents the daily weights of pollen trapped, the maximum daily temperature and the daily precipitation.

Melilotus officinalis Lam. and M. alba Desf., Yellow and White Sweet Clover. These two plants were widely distributed in this area. They furnished large quantities of pollen as well as being major nectar sources. The separation of these two sources was difficult either through the quantities of pollen collected or the collecting period. This was due to the similarity of color of the pollen loads and morphology of the pollen grains. The collection of pollen from these two sources was from May 20 to June 27. The total quantity of pollen collected was 793.21 grams. Color of the loads was yellow fading to brown. Pollen grains of these two sources were alike. Wodehouse (1942) described the grains as ellipsoidal about 24 x 18 microns, furrows thin, long and tapering, margins rough, membranes flecked with granules in a median strip provided with vaguely defined germ pore through which the germinal papilla usually bulges prominently, exine finely reticulate pitted (Plate III, Fig. 5).

Medicago sativa L., Alfalfa. This plant is widely grown in this area. Bees work on this plant as a major nectar source. Pollen from this plant was obtained through a long period, yet the daily quantities of pollen collected from it was comparatively small. Pollen was collected from June 25 to August 13.

The total quantity of pollen collected was 175.75 grams. Pollen loads were khaki in color.

Wodehouse (1942) described the pollen grains as spheroidal or rounded, triangular in outline not oblately flattened even when full expanded, 30 - 33 microns in diameter, furrows thin long tapering, margins rough, membranes smooth, without a well defined pore but generally with germinal papilla bulging prominently, exine finely pitted, either uniformly over the surface or with the pits joining to form striae (Plate III, Fig. 6).

Zea mays L., Indian Corn. This plant was an important pollen source for the late summer, a large acreage was planted with it in this area. The hot dry weather and the low moisture content of the soil which prevailed during the latter part of June and the beginning of July affected the growth of the tassels of this plant. A heavy rain which occurred on July 16 was followed by a heavy yield of pollen from this plant which occurred on July 18. The quantity of pollen trapped that day was 157.25 grams and 133.25 grams on the following day. Bees collected pollen from this plant from July 4 to August 18. The total quantity of pollen trapped was 1,517.56 grams. Color of the loads was light yellow.

Wodehouse (1942) described the pollen grains as spheroidal, ovoidal or ellipsoidal, 88-114 microns in diameter, exine finely reticulate with one germ pore approximately 10 microns in diameter, its operculum sometimes fragmentary (Plate IV, Fig. 1).

EXPLANATION OF PLATE III

Fig. 1. Pollen grains of *Lonicera tartarica*, magnified 645 times.

Fig. 2. Pollen grains of *Spiraea vanhouttei* Zabel., magnified 645 times.

Fig. 3. Pollen grains of *Robina pseudoacacia* L., magnified 645 times.

Fig. 4. Pollen grains of *Gleditsia triacanthos* L., magnified 645 times.

Fig. 5. Pollen grains of *Meliotis officianalis* Lam. and *M. alba* Desf. magnified 645 times.

Fig. 6. Pollen grains of *Medicago sativa* L., magnified 645 times.

PLATE III

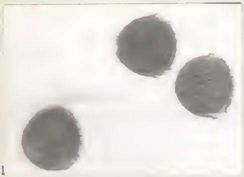

Fig. 1

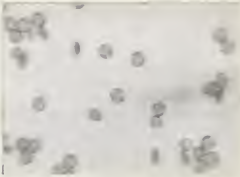

Fig. 2

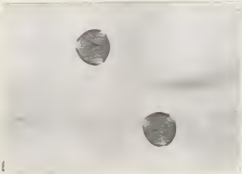

Fig. 3

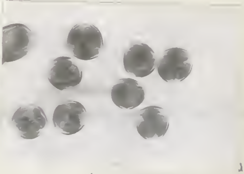

Fig. 4

Fig. 5

Fig. 6

Table 2. Daily weights of pollen trapped, daily maximum temperature and daily precipitation in May, 1954.

Date May	Grams	Maximum Temperature, degrees F.	Precipitation in inches	Remarks
1	0.0	51	0.39	Rain from 2:00 p.m.-3:30 p.m.
2	0.0	51	0.48	Rain from 4:30 a.m.-7:00 a.m.
3	0.0	50	Trace	
4	31.7	60		
5	97.6	70		
6	130.0	71		
7	27.7	66	0.05	
8	14.75	68		
9	8.4	64		
10	30.8	70		
11	66.5	75		
12	109.0	77		
13	101.1	77		
14	76.9	80		
15	150.75	86	0.18	Rain from 10:00 p.m. - 11:30 p.m.
16	70.5	76	0.22	Rain from 4:00 a.m.-7:00 a.m. 9:00 a.m. -12:30 p.m. Bees began flight at 2:00 p.m.
17	50.0	66	Trace	
18	120.0	76	0.16	Rain from 5:00 p.m.-10:30 p.m.
19	45.5	68		
20	60.4	73		
21	71.4	86		
22	103.5	91		
23	87.5	82		Began raining at 11:00 p.m. -2:00 A.m.
24	36.7	68	0.58	11:00a.m.-1:30p.m.
25	36.9	62	0.04	6:30 a.m.-7:00 a.m. 12:30 p.m.-1:30 p.m.
26	82.9	77	Trace	Rain from 4:00 a.m.-6:30 a.m.
27	74.0	84	0.87	
28	49.3	77	1.07	Rain from 2:00 a.m.-4:00 a.m.
29	68.20	74		

Table 2. (Concl.)

Date May	Grams	Maximum Temperature, degrees F.	Precipitation in inches	Remarks
30	33.3	84	0.21	Rain from 6:00 a.m.-8:00 a.m.
31	45.0	82	0.23	Rain from 3:30 p.m.-7:00 p.m.
Total	2348.2			

The other group of plants which bloomed during the summer and were recorded to be of minor importance, Fig. 3, showing the relative importance of the different pollens trapped, and Table 1 representing the quantities and periods of pollen collection, were <u>Rhus glabra</u> L., (sumac), <u>Diospyros virginiana</u> L., (persimmon), <u>Trifolium repens</u> L., (white clover), <u>Persicaria</u> sp. (smartweed), and <u>Portulaca</u> sp.

Autumn Pollen Sources

These plants bloom during the latter part of the summer and extend their bloom into autumn. They are of great importance in furnishing the pollen which will be stored by the bees and then used for the early spring brood rearing. The blooming period and the quantities of pollen furnished by these plants were also influenced by hot dry weather and low moisture content of the soil as shown in Fig. 2.

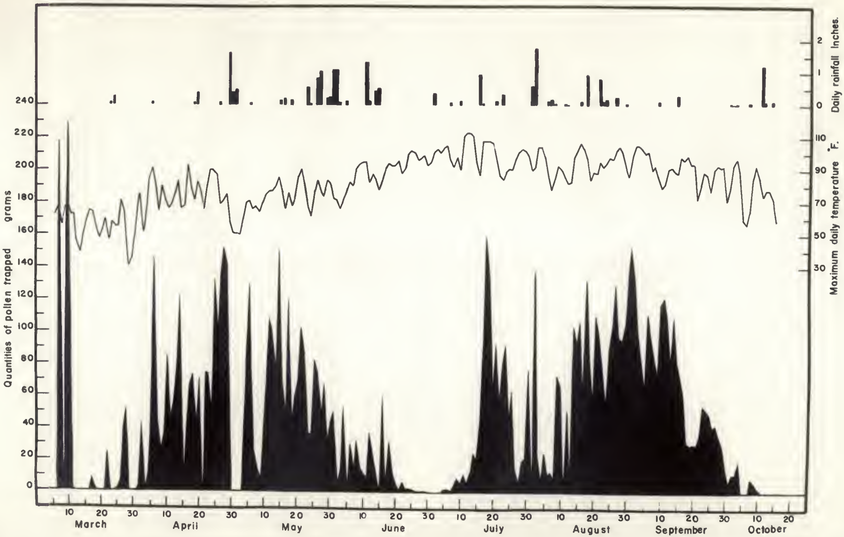

Fig. 2 Total daily grams of pollen trapped. Maximum daily temperature and daily precipitation, March 6 to October 12, 1954.

Polygonum lapathifolium L., and P. pennsylvanicum L., Smartweed. These plants are widely abundant in this area. They grow as weeds in damp places and in poorly cultivated fields. The smartweed is considered to be the most important plant during this period. Bees collected smartweed pollen from August 13 to October 12. The greatest quantity of pollen trapped from this plant in one day was 102.5 grams. The greatest quantity of pollen trapped from any plant was smartweed, which totaled 2,484.82 grams. The great similarity of the color of the loads and the morphology of the grains made it difficult to differentiate between the different species. Color of the loads was light gray. Pollen grains were spherical with numerous pores, exine sculptured by reticulate papillose ridges, diameter 42-49 microns (Plate IV, Fig. 2).

Sorghum vulgare Pers., Sorghum. This plant also is cultivated in this area. Bees began working on it from August 10 to September 8. The total quantity of pollen trapped was 354.45 grams. Pollen loads were yellow in color. Pollen grains were similar in shape to the pollen grains from corn. The only difference which was noticed was the size which was smaller, diameter 45.5 microns (Plate IV, Fig. 3).

Helianthus sp., Sunflower. A great variety of the sunflower plants grows as weeds in this area on the hillsides, along the streams and roads. This source provided the bees with good quantities of pollen from August 23 to October 12. The total quantity of pollen trapped was 698.20 grams. Pollen

EXPLANATION OF PLATE IV

Fig. 1. Pollen grains of Zea mays L., magnified 430 times.

Fig. 2. Pollen grains of Polygonum sp. magnified 645 times.

Fig. 3. Pollen grains of Sorghum vulgaris Pers., magnified 430 times.

Fig. 4. Pollen grains of Helianthis sp. magnified 645 times.

PLATE IV

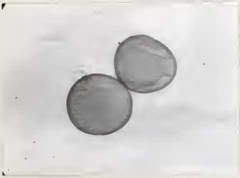

Fig. 1

Fig. 2

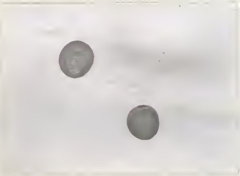

Fig. 3

Fig. 4

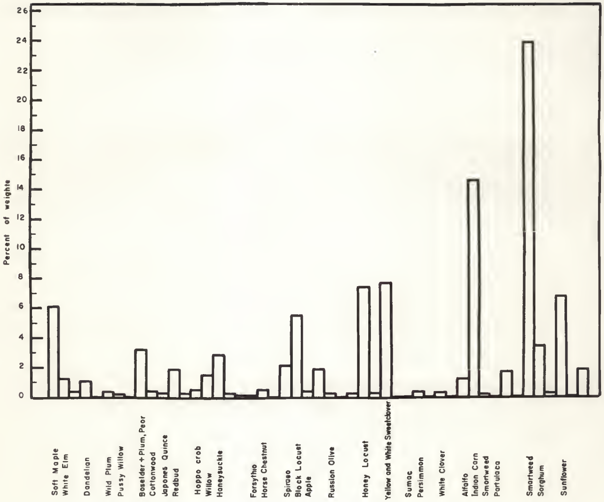

Fig. 3 Relative importance in percentage of different pollens trapped.

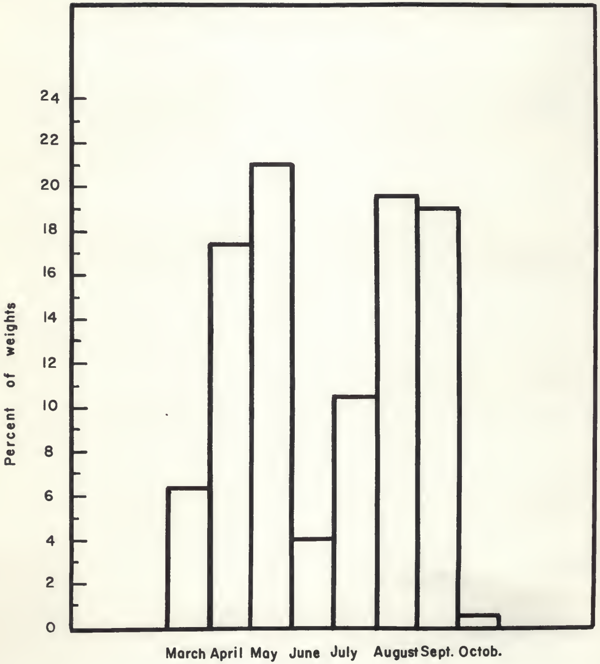

Fig.4 Percentage of total pollen trapped in the different months.

loads were orange in color. Wodehouse (1942) described the pollen grains as spheroidal with three furrows and three germ pores, exine provided with sharp pointed spines apart at their tips. The grains examined were found to be 21-24.5 microns in diameter (Plate IV, Fig. 4).

Other sources of pollen which came in different periods in the growing season, their relative importance, quantities of pollen trapped and periods in which pollen was collected were recorded in Table 1 and Figs. 2 and 3.

DISCUSSION

The results obtained in this work show that the activity of the bees in pollen collection began early in the spring as soon as the soft maple and the elm began their bloom. Trapping pollen began on March 6 and ended on October 12, 1954. The total quantity of pollen trapped from one over wintered colony through the active season was 10,508.84 grams in pollen loads and 536.24 grams in pollen dust or a total of 11,045.08 grams. Forty-nine plants were found to furnish this quantity of pollen and out of these, thirty were identified. The greatest quantities of pollen collected were during April, May, August and September which were the spring and autumn months as represented in Table 3 which shows the weights of pollen trapped during the different months and Fig. 4, representing the percentage of the total pollen trapped in these months. This

Table 3. Weights of pollen trapped during the different months.

Month 1954	Grams of pollen
March	728.80
April	1933.20
May	2348.20
June	465.27
July	1174.35
August	2190.94
September	2133.95
October	70.37
Total	11,045.08

condition was an advantage because bees during these months were in need of pollen to furnish the protein food for brood and young nurse bees.

In the spring incoming pollen is important as a stimulus which causes increased brood rearing activity and building the large colony population to be ready for the first major nectar-flow which will begin during late spring and for other nectar-flows during the summer. Pollen is of vital importance during the autumn months. During this period the new population, which will carry the colonies through the winter period is being reared and there must be enough pollen for feed to produce the large population on which successful wintering depends. There also must be enough pollen to be stored for the early spring feed of brood as brood rearing usually begins early before plants bloom. The following period in which plants begin their bloom is a critical period as it is usually subjected to unfavorable weather and may interfere with the flight activity and pollen collection; therefore, the quantity of pollen stored must be large enough to maintain brood rearing and to keep the larvae from starving. During the summer period although pollen must be enough for larval food yet its importance is less if it is compared to the spring and autumn activities of a colony.

Major Pollen Sources of the Active Season

Pollen collection was influenced by two important factors, weather and the abundance of plants in bloom in a certain period as shown in Figs. 1 and 2. The greatest quantity of pollen collected in a day through the whole season occurred on March 10, 1954, and was 229.1 grams. The trees in bloom during that time were soft maple and elms. They yielded good quantities of pollen during their blooming period, yet the unfavorable weather which prevailed restricted the flight activity of the bees in pollen collection. During the early spring the pollen sources were forest and shade trees followed by the bloom of shrubs and ornamental trees. The major pollen sources in the early spring were soft maple, elms, dandelion, boxelder, and redbud. Willow, spiraea, honeysuckle, honey and black locust were the main pollen sources of the late spring. When approaching the end of the bloom of a major source, the bees began searching for new sources resulting in an increase in the number of pollen sources and more persistent work devoted to the plant yielding pollen abundantly.

During the summer period pollen collection was mostly from forage plants. Yellow and white sweet clover, alfalfa and corn were the major pollen sources during this period. The yield of pollen from these plants was greatly influenced by weather factors and soil moisture content. The hot weather and the drought retarded plant growth and bloom and resulted in a decrease in pollen collection as will be discussed later.

Autumn plants were mostly weeds which grow along borders of the streams, roads and in uncultivated fields. Their growth and yield of pollen were influenced also by weather factors and soil moisture content. Major pollen sources during this period were smartweed and sunflower. Sorghum also yielded a good quantity of pollen during this period.

Table 1 and Fig. 3 summarize the relative importance of the different pollen and Fig. 3 presents the various sources chronologically. Smartweed is shown to have been the major source (23.64%), followed in descending order of importance by corn (14.44%), yellow and white sweet clover (7.54%), honey locust (7.3%), sunflower (6.64%), and soft maple (6.1%).

Weather Factors

Weather factors had considerable influence both on plant growth and the activity of the bees. During the early spring, flight activity of the bees and pollen collection was limited to warm sunny days, Fig. 2, as shown by a sharp rise in the temperature was followed by a sharp rise in pollen collection. The maximum daily temperature on March 7, 1954, was 69° F. The amount of pollen collected in that day was 217.0 grams. On March 8, unfavorable weather prevailed and the maximum daily temperature was 56° F. which was favorable for good flight. The quantity of pollen trapped was 128.7 grams. On March 10, the maximum daily temperature was 70° F. and the quantity of pollen trapped was 229.1 grams. These results show clearly the important part played by the weather which was expressed here by the maximum daily temperature and its influence on the flight activity of the bees and on pollen collection. If a period of bad weather is prolonged and covers the flowering period of a plant, it will depress flowering as well as bee activity and will result in the collection of little or no pollen from the plants blooming in that period.

Rainfall occurring during daylight hours hindered the bee flight and resulted in a decrease in pollen collection. In relation to plants it was beneficial and resulted in the continuance of growth and bloom. Forest and shade trees were in less need of rainfall for their bloom as they were able to reserve moisture enough in their tissues and to absorb enough moisture from the subsoil to continue growth and bloom. The most important factor influencing these plants to induce flowering was the temperature which forces them out of the dormant condition and this causes the difference in blooming dates from year to year.

During the latter part of the spring the temperature was usually more favorable for bee flight although a cold rain period prevailed during the last day of April and extended through the first three days of May as shown in Table 2, representing the daily weights of pollen trapped, daily maximum temperature and daily precipitation of that month. This unfavorable weather resulted in no pollen collection for these days. Rainfall was an important factor in this period for plant growth and bloom as its influence will extend to the summer pollen sources which will need adequate soil moisture content for growth and bloom.

During the summer period, the rainfall which occurred during the latter part of May and the early part of June gave the plants the first good stimulus for growth. The hot weather and the drought which occurred during the latter part of June affected plant growth and bloom severely and resulted in a period of deficiency in pollen yield. This unfavorable condition ended when about an inch of rain occurred on July 16 and was followed by a good yield of pollen, Fig. 2. On July 18, the pollen trapped weighed 158.5 grams and was followed by 133.25 grams the next day.

For the autumn period, the rainy days which occurred during August were of much influence on the growth and bloom of the pollen sources of that period and resulted in a good yield of pollen. This favorable period ended with the drought which occurred during September and caused the decline in pollen collection.

SUMMARY

Trapping pollen for studying the important pollen sources in the Manhattan, Kansas, area began on March 6, 1954, and ended on October 12, 1954. The total quantity of pollen trapped through the whole season was 11,045.08 grams. The daily amounts of pollen collected by the pollen trap were weighed and then sorted according to colors. The pollen grains were examined microscopically for identification. Forty-nine plants were found to be used as pollen sources by the bees through the active season. Thirty of these sources were identified.

For the early spring period, the major pollen plants were shade trees which were soft maple, elms, boxelder and redbud. During the late spring, the major pollen plants were willows, honeysuckle, spiraea, black locust and honey locust. Dandelion furnished pollen through the two periods. During the summer period, the major pollen plants were pasture and field crop plants, yellow and white sweet clover, alfalfa, and corn. During the autumn, plants which grow as weeds were the major pollen sources. They were smartweed and sunflower. Sorghum which was grown in this area yielded good quantities of pollen.

The greatest amounts of pollen collected were during April, May, August, and September which were the spring and autumn

months. Pollen collection during the spring months was of importance for increasing the colony population in anticipation of the nectarflow. During the autumn months pollen was also of importance for building the new population which will carry the colonies through the winter. Considering the season as a whole, the sources ranked as follows in descending order of magnitude: smartweed, corn, yellow and white sweet clover, honey locust, sunflower and soft maple.

Weather factors had a great influence both on bee activity and plant growth and bloom. Flight activity and pollen collection depend upon warm sunny days. Rainy days hindered the flight and, consequently, pollen collection. During the early spring good quantities of pollen were collected on warm sunny days. The relation between pollen collection and temperature was due to the increase in flowering as well as the greater activity of the bees, both being caused by a rise in the temperature. Dry hot weather and low soil moisture content affected the plant growth and bloom during late June and the early part of July and caused a decrease in pollen yield. The rainfall which occurred after that time was followed by a good yield of pollen. A similar case happened during September in which there was in increased yield followed by a decline in pollen collection.

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MAJOR POLLEN SOURCES IN THE MANHATTAN, KANSAS AREA
AND THE INFLUENCE OF WEATHER FACTORS UPON
POLLEN COLLECTION BY HONEYBEES IN 1954

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ABSTRACT

The study of pollen grains in relation to the field of apiculture has interested many research workers because pollen is the source of protein food of the larvae and young nurse bees. Identification of pollen grains found in honey in some cases has helped to determine the sources of nectar gathered by the bees. The study of the pollen sources in a region is of importance to bee-keeping management as it helps to determine whether the locality is a good or poor beekeeping district. Some of the plants which grow in a region may be more attractive to the bees while others, although they also can be considered as a good source, are less valuable because either they furnish small quantities of pollen or they blossom when other plants, more attractive to the bees, are in bloom, or their blooming period is subjected to unfavorable weather factors which decrease their value.

This study was undertaken to find the important pollen sources in the Manhattan, Kansas area, including the relative importance of these different sources, periods of availability, deficiency and abundance of pollen during the different months as they are of great importance for proper beekeeping management. Weather factors were also studied as they have a considerable influence upon plant growth, bloom, yield of pollen and the activity of the bees in pollen collection and the quantities of pollen gathered.

Trapping pollen from an over wintered colony began on March 6, 1954, and ended on October 12, 1954. A pollen trap was inserted between the bottom board and the brood chamber. The bees when entering the hive, pass through this trap by a means of a corridor leading through a piece of 5 meshes to the inch hardware cloth which serves as a scrape for removing the pollen loads from the hind legs of the bees. The loads drop through another piece of hardware cloth to the pollen trap tray. The daily quantities of pollen trapped were weighed and a proportion of the total weight was taken as a sample and sorted according to the different colors. The homogenous colored loads were weighed and multiplied by the proportion taken. A representative sample of each type of pollen was mounted on slides and examined microscopically for identification. Identification of the pollen grains was determined either by comparison with other microscopical preparations of pollen grains taken from flowers of identified plants or from pollen loads from bees working on definitely known species of plants. Drawings and descriptions noted in the published information on pollen grains of the plants distributed in this area helped also in identification of some of the pollen sources.

Forty-nine plants were found to be used by the bees for pollen collection through the active season from March 6 to October 12, 1954. Out of this number thirty plants were identified. The total quantity of pollen trapped through the whole season was 11,045.08 grams. For the early spring period, the major pollen plants were shade trees which were the soft maple, elms, boxelder, and redbud. During the later part of the spring the major pollen sources were shade trees and ornamental shrubs which were the willow, honeysuckle, spiraea, black locust and honey locust. Dandelion furnished pollen through the entire spring. For the summer period the major pollen plants were pasture and field crop plants. They were yellow and white sweet clover, alfalfa and corn. During the autumn, plants which grow as weeds were the major pollen plants. They were smartweed and sunflower. Sorghum which was also cultivated in this area yielded good quantities of pollen.

The greatest quantities of pollen collected during April, May, August, and September which were the spring and autumn months. Pollen collection during the spring months was of great importance for increasing the colony population for the nectarflow. During the autumn months pollen was also of importance for building the new population which carries the colonies through the winter. Considering the season as a whole, the sources ranked as follows in descending order of magnitude: smartweed, corn, yellow and white sweet clover, honey locust, sunflowers, and soft maple.

Weather factors have considerable influence both on the activity of the bees and plant growth and bloom. Flight activity and pollen collection depend upon warm sunny days. Rainy days stop the flight and, consequently, pollen collection. During the early spring good quantities of pollen were collected on warm sunny days. The relation between pollen collection and temperature was due to the increase in flowering as well as the greater activity of the bees, both being caused by a rise in the temperature. Dry hot weather and low soil moisture content affected the plant growth and bloom during the late part of June and the early part of July and caused a decrease in pollen collection. A good yield of pollen followed rainfall which occurred after the hot dry period of July. A hot dry period occurred also during September and caused a decline in pollen collection.

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