A STUDY OF THE DEVELOPMENT AND PERFORMANCE OF PACKAGE BEES IN MANITOBA

A Thesis

Presented to

The Department of Entomology

Faculty of Agriculture and Home Economics

The University of Manitoba

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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April, 1970

ABSTRACT

An analysis of package bee colonies was done in order to determine the growth patterns of the colony and how certain variable factors can influence the colony's growth pattern.

In this study two approaches were used: (1) An analysis of commercial honey bee colonies for populations of adults and brood along with trials on a large scale to test the effects of package size and time of hiving of the packages on the honey production of a colony, (2) the use of forty-eight colonies of bees to investigate, over a three year period, the changes in brood areas, adult numbers, flight activity and hive weights. The forty-eight colonies consisted of two and three pound packages established on three dates at twelve day intervals during April and early May. This arrangement allowed for the testing of the effect of package size and date of package hiving by comparing periodically brood and adult numbers as well as flight activity.

The commercial colony studies attained populations of 20 to 25 thousand adult bees at the beginning of the July honey flow. Neither two or three pound packages nor a three week difference in hiving date significantly affected honey production on a three year average.

The six groups consisting of two package sizes hived

on three different dates showed that the effects of package size and hiving date varied from year to year; the three pound packages supported larger brood areas at least up to 43 days after hiving and the two pound packages used adult bees more efficiently during the rearing of the first brood. Hiving date had a greater effect than did package size on the production of adult bees. This date effect varied yearly; the tendency of the later hived packages to reach equal adult and brood population levels appeared to be governed by springtime food or forage supplies and air temperature levels. The growth and performance of the colonies are analysed in this thesis.

ACKNOWLEDGEMENTS

I wish to express my appreciation to Dr. S. C. Jay (Associate Professor, Department of Entomology, University of Manitoba) for his generous encouragement and guidance during the course of this investigation. My appreciation is also extended to Dr. A. J. Thorsteinson (Professor and Head, Department of Entomology, University of Manitoba) and Dr. A. J. W. Catchpole (Associate Professor, Department of Geography, University of Manitoba) for their helpful criticisms of the text. I am also indebted to the dedicated assistance of student technicians who assisted in the project and in particular to Mr. Don Nelson for his assistance in developing certain techniques used in the study.

This investigation was made possible by funds supplied by the National Research Council of Canada.

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CHAPTER I

INTRODUCTION

The commercial beekeeping industry in the Prairie Provinces of Canada is based on the initiation of colonies with packages of bees (Apis mellifera L.) imported from the Southern and South Western United States each spring. The success or failure of a beekeeping operation is dependent on the ability of the beekeeper to manage the bees from the packages so that full strength colonies are obtained for harvesting nectar during the honey flow.

Genetic and environmental factors influence the development of the colony after the bees in the package are installed. Most of these factors are discussed under the Literature Review (see Chapter II).

Of the variable factors influencing honeybee colony development, the beekeeper can control (1) the size of the packages, i.e. number of bees initiating the colony, and (2) the dates when the packages of bees are installed, i.e. the time period allowed for population growth before the honey flow commences. Some studies have been done in the United States to determine the most efficient size of package and hiving date to use. However few data which apply to Western Canadian conditions are available.

The present study was designed to investigate certain parameters which could be used to determine the developmental efficiency of the honey bee colony. These parameters were then used to measure the performance of colonies which were initiated at different dates by different numbers of bees, i.e. package size. Forty-eight colonies were studied for each of three years; three dates of hiving, and three package sizes were used. During the three year period, the parameters for examining hive development were expanded. Data were pooled for the hives in each of the six combinations in order to obtain average parameter values.

Complementing this central study of honey bee colony development in Manitoba were (1) an updating of the Manitoba honey flow records from scale colonies kept by selected "beekeepers"; (2) a three year population survey of "normal" commercial colonies in the province and (3) a large scale commercial honey production study covering three years, which investigated the effect of package size and time-of-hiving on honey production.

CHAPTER II

LITERATURE REVIEW

The review of literature covers:

A. The general development and performance of honey bee colonies;

B. The development and performance of package bee colonies;

C. Specific variable factors and their effect on a developing honey bee colony.

A. The General Development and Performance of Honey Bee Colonies.

Bodenheimer (1937 a:b), Bodenheimer and Ben Nerya (1937) studied the seasonal changes in populations and the activities of honey bee colonies. These studies included foraging populations of bees of different ages, as well as rate of growth of the colonies in the active season. Bodenheimer and Ben Nerya (1937) outlined an empirical method of calculating the population age structure of a colony from measurements of sealed brood quantities at various intervals throughout the season.

Farrar (1931) outlined a relationship between adult worker bees and brood production. A colony of ten thousand worker bees was considered to be the most efficient at produc-

ing sealed brood; at a population of forty thousand adult worker bees a maximum quantity of sealed brood was produced. The relationship of declining brood rearing efficiency as the adult population of the colony increased has been shown to be generally true for the Hymenopterous social insects (Michener, 1964).

The increasing efficiency of honey production per bee as the colony population increases has been calculated by Farrar (1937). Increasing population levels theoretically allow each worker to spend a greater proportion of her life in foraging and less in brood production duties. Moeller (1961) in an area of diversified forage, obtained a similar but less conclusive effect.

Free (1968) considered that a colony which is actively producing increased amounts of brood and hence increasing its adult population will forage more aggressively than a colony at or near a static brood or population level.

Jeffree (1955) studied the changes in colony populations throughout the season. The effect of Nosema disease on population levels and the effect of colony population on honey production were also measured. His analyses were done on the basis of individual colonies.

Nolan (1925a, 1925b) measured the sealed brood production of sixteen colonies for one season and showed a correlation between the changes in quantities of sealed brood

and various factors of the environment, including queen performance. He (Nolan, 1925b) considered that maximum bee populations of honey producing colonies should be produced to coincide with the main honey flow.

B. The Development and Performance of Package Bee Colonies.

The beekeeping industry of the North Central United States and Western Canada is dependent on package bees for establishing colonies each spring. While general principles of colony development apply to these colonies, little specific research is available on the establishment and development of a colony initiated from package bees.

Braun (1936) showed in experiments conducted over an eleven year period with 164 colonies, that early hived colonies (April 25 - May 5) produced more honey than the late hived colonies (May 10 - June 8).

Kelty (1948) in Michigan tested the effect of package size on honey production over a three year period. The system varied over the three experimental years and in some cases two variables were tested (i.e. system of queen release and time of hiving). Moving the colonies to summer forage and the arrangement of colonies in rows, probably caused some redistribution (i.e. drifting) of population between hives. The two and three pound packages gave the most consistent results, but in general there was no relationship between package size

and the resulting honey crop. The differences in honey production of colonies initiated from packages of different sizes were found to be non-significant by L'Arrivee and Geiger (1966).

L'Arrivee and Geiger (1966) studied the effect of one, one and one half, two, three and four pound packages on brood and honey production. The one pound packages were significantly lower in honey production than the other sizes. The three and four pound package colonies produced large quantities of brood in June and early July; honey production was high early in the season, but it declined in late July and August.

The effect of early spring weather in depressing the spring level of brood production was demonstrated by Geiger (1967). The growth rate of both the two and three pound packages increased with the later hiving date; the 12 May hiving date showed the greatest early growth rate and the 14 April date showed the slowest early growth rate, at Brandon, Manitoba.

The lower brood production of early hived packages (April 10-12) resulted from a lower egg laying rate of the queen when compared to late hived packages (May 5-13), (Pankiw, 1968).

Merrill (1924a) calculated, every twenty-two days throughout one season, the brood and adult bees produced by

four colonies from three pound packages. Maximum average population of 24,800 worker bees was recorded on September 15th. Compared to various other studies these results seem atypical.

Mitchener (1931) observed that a higher honey production occurred over a five year period from packages hived before first May, compared to packages hived after first May. The difference varied yearly, but averaged 35.8 pounds over five years.

Package size and spring hiving times were investigated by Nolan (1932). One each of one, two, three, four and five pound packages were hived at ten week intervals in Maryland, U.S.A. The smaller packages (one and two pounds) developed more efficiently, while the larger packages (three, four and five pounds) attained a high absolute population more quickly. He recommended that the installation of package bees be done eight to nine weeks before the main nectar flow.

Many of the studies of package bees relate the size of package used to initiate the colony and the eventual honey produced by the colony. Unless this type of study is done on a long term basis, with large numbers of colonies, the results are probably not meaningful due to the effect of several variable factors (Chapter III - Section C). More information on the growth rates of colonies and the relationship between population and honey production as investigated by Farrar (1931,

1937) are required.

Most data obtained to date suggest that good colony performance results from colonies initiated with two pound packages. The installation of packages between mid-April and May 7th appears to provide satisfactory results. In most years little gain in honey production appears to result from early hivings.

C. Specific Variable Factors and Their Effects on a Developing Honey Bee Colony.

Many factors affect the development and performance of package bee colonies during the spring and summer seasons.

Factors, both within the colony, as well as outside of it, set limits on the rate of growth and the ultimate numerical size it will attain, which in turn affects its honey production or pollination capabilities. These factors may be listed as follows:

1. Factors Within the Colony
   - Queen performance
   - Brood Survival
   - Number of bees present
   - Diseases
   - Spatial restrictions
   - Stores or food
   - Length of life of the worker bee.

2. Factors Outside the Colony
   - Forage availability
   - Weather conditions
   - Drifting
   - Predators

1. Factors Within the Colony.

The queen's performance is considered to be the major cause of variation in colony performance (Kelty, 1948; L'Arrive and Geiger, 1966; Nolan, 1925 a,b, 1932; Simpson, 1969). The egg laying capacity of the queen limits the absolute adult population of a colony (Moeller, 1961). Viability of the eggs produced (Cale, 1952; Roberts and Mackensen, 1951) as well as the production of queen substance (Butler, 1959) are important in queen effectiveness. Different pure varieties or hybrids of pure varieties may perform differently (Moeller, 1961; Adam, 1968). Correlations between high egg laying rate and pollen foraging ability of the progeny have been shown (Cale, 1967) and honey production of a colony (Soller and Bar-Cohen, 1967).

Merrill (1925a) believed that the colony determined the queen's performance; however, Ribbands (1953) notes that this conclusion was not justified as only four experimental colonies were used.

Brood survival is affected by many variable factors (e.g. eggs may be eaten by the workers) (Nolan, 1925; Brian, 1965). Merrill (1924b) found considerable variation in the percentage of eggs which reached the sealed brood stage. The quantity and quality of pollen, or a suitable substitute, often determines the quantity of brood reared. This is discussed in a following paragraph.

The number of adult worker bees present influences the rate of colony growth (Farrar, 1931) and the effect of size of package is discussed in Chapter II, Part B.

Nosema disease in package bees and queens is common (Farrar, 1947; Jay 1966). Cantwell and Shimunuki (1969) have a general review on Nosema disease and research. American foul brood and European foul brood can be transmitted by package bees (Pankiw and Corner, 1965; 1966). Gochnauer (1965) has written a general review about these two diseases and their effect on the colony.

Restriction of space for egg laying by the queen, where the brood cells have been used for nectar storage, has been observed by Nolan (1925a). Cell space may be restricted when three and four pound packages are used (L'Arrivee and Geiger, 1966). Farrar (1927) observed a tendency for smaller package colonies to initially place nectar in the brood nest thus restricting egg laying by the queen. Simpson (1969) concluded that an average hive required three, ten comb Langstroth boxes to accommodate its maximum adult population, and one brood chamber to allow for maximum brood rearing. Spatial restriction may encourage swarming due to congestion (Simpson and Riedel, 1963); however, diminishing brood areas may also cause adults to crowd together and create an artificial congestion (Simpson, 1966).

Brood rearing in the early spring requires supplies

of nectar and pollen, usually stored in the previous year (Farrar, 1968). The necessity of pollen for brood survival has been demonstrated by Farrar (1934); Allen and Jeffree (1956); Moeller (1967); and Cale (1967). Spencer-Booth (1960) reviewed the protein substitutes and supplements available for artificially promoting brood production.

During the active season worker bees, which forage early and late in life, live for an average of 30.4 and 37.1 days respectively (Ribbands, 1953).

2. Factors Outside the Colony.

Suitable sources of pollen and nectar are necessary for the self provisioning of a honey bee colony and for the storage of a honey surplus. These sources must be within flying distance of a colony and weather conditions must, therefore, be considered (Sturtevant and Farrar, 1935; Ribbands, 1953).

Free (1968), discussed the stimulating effect of foraging on brood production and the stimulating effect of brood production on foraging activity. Certain increases in sealed brood production are attributed to nectar or pollen being taken into the colony (Nolan, 1925a). However, Merrill, 1924a, 1924b), suggested that the production of sealed brood is negatively correlated with the nectar foraging activity of the colony, and that a lack of nectar flow or inclement weather would allow the bees to concentrate on brood rearing.

Brood rearing stimulation was noted when concentrated syrup was fed to colonies (Ribbands, 1950), or when dilute syrup was fed to colonies located far from water (Crane, 1950). Butler (1946), found no such effect and Free and Spencer-Booth (1961) found stimulation in brood rearing occurred in one of two experimental years by feeding either dilute or concentrated syrup. He concluded that weather factors controlling food input into the colony could be important.

Cool spring temperatures are said to restrict brood rearing (Pankiw, 1968; Geiger, 1967). Cold periods may cause a decrease in honey production (Nolan, 1925a). Merrill (1924a) considered that a drop in temperature after the winter cluster had broken would provide the stimulus to begin brood rearing.

Weather conditions may prevent bees from foraging, even when pollen and nectar sources are available. Nectar secretion by plants is also determined by weather conditions (Moffat and Parker, 1953). Temperatures of 80 to 100 degrees Fahrenheit appear to favour foraging during the nectar flow (Moffat and Parker, 1953).

Drifting, or movement of bees from one colony to another, results in a redistribution of the populations. This inhibits the development of some colonies and results in inefficient brood rearing and swarming problems in others which have gained in bees. Drifting may occur in spring at hiving

time (Kelty, 1948), and during the active season (Ribbands, 1953; Free, 1958) due to environmental factors (Jay, 1965).

Each of the variable factors mentioned above must be carefully considered when one studies the performance of various populations of honey bees. When two or more groups of hives are compared, changes in the effect of any one variable factor on the different groups must be noted.

CHAPTER III

GENERAL METHOD

The investigations were divided into two sections as follows:

A. Extensive Studies of Commercial Honey Bee Colonies in Manitoba, and

B. Intensive Studies on Honey Bee Colonies at the University of Manitoba.

A. Extensive Studies of Commercial Honey Bee Colonies in Manitoba.

1. Population Survey of Commercial Honey Bee Colonies in Manitoba.

A survey was done to determine the populations of immature and adult bees within commercial honey bee colonies at three specific dates during the 1966, 1967 and 1968 seasons. The population levels within commercial colonies in the Manitoba area were not hitherto accurately known.

Twelve Manitoba commercial beekeepers in 1968, and ten in each of 1968 and 1969 provided colonies for the survey. These colonies were located within a one hundred mile radius of Winnipeg, the majority being in mixed farming areas. Each beekeeper hived eight colonies from two pount packages in a way which prevented bees from drifting between colonies.

The shipper who supplied the packages and the date on which packages were hived were recorded but not regulated.

Colony development was determined by killing one colony in each apiary with cyanide gas (HCN), collecting the dead bees, and tracing on plastic sheets the outline of the various brood stages present (See Fig. I). Brood areas were measured by placing the plastic sheets on a grid ruled in one inch squares.

Adult bee populations were determined by hand counting if the numbers were approximately 10,000 or less. When hive populations were larger, the numbers were determined by counting out three sample lots of 500 bees, weighing them, and using the mean of the three samples to convert the weight of the total hive population into numbers of adult bees.

Three hives were used each year in each apiary, on the following dates; nineteen days after hiving, (i.e. before the first generation of adults emerged); during the last week of June, and during the last week of August.

2. Commercial Honey Production Studies.

During 1967, 1968 and 1969, ten apiaries of experimental colonies were managed by local commercial beekeepers. The packages were hived in these apiaries by personnel from the University of Manitoba, but were managed completely thereafter by the beekeeper. Before hiving, all packages were corrected for weight as described under Section B. In

1967, three sets of eight, two pound packages and eight, three pound packages were hived. Sets were hived on April 15th, on April 25th, and on May 8th. During 1968 and 1969, two sets of ten, two pound packages, and ten, three pound packages were hived; the first being on April 18th, and the second on May 9th.

The beekeepers managed the colonies in the normal way for his operation, noted queen loss and swarming, and in the fall weighed the honey produced from each group. This data was forwarded to the University of Manitoba.

3. An Analysis of Nectar Flow Records in Manitoba.

The productivity of a honey producing colony is dependent on the utilization of the midsummer nectar flow; a period when important nectar source flowers secrete nectar profusely. Determining the dates of the nectar flow should provide an indication of the time of the season at which colonies should have high adult populations.

The nectar flow period was determined by using existing records. The method of analysis was patterned after Mitchener (1947; 1955). Daily gains or losses in weights of colonies on scales were recorded by several* beekeepers throughout the southern part of Manitoba. The average gain for a five day period was calculated. Mitchener's records extended from May 1st to September 30th. The present analysis

* varied from 9-23 in years 1955-69.

includes the period from mid June to the beginning of September.

B. Intensive Studies of Honey Bee Colonies at the University of Manitoba (1967-1969).

1. Design and Treatment of the Experimental Colonies.

The purpose of this study was to select and utilize various parameters to determine the development and performance of honey bee colonies. These parameters related to brood production, adult populations, and entrance flight activity.

On three dates, beginning in mid-April and approximately twelve days apart, one group of eight, two pound and one group of eight, three pound packages were established. For any one year (1967, 1968 or 1969), the experimental design consisted of forty-eight colonies in six groups. The first hived packages were designated Date I - two pound or three pound. The second and third hiving dates were designated Date II and Date III respectively. This system is used for the 1967, 1968 and 1969 data.

Packages ofa yellow strain of commercial stock honeybees, were obtained from the same California shipper in each of the three years. The packages were corrected for weight by removing the feeder cans and removing or adding bees to give an accuracy of plus or minus two ounces of bees in each

package.

The packages were hived in brood chambers provided with similar amounts of honey and pollen stores. The hives of a group were set in a horseshoe arrangement with the entrances of individual hives offset in order to minimize drifting (Jay, 1969). In 1968, honey, and in 1969, sugar syrup, had to be provided to the I and II groups in addition to the initial stores. Pollen shortages in 1969 necessitated the use of pollen substitute (See Farrar, 1968) in all of the colonies.

Second brood chambers and honey supers were added as required. In all years the queens were allowed access to both brood chambers and all of the supers. In 1969 entrance traps were fitted to each of the colonies in mid-July. In 1967 and 1969, honey was removed from the colonies at the end of July: at the end of August, and again when the colonies were killed in early September. In 1968 honey was removed only when the colonies were killed.

Management of the colonies was done by a commercial beekeeper in 1967. This management was of an extensive commercial type. In 1968 and 1969, the management of the apiary was done by the author, assisted by laboratory technicians. The treatment during 1968 and 1969 was probably of a more intensive nature than is usual in commercial colony management in the area.

The 1967 measurements of sealed brood were done on only two colonies in each of the six groups. In 1968 all stages of brood, (eggs, larvae and sealed brood) were measured on the forty-eight experimental colonies, and in 1969 sealed and unsealed worker and drone brood were both measured.

For the 1967 and 1969 seasons brood measurement commenced at nineteen days after hiving and continued on a twelve day cycle (plus or minus one day) until mid-August. The twelve day cycle allowed sealed brood measured on one reading date to hatch and thus provide a record of all sealed brood produced by a colony. In 1968 all brood measurements began simultaneously at the end of May, after the colonies were known to have a normal queen; otherwise the measurements were done as in 1967 and 1969.

During the 1969 season, queen replacement was done up to one week after hiving, and queens which were lost or showed poor performance were replaced during this period.

Data from hives developing problems during the season (e.g. swarming, queen loss) were excluded from the tests only after the problems had arisen. Where a problem occurred from the outset the data from that hive have not been included.

2. Analysis of Methods Used to Measure Adults and Brood

(a) Literature Review.

In measuring the development of a colony, experimenters have had to consider labour requirements, measurement accuracy, and colony disturbance or damage.

Actual counts of eggs (Berlepsch, 1860), egg, larvae, and pupae (Baldridge, 1861); (Dufour, 1901); are useful for small scale studies; the problem of killing brood in cool weather is inherent in these studies.

Brunnich (1922) used the length and depth of the elliptical brood area and the formula (height times breadth times 1.6) to calculate the brood area on the two comb sides. The reliability of this method depends on a compact brood nest. Ebert (1922) appears to have used a similar mathematical method and Bodenheimer and Ben Nerya (1937) measured the total brood areas in the hive with this method.

Photographic reproductions of sealed brood areas were used by Nolan (1925, 1932) and Pankiw (1968), and apparently by Free and Racey (1968).

A calibrated wire grid placed over the combs for a visual count was used by Moeller (1961); Geiger (personal communication); Pankiw (1968) and Jeffree (1958). In this method one operator is required to do all measurements in order to avoid variations in estimation of combs of spotty brood.

Adult population measurements have generally been

made by weighing the bees in a hive and converting the weight to a number of counting a representative weighed sample (Farrar, 1937; Moeller, 1961; Jeffree, 1955).

Jeffree (1951) developed a system of comparing frames of actual bees to a graduated set of calibrated photographs.

Geiger, (1967) and Farrar (1952) killed representative colonies to obtain adult population data.

Bodenheimer and Ben Nerya (1937) calculated the population of a honey bee colony by using measured sealed brood quantities.

Simpson (1969) measured the adult population in a colony by recording the number of frames occupied by the bees and determing the average density of bees to be 1095 per standard frame.

(b) Methods Used in the University of Manitoba Studies (1967-1969)

(i) Brood Measurement

In 1967, as only two hives in each group were measured, the same apparatus as used in the survey work was used (See Figure 1 and Section 1 of this chapter).

The methods used in 1968 and 1969 were planned (1) to provide accurate, comparable measurements when used by different operators, (2) to prevent brood chilling in spring and (3) to prevent robbing of colonies of bees.

In 1968, all three brood stages (i.e. eggs, larvae and pupae) were measured. As eggs and larvae were often in-

termixed, there was difficulty in accurately delineating the areas of each stage, and in 1969, the areas of eggs and larvae were measured together as unsealed brood. Calculations of the 1968 data combined the egg and larvae measurements into unsealed areas.

Drone brood areas were included in the 1968 brood measurement (i.e. drone eggs were measured with worker eggs, drone larvae with worker larvae, and drone pupae with worker pupae). In 1969, the drone brood was measured separately in order to provide data on drone production in each group. For both 1968 and 1969 total brood measurements included all brood present in the colony at the measurement time; in 1969 sealed brood is only worker area, while that of 1968 includes sealed drone brood.

The queen cells present at the time of each brood measurement were recorded in 1969 only.

Preliminary studies were done in 1967 when sealed brood areas were measured in two colonies in each of the six groups by using the apparatus shown in Figure I; in 1969 sealed and unsealed brood areas were measured on the forty-eight colonies. The apparatus used in 1968 and 1969 is shown in Figure II. Brood areas were traced on glass sheets upon each of which was drawn a grid of one inch squares. The person who drew the pattern on the glass was called the "tracer". The traced areas were counted, recorded and removed by a sec-

ond person called the "reader". The operation was usually done by two "tracers", assisted by two "readers", and during mid-season another assistant removed brood from the colonies. The brood from one brood chamber was placed in a transfer box (See C in Figure II). The frames and bees, kept intact in this manner, prevented brood chilling and, to a large degree, robbing. On some occasions bees had to be shaken from the frames in order to expose unsealed brood. This practise was normally avoided in the cool spring weather.

The personal judgment of a "tracer" in marking the outline of spotty or irregular brood patterns was compensated for by having one "tracer" do all the even numbered hives, and another "tracer" do all the odd numbered hives of a single group.

Figure III shows the usual method of using the brood measuring apparatus. In cool weather, two glasses, (a lower and an upper) were placed on the apparatus to aid in brood protection; however, in warm weather only the top one was used, as nectar dripped from the combs onto the lower glass. Flood lights were used on cloudy days to locate areas of unsealed brood.

Using this apparatus, a five member crew could, at the time of heaviest brood production, measure the various brood stages of twenty to twenty-six hives per working day.

Limitations of the method included such factors as

forager confusion when returning to the colony to feed the missing brood, high labour input, shaking bees to expose unsealed brood in the combs and a higher than anticipated variation in the estimation of spotty and irregular brood areas by the "tracers".

An analysis of the maximum variation between the same and different persons tracing brood areas and between the same and different persons reading the brood areas is given in Tables I and II.

The variations are given only to show to maximum variations possible in the method used. Table 1 shows the maximum variation occuring when three or four different "readers" counted the same outlined area on the grid-glass plates for one colony. In trials E and F each "reader" counted twice in order to check one person's consistency. The average of the maximum variations of five trials between different readers was 5.1 to 7.2 per cent according to the type of area counted. The greatest variation in two countings by one reader (Trials E and F) was 9.7 per cent; however 4 to 5 per cent were the usual values.

Variation in measuring the brood area of one colony between two teams, (one team being one "tracer" and one "reader") were 8.5 per cent and 4.4 per cent for sealed and total brood areas respectively (Table II). The variation that occurred when one team tried to duplicate its previous

measurement made on one colony was 1.7 and 2.3 per cent for Team I and 2.4 and 3.1 for Team II when measuring sealed and total brood areas respectively.

(ii) Adult Estimations

In 1967 one hive from each of the six groups was killed on three dates during the season; the times were similar to those used in the survey work (Chapter III - A - 1.)

The method of Jeffree (1951) was adopted and used during the 1969 season as it avoided hive disturbance and possible loss of bees and, as the work was done in the morning before flight commenced, it did not interfere with nectar gathering by the colony during that day.

The method was found to provide an accuracy of -8.3% by estimator A and -7.1% for estimator B. The check was done by estimating and then killing twelve colonies during the 1969 season as described in detail by Nelson, (1970).

(iii) Entrance Activity Measurements.

The entrance trap used in the studies is shown in Figure IV. The traps, designed to capture incoming foragers, were not installed on the hives until mid-July.

Five hives per group were used in sampling the foraging force. This sample was reduced to four, in some groups, whenever a hive which was being used for entrance measurements developed a problem. To obtain a sample of bees the removable part of the trap A was replaced with a

similar part B, which was screened on the hive side and had a sliding door on the entrance end. The foragers were allowed to enter the trap box for a thirty second period and then the slide was closed. Collections were made between 1300 hours and 1600 hours Central Standard Time on days suitable for foraging; (i.e. on clear days when the temperature was at least seventy-five degrees), and under low wind conditions.

The trap box containing the bees was removed to a CO_2 gas chamber. The anaesthetized bees were emptied into marked containers and then they were counted by hand either in a counting box with a CO_2 atmosphere or more usually in a forty degree Fahreinheit cooling room. After counting, the bees were released.

TABLE I - CONSISTENCY OF READERS IN CALCULATING THE SAME BROOD AREA

Trial	Reader	TSWB[1]	TUSWB[2]	TB[3]
A	1	453[4]	470	937
	2	479	498	993
	3	474	495	984
	4	449	484	947
Variation[5]		30(6.6%)	28(6.0%)	56(6.0%)
B	1	513	448	961
	2	522	456	982
	3	522	432	958
Variation		9(1.8%)	24(5.6%)	(2.5%)
C	1	424	438	880
	2	434	462	922
	3	424	457	898
Variation		10(2.4%)	14(3.2%)	42(4.8%)
D	1	430	452	891
	2	457	460	928
	3	453	451	913
Variation		27(6.3%)	9(2.0%)	37(4.2%)

continued.....

1) Total sealed worker brood

2) Total unsealed worker brood

3) Total brood

4) In square inches

5) $\frac{\text{Highest value - lowest value}}{\text{Lowest value}}$

TABLE I (continued)

Trial	Reader	TSWB	TUSWB	TB
E	1	144	167	311
	1	141	168	309
	2	148	170	318
	2	150	155	305
	3	151	176	327
	3	151	180	331
	4	146	173	319
	4	140	164	304
Variation (between readers)		11(7.9%)	25(16.1%)	23(7.6%)
Greatest variation by a reader		4.3%	9.7%	4.9%
F	1	76	100	176
	1	78	101	179
	2	76	98	174
	2	79	102	181
	3	79	109	188
	3	80	109	189
	4	76	97	173
	4	77	99	176
Variation (between readers)		4(5.3%)	10(10.3%)	16(9.2%)
Greatest variation by a reader		3.9%	4.1%	4.0%

TABLE II - BROOD AREA MEASUREMENT VARIATIONS OF A COLONY MEASURED BY THE SAME AND A DIFFERENT TEAM

Reps.	Brood	TEAM 1 Trial #1	TEAM 1 Trial #2	Trial#1 vs. Trial#2[2]	TEAM 2 Trial #1	TEAM 2 Trial #2	Trial#1 vs. Trial#2	Team#1 vs. Team#2
	A	449[1]			509	519	1.9	14.5
1	B	947			991	958	3.3	3.0
	A	423	416	1.6	439			4.5
2	B	894	881	1.5	888			.33
	A	415	406	2.2	445			8.5
3	B	1029	1030	.1	1093			6.2
	A	450			460	454	1.3	1.6
4	B	1012			1097	1031	6.4	5.1
	A		356		422	400	5.5	15.4
5	B		1100		1002	983	1.9	1.2
	A	613	617	.7	680			10.6
6	B	1294	1277	1.3	1307			1.6
	A		524		557	552	.9	5.9
7	B		1187		1129	1120	.8	5.5
	A	446	456	2.2	420			7.4
8	B	886	943	6.4	815			12.2
				CB=1.7%			CB=2.4%	CB=8.5%
				TB=2.3%			TB=3.1%	TB=4.4%

Key: A = Sealed Brood

B = Total Brood

1) In square inches

2) Trial #1 vs. Trial #2 is a percentage

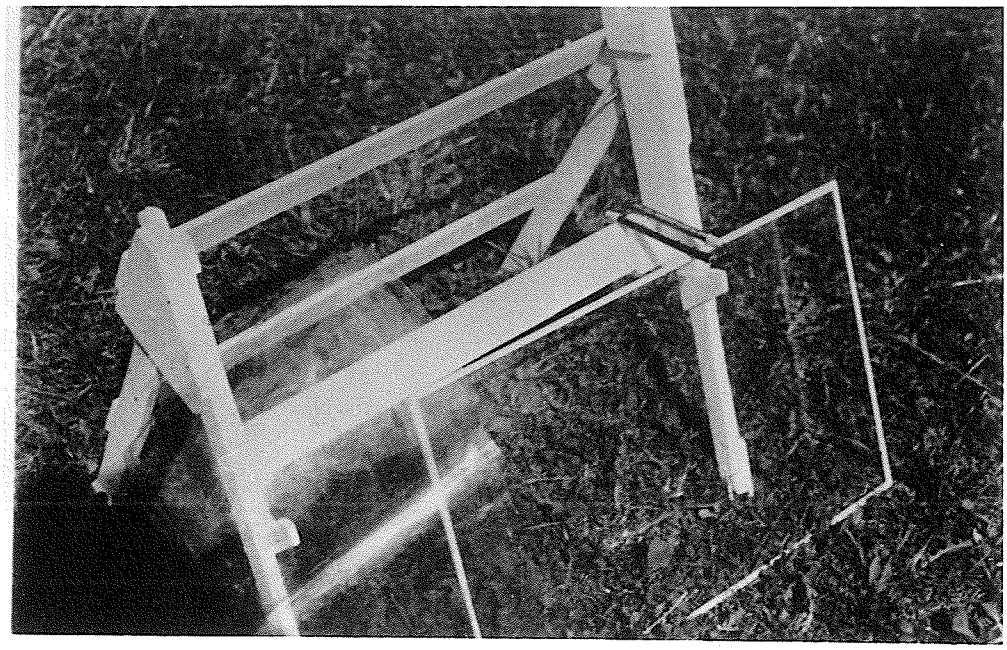


FIGURE 1 - APPARATUS FOR RECORDING BROOD AREAS IN HONEY BEE COLONIES

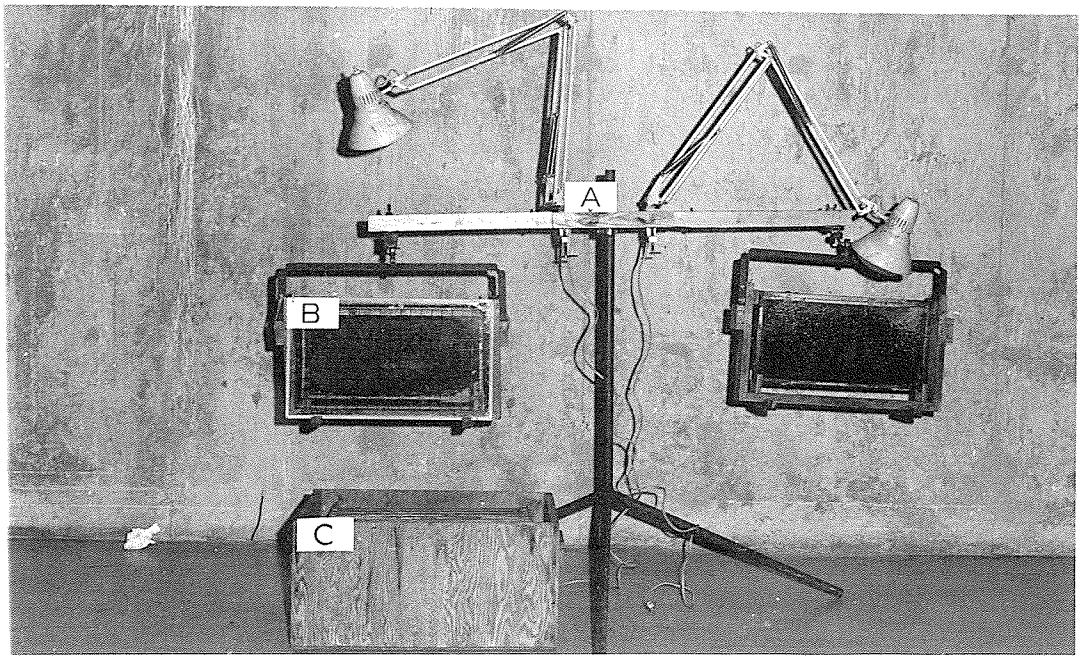


FIGURE 11 - APPARATUS FOR MEASURING BROOD AREAS IN UNIVERSITY STUDIES (1968-1969)

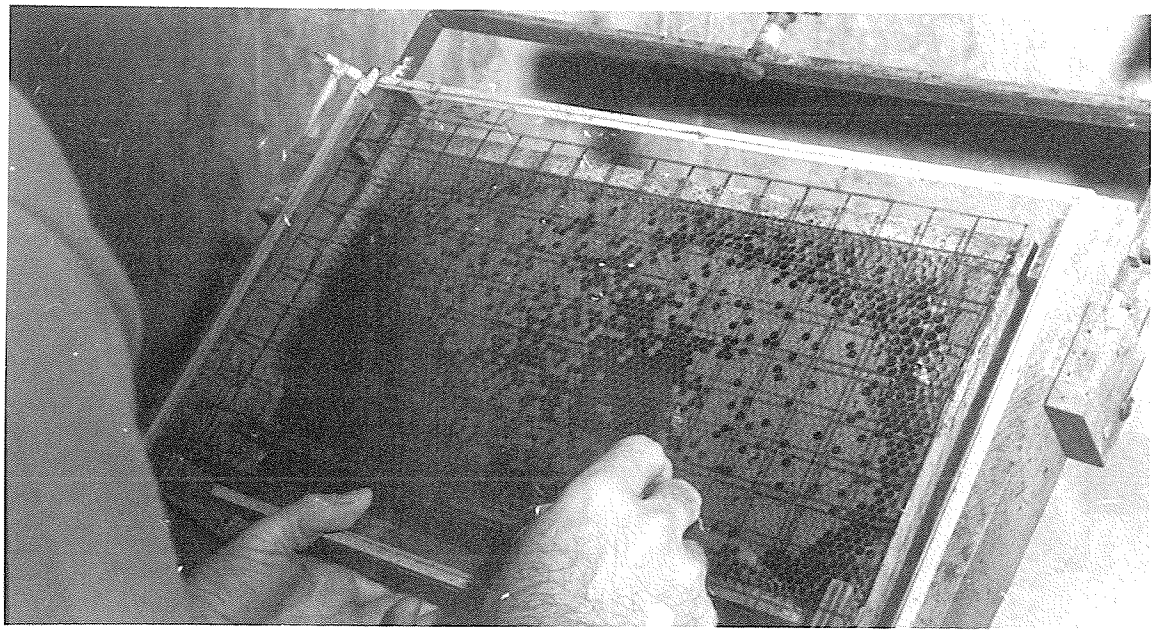


FIGURE 111 - USING THE APPARATUS TO MEASURE BROOD AREAS

(1968-1969)

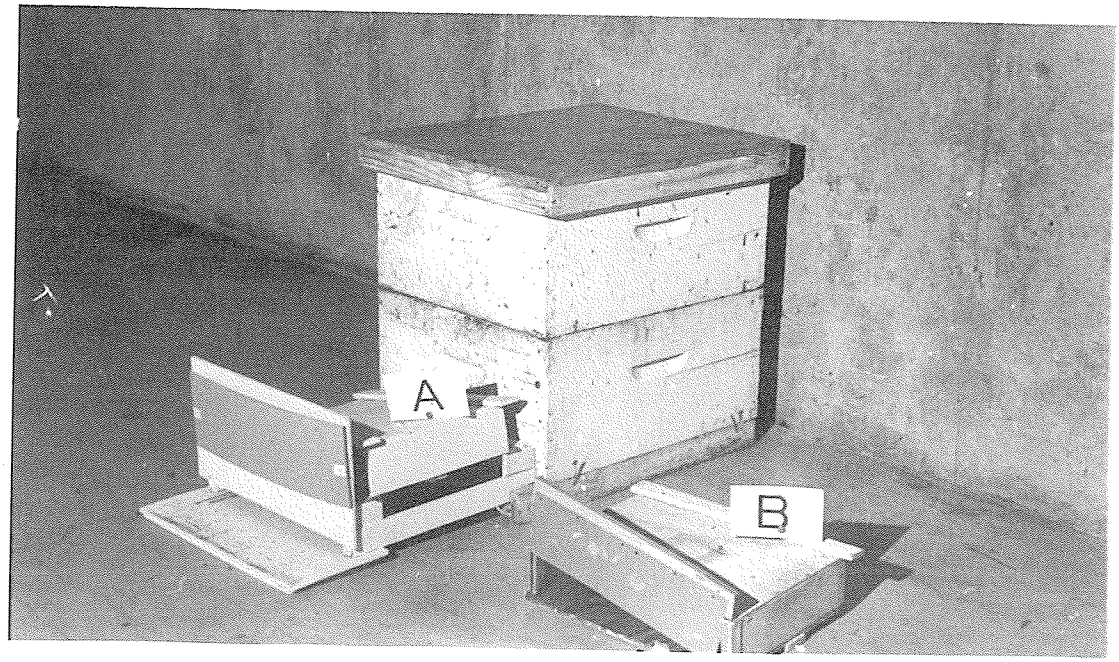


FIGURE 1V - ENTRANCE TRAPS FOR MEASURING INCOMING FLIGHT

(1969)

CHAPTER IV

RESULTS AND DISCUSSION

A. Results and Discussion of Extensive Studies of Commercial Honey Bee Colonies in Manitoba.

1. Results and Discussion of Population Survey of Commercial Honey Bee Colonies in Manitoba.

The data for the three year survey are summarized in Tables III, IV and V. The performance of colonies hived early (before May 1st) and those hived late (May1st or later) is compared in Table VI.

The survey includes three measurements of brood areas and adult numbers during the progressive development of the honey bee colony.

At nineteen days after hiving (i.e. the first sample); the adult population usually reached its lowest level because the original package bees were dying off and were not being replaced as yet by young emerging bees. The colonies at this time were concentrating on brood production as shown in the high total brood to adult bee (TB/Ad) ratio. The sealed brood to adult bee (SB/Ad) ratio is indicative of the number of young bees which were hatching in the colony. These ratios decreased progressively with each subsequent census (Tables

III, IV, V). At 19 days the brood cells to adult bee ratio differed considerably from year to year. At the end of June and the end of August, these ratios were rather constant from year to year. The yearly weather conditions of early spring probably had considerable effect on the ability of the low population colonies to raise brood.

The survey results showed that the largest quantity of brood was present at the end of June and the largest adult population at the end of August.

In Part 3 (following) it is shown that the expected date of Manitoba's honey flow occurs during the first part of July. The adult populations of twenty to twenty-five thousand bees which occur at this time are well below the colony populations which are required for a colony to be an efficient honey producer (Farrar, 1937). At the August census, when the honey flow is typically declining, there are large quantities of brood present. This brood, upon emergence, would appear to be of little use for storing honey, and in addition, it used honey while being reared. However, the presence of brood may stimulate foragers to gather nectar (Free and Preece, 1969). This brood thus may serve a useful purpose.

Table VI shows that the number of bees surviving at nineteen days does not differ ($P \leq 0.05$) between the late and early hived packages in the three years. The total brood

TABLE III - BROOD AND ADULT SURVEY OF HONEY BEE COLONIES SAMPLED AT 19 DAYS AFTER HIVING

	No.	1966		1967		1968		Three Year Means	
		Mean[1]	S.E[1]	Mean	SE	Mean	SE	Mean	SE
Eggs		2800	±1256	2349	±559	1200	±500	2257	±1032
Larvae		2380	1500	2565	1233	2140	227	2400	1169
Pupae		6889	2709	5652	2063	6715	889	6344	2138
Total Brood		12065	3660	11119	3232	10075	1002	10999	3146
Adults		5252	909	6361	1096	7087	1483	6075	1326
Total Brood Adults		2.30		1.75		1.42		1.82	
Sealed Brood Adults		1.31		.89		.95		1.05	

TABLE IV - BROOD AND ADULT SURVEY OF HONEY BEE COLONIES SAMPLED DURING THE LAST WEEK OF JUNE

	No.	1966		1967		1968		Three Year Means	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Eggs		4305	±1823	3762	±1265	4375	±1640	4111	±1545
Larvae		6888	1266	7071	2419	6941	1652	6966	1783
Pupae		16890	2543	14497	4625	14313	3000	15376	3608
Total		28083	3049	25330	4087	25628	5074	26472	4085
Adults		22796	6657	21695	5972	24035	1419	22593	5337
Total Brood Adults		1.23		1.17		1.15		1.15	
Sealed Brood Adults		.74		.67		.60		.67	

TABLE V - BROOD AND ADULT SURVEY OF HONEY BEE COLONIES SAMPLED DURING THE LAST WEEK OF AUGUST

	No.	1966 Mean	1966 SE	1967 Mean	1967 SE	1968 Mean	1968 SE	Three Year Means Mean	Three Year Means SE
Eggs		3965	±1837	3039	1376	3715	1373	3585	1554
Larvae		5715	2112	4699	1915	6570	967	5661	1848
Pupae		14377	3115	13044	4395	11285	5544	12642	4340
Total		23907	5033	20788	6681	21570	5948	21916	5900
Adults		51905	17010	42836	5041	47757	13211	47499	12886
Ratio Total Brood /Adults		.46		.49		.45		.47	
Ratio Sealed Brood /Adults		.28		.30		.24		.27	

TABLE VI - VARIATIONS IN LATE AND EARLY HONEYBEE COLONY PERFORMANCE OF NINETEEN DAYS

Year	Bees and brood before May 1st: Total Brood	Adults	Ratio TB/A[2]	Bees and brood after May 1st: Total Brood	Adults	Ratio TB/A
	6210[1]	4468	1.39	13420	5253	2.55
1966	7333	4291	1.71	11901	6357	1.87
	12248	5423	2.26	17221	6253	2.75
				14531	4180	3.48
				13656	3836	3.56
Average	8597	4727	1.78	14145*	5176[NS]	2.84[NS]
	6685	5470	1.22	13856	6058	2.29
1967	7425	7000	1.06	14051	8342	1.68
	7656	6222	1.23	13228	5295	2.50
				13031	6110	2.13
				13020	6622	1.97
Average	7255	6231	1.17	13437**	6485[NS]	2.11**
	9975	6769	1.47	9425	8367	1.13
1968				8975	5992	1.48
				10425	5443	1.92
				11575	8863	1.31
Average				10100	7166	1.46
3 year average	8218	5663	1.48	12736**	6212[NS]	2.19*

1) Number of cells or bees

2) Ratio - Total brood/Adults

* $P \leq 0.05$

** $P \leq 0.01$

N.S. - Not significant

produced by the late packages was greater in 1966 ($P \leq 0.01$) and in 1967 ($P \leq 0.01$). The TB/Ad ratio supports this result ($P \leq 0.05$).

2. Results and Discussion of Commercial Honey Production Studies in Manitoba.

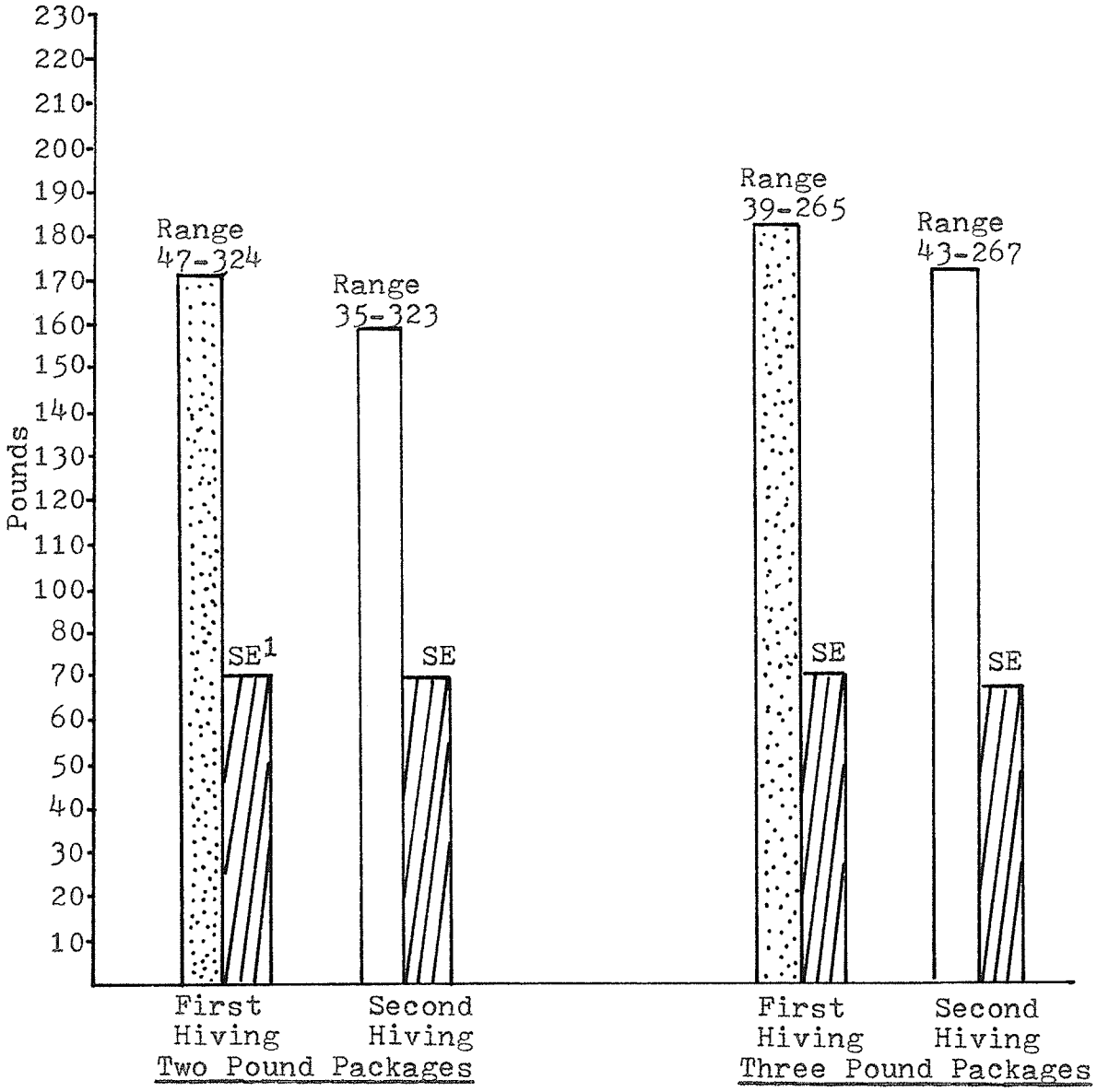
Average honey production by each of the four groups during the three experimental years is shown in Table VII. The mean of the three year averages for each group is shown in Figure V.

A comparison of the four groups, for each of the three experimental years, showed only the 1968 groups to be different in yield ($P \leq 0.05$). The difference in this year was due to the low average yield of the second hived two pound packages. The mean differences between the groups for the three years were not significant.

The range of yields of individual hives within one group on one year was large (Figure V). However, the variation of the four groups was similar (Figure V). There was a significant difference ($P \leq 0.01$) between the yields obtained by individual beekeepers on any one year.

The yield differences between the groups were nearly all non-significant (Table VII). The economic advantage to the beekeeper of these yield differences were calculated (Table VIII). Honey was valued at 15¢ a pound and a three pound package at $1.75 more than a two pound one. The great-

FIGURE V - MANITOBA HONEY PRODUCTION STUDIES: MEAN (LB.) OF THREE YEAR AVERAGES (1967-1969)



1) Standard Error

TABLE VII - AN ANALYSIS OF HONEY YIELDS (1B) BY EARLY AND LATE HIVED TWO AND THREE POUND PACKAGES

Year	Significance	FIRST HIVING		SECOND HIVING	
		Ave. of Two Pound Pkgs.	Ave. of Three Pound Pkgs.	Ave. of Two Pound Pkgs.	Ave. of Three Pound Pkgs.
1967	ns	210±73	228±59	200±55	212±42
1968	$P \leq 0.05$	103±55	103±49	86±56*	98±56
1969	ns	166±32	176±30	150±46	171±42
3 yr. Mean	ns	162±69	171±69	148±68	162±66

* Significant difference occurred here.

TABLE VIII - THREE YEAR MEAN YIELD DIFFERENCES IN POUNDS AND VALUE IN THE COMMERCIAL HONEY PRODUCTION EXPERIMENTS

Comparison	Difference (lb)	Difference Value (15¢/lb.)
3 lb. First[1] versus 2 lb. First	+9	$1.35
2 lb. First versus 2 lb. Second[2]	+14	$2.10
3 lb. First versus 3 lb. Second	+9	$1.35
3 lb. Second versus 2 lb. Second	+14	$2.10
3 lb. First versus 2 lb. Second	+23	$3.45

1) First Hiving (See Table III)

2) Second Hiving (See Table III)

est yield difference was shown by the first hived three pound packages when compared to the second hived two pound packages; this amounted to twenty-three pounds of honey valued at $3.45. In this case the additional cost was $1.75 for the extra pound of bees, plus the costs of feeding and mangement for three weeks longer during a period of normally cool and often wet weather conditions. The first hived two pound packages returned an average of $2.10 more per colony than did the second hived two pound packages. Considering the extra cost of the three pound packages, the first hived two pound ones gave a greater return than did the first hived three pound ones. The extra cost of the three pound packages was justified only in the second hiving when the three pound packages gave an additional return of $2.10.

In comparing the two and three pound packages at one hiving time, the three pound packages showed more advantage at the second hiving (fourteen pounds versus nine pounds). The first hived packages would have time (three more weeks) to equalize in brood production and adult bee production (See Chapter lV B-1) while the three pound packages in the second hiving would have a population advantage at the beginning of the nectar flow.

Three pound packages showed an economic advantage on one of the three years in each of the first hiving and second hiving. In most cases the use of the three pound package is

not economically feasible. However, the location and particular year may in some instances make the three pound size desirable.

3. Results and Discussion of Nectar Flow Records for Manitoba 1955-1969.

Table I (Appendix) shows the records kept by Manitoba beekeepers. These data are shown in Figure I which also includes one five year period from the data of Mitchener (1955).

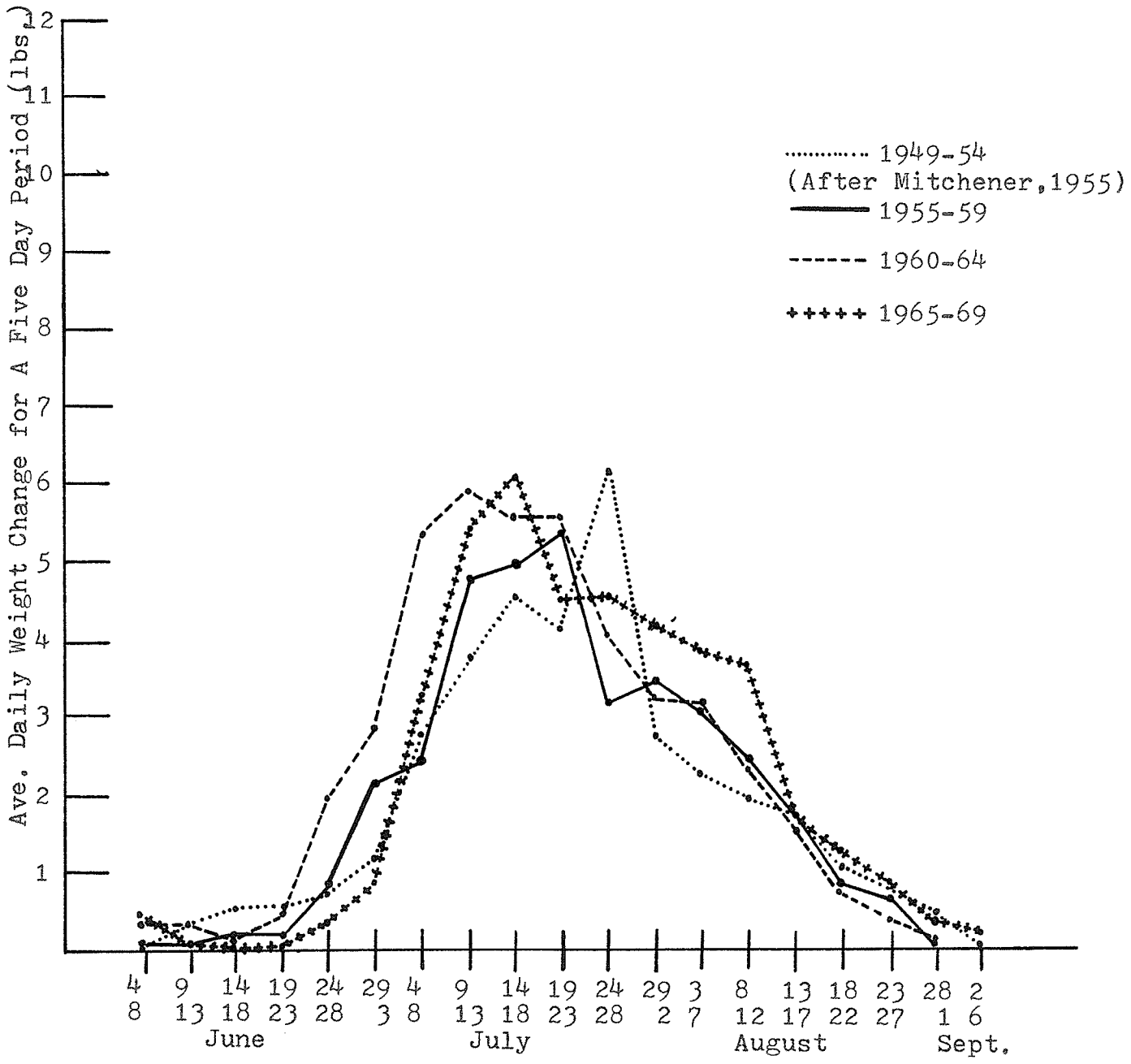
Nectar flows begin about June 24th and intensify by the first week in July (Figure VI). This pattern can vary from year to year (See early flow of 1962 in Appendix Table I). In most years, the flow terminates by the end of August.

Mitchener, (1955) showed that July is the most productive month, when 68 and 66 per cent of the honey crop was produced in the 1945-49 and 1950-54 periods respectively. My analysis shows that 67, 67 and 64 per cent of the honey was produced in July during the 1955-59, 1960-64 and 1965-69 periods respectively.

The August nectar flow produced 25 per cent of the total crop in 1945-1949 and 26.4 per cent in the period 1949-54. (Mitchener, 1955). My analysis shows that 28, 22 and 32 per cent of the total crop was produced in August in the periods 1955-59, 1960-64 and 1965-69 respectively.

This analysis demonstrates the necessity of having strong colonies by the first of July in order to take advan-

FIGURE VI - NECTAR FLOWS IN MANITOBA 1949-69



tage of the major part of the July nectar flow.

B. Results and Discussion of Intensive Studies of Honey Bee Colonies at the University of Manitoba (1967-69).

1. Brood Measurements.

(a) 1967. The data for the 1967 experimental colonies are shown in Tables IX and X and Figures VII and VIII. This year was the preliminary study year and only two colonies per group were measured. In some groups this was reduced to one hive due to queen loss or swarming loss.

Figure VII shows the amounts of sealed brood produced at twelve day intervals during the season by two sizes of packages which were initiated at three spring dates.

Figure VIII shows the amount of sealed brood each "date-size" group had at certain times after the packages of a group were hived. Figure VIII is a direct comparison of the six groups after each had been developing for certain time periods. This shows that, at nineteen and thirty-one days after hiving, the later a group was hived the more sealed brood it was supporting. At forty-three days Date II and Date III groups were similar but much ahead of Date I's production of sealed brood. Date II showed the most rapid and consistent growth.

Also of interest is the tendency of the three pound package colonies to initially produce more sealed brood, but

TABLE IX - MEASUREMENTS ON THE 1967 EXPERIMENTAL COLONIES: SEALED BROOD AREAS (SQ.IN.)

Measurement Date	Date I 2 lb.	Date I 3 lb.	Date II 2 lb.	Date II 3 lb.	Date III 2 lb.	Date III 3 lb.
May 6	124[1]	176[1]				
May 18	185	199	172[1]	209[1]		
May 30			392	314		
June 1	306	454			368[1]	390[1]
June 12			518	571		
June 13	562	493			404	448
June 23			739	678		
June 26	550	513			550	569
July 7	739[2]	728[2]	807	703	708	582
July 18			901	670		
July 19	653	482			651	385
July 31			653	371		
August 1	677	539			440	378
August 14	291	350	99	376		225
August 25	210	128	540	446[2]		208[2]

1) Average of two colonies

2) One colony

TABLE X - MEASUREMENTS ON THE 1967 EXPERIMENTAL COLONIES: ADULT POPULATIONS

Measurement Date	Date 1 2 lb.	Date 1 3 lb.	Date 11 2 lb.	Date 11 3 lb.	Date 111 2 lb.	Date 111 3 lb.
19 days after hiving	5470[1]	8036	7000	7265	6622	8225
End of June	18650	29100	21850	30000	18800	26600
End of Aug.	46170	40720	38640	41860	47070	35950

1) one colony

FIGURE VII - SEALED BROOD AREAS IN 1967 EXPERIMENTAL COLONIES ACCORDING TO TIME OF SEASON

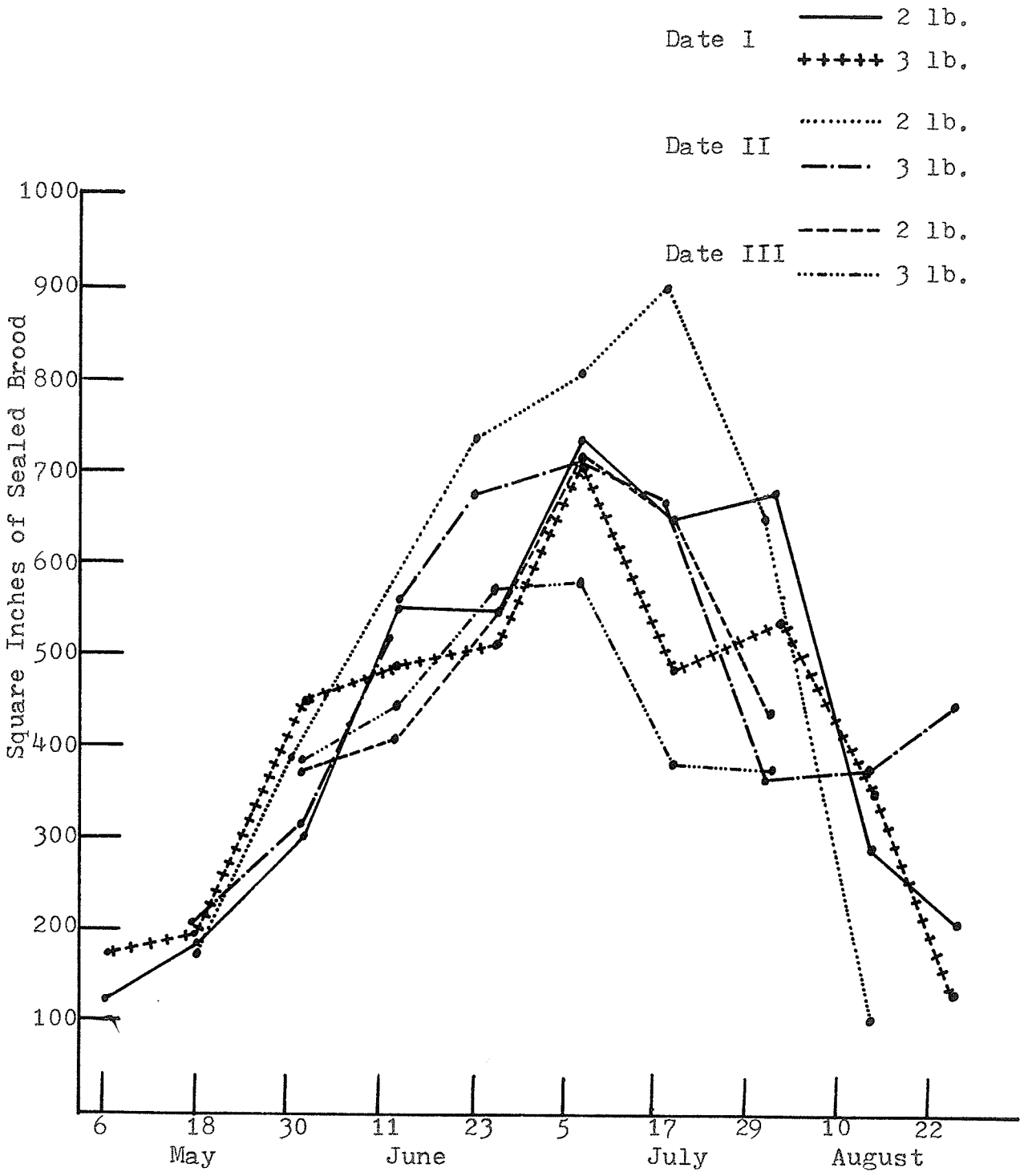
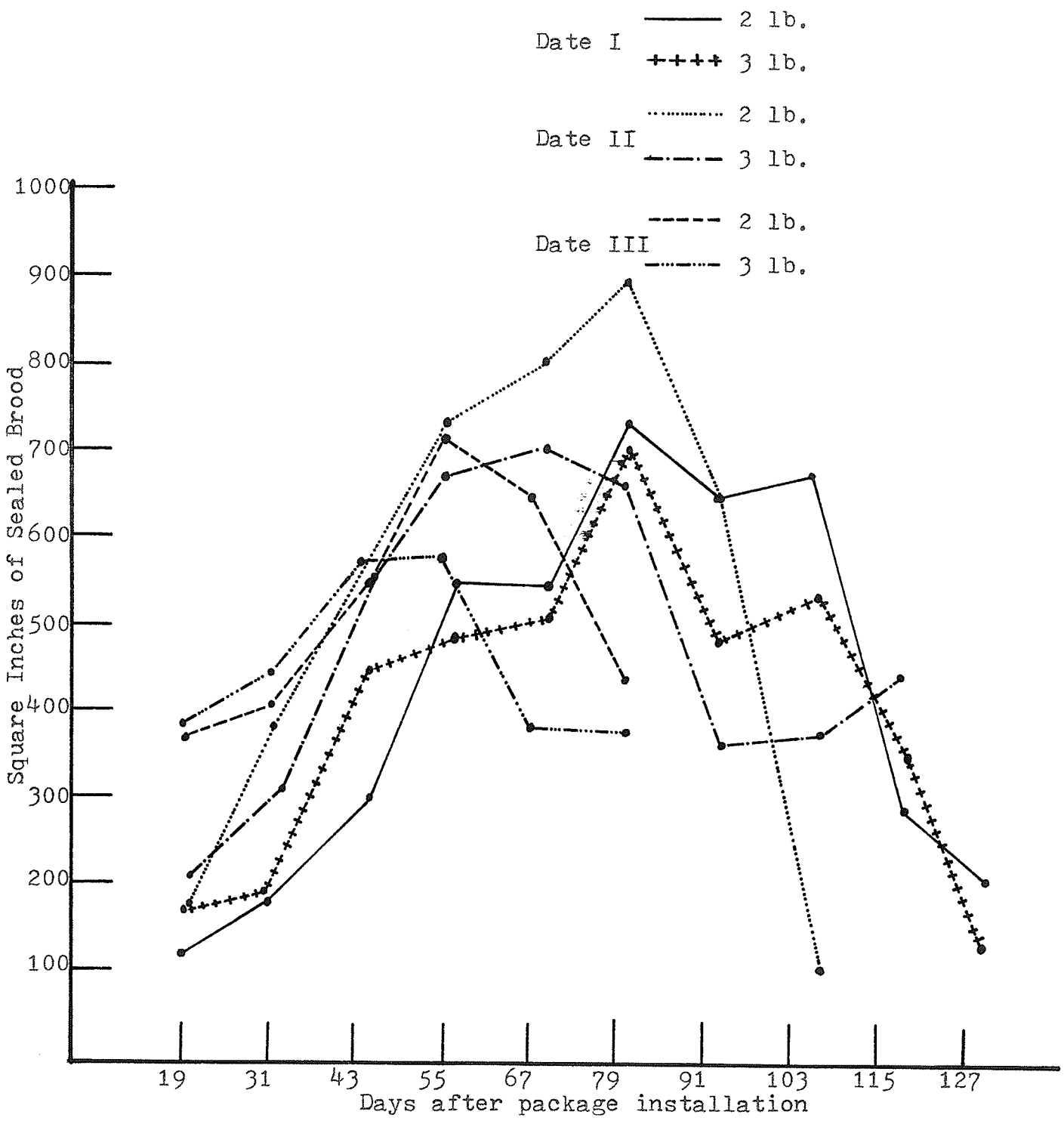


FIGURE VIII - SEALED BROOD IN 1967 COLONIES ACCORDING TO PERIOD OF DEVELOPMENT



the two pound colonies attain the level and often surpass the three pound colonies in sealed brood production during June. The peak brood production period of the colonies was shown at the July 5 readings for five of the six groups. This appears to be seasonally affected (Geiger, 1967). The adult population of hives destroyed on the dates indicated (Table X) show the two pound of all groups were similar in populations to those of the survey colonies (Part A-1). The three pound colonies had a large numerical advantage at the end of June. The small sample size prevents any statistical analysis.

(b) 1968 and 1969.

The measurement of colony growth and development, and systems of analyses used, was similar in both years. However, in 1969, additional parameters were measured. Table II (appendix) shows the brood production and adult populations of individual hives within the six "date-size" combinations. Table X summarizes the above data for normal hives (See Chapter III-B-1 for details).

Two methods were used for examining colony development; (1) the rate of growth was measured in days from package installation so that each "date-size" combination had equal time periods for development; (2) a comparison of adult populations for each group was done for certain calendar dates in the months of July and August.

(i) Total Brood.

An examination of Figures IX, X, XI and Table XII shows the relative effect of package size in total brood production at the three hiving dates in 1968 and 1969.

At forty-three days the three pound package produced more total brood than the two pound ones ($P \leq 0.05$) (Table XII). In 1968 and in 1969 this pattern was also repeated at nineteen, thirty-one and forty-three days ($P \leq 0.01$) (Table XII). However, at seventy-nine and ninety-one days in 1968 the two pound packages produced more total brood than did the three pound ones ($P \leq 0.01$ and $P \leq 0.05$) respectively, (Table XII).

An examination of Figure IX, X, XI and Table XII shows the relative effect of date of hiving on total brood production in 1968 and 1969. At forty-three days after hiving in 1968, the date when the packages were hived had a significant effect ($P \leq 0.01$, Table XII) on total brood produced (i.e. Date II > Date I > Date III; $P \leq 0.05$). In 1969 at thirty-one, forty-three, sixty-seven, ninety-one, 103 and 115 days after hiving, the date when the packages were hived had a significant effect (See Table V for P values) on total brood production. The differences in total brood produced in 1969, according to the date of hiving of the package, is shown in Table XIII.

A peak in brood production in the three pound package

TABLE XI - SUMMARY OF GROUP DEVELOPMENT IN THE 1968 AND 1969 EXPERIMENTAL COLONIES

Time	Date I - 2 lb.				Date I - 3 lb.			
1968	US	S	T	Ad	US	S	T	Ad
19 da Ave								
SE								
31 da Ave								
SE								
43 da Ave	307[1]	347[1]	654[1]		434	361	795	
SE	41.8	23.8	45.1		29.2	41.9	61.1	
55 da Ave.	517	686	1204		531	706	1238	
SE	40.5	38.8	56.0		21.7	66.6	82.3	
67 da Ave	479	727	1206		451	747	1198	
SE	46.5	34.8	77.6		38.6	62.4	76.1	
79 da Ave	606	749	1354		492	661	1153	
SE	54.1	55.2	99.0		26.2	67.6	88.7	
91 da Ave	419	819	1238		426	773	1200	
SE	49.1	44.1	78.6		36.3	64.9	84.7	
103 da Ave	524	631	1155		602	629	1231	
SE	94.2	48.8	120.7		81.0	78.5	149.4	
115 da Ave	317	601	918		436	623	1059	
SE	69.0	48.4	94.1		44.4	70.7	96.6	
1969								
19 da Ave	199	251	451	56.6[2]	223	341	564	79.1
SE	14.5	13.3	12.5	2.1	15.4	19.2	32.4	2.6
31 da Ave	305	248	553		358	375	733	
SE	16.6	14.2	14.6		22.9	19.0	27.4	
43 da Ave	397	400	797	146.8	479	449	928	216.7
SE	24.9	13.8	34.5	8.0	17.8	19.8	19.6	6.0
55 da Ave	572	599	1170		533	566	1099	
SE	31.5	14.7	31.1		33.3	17.6	37.8	
67 da Ave	582	654	1236	260.2	522	559	1081	325.1
SE	23.5	20.4	35.9	16.3	41.3	28.7	62.2	11.6
79 da Ave	568	540	1108	356.8	586	473	1059	368.7
SE	48.0	18.1	57.0	15.4	43.6	32.7	48.2	11.8
91 da Ave	723	548	1271	395.0	553	531	1084	429.8
SE	77.4	55.5	75.2	21.0	33.3	42.7	69.6	16.9
103 da Ave	662	623	1285		531	529	1060	
SE	47.6	50.3	95.0		25.2	32.3	47.3	
115 da Ave	567	489	1056	491.6	472	585	1057	491.0
SE	58.1	33.7	78.8	12.5	23.1	43.8	61.9	25.2
127 da Ave	557	647	1205	500.7	574	587	1160	521.0
SE	45.2	12.0	50.2	26.7	35.3	23.9	54.4	38.5

continued .....

TABLE XI (continued)

Time 1968	Date II - 2 lb. US	S	T	Ad	Date II - 3 lb. US	S	T	Ad
19 da Ave								
SE								
31 da Ave	374.3	230.5	604.8		426.9	309.1	736.0	
SE	32.8	24.0	47.4		21.2	26.4	30.4	
43 da Ave	488	620	1107		513	677	1190	
SE	42.0	56.2	92.5		33.0	24.1	41.1	
55 da Ave	545	747	1292		499	726	1225	
SE	30.4	56.8	74.4		44.8	48.2	73.6	
67 da Ave	588	753	1341		481	746	1227	
SE	48.8	82.1	123.6		61.5	56.0	72.9	
79 da Ave	546	844	1390		473	691	1164	
SE	43.0	56.9	52.6		53.0	32.0	62.3	
91 da Ave	660	847	1507		500.4	691	1191	
SE	25.2	27.8	35.1		61.0	26.0	81.9	
103 da Ave	560	796	1355		478	657	1135	
SE	33.0	38.3	37.0		63.3	40.3	51.5	
115 da Ave								
SE								
1969								
19 da Ave	197.0	245	442	59.1	277	312	589	86.8
SE	11.5	12.2	21.1	2.3	21.8	9.2	27.6	4.3
31 da Ave	380	229	608		407	350	757	
SE	21.8	10.9	20.5		16.7	17.1	19.1	
43 da Ave	459	481	939	155.5	581	513	1094	193.5
SE	39.0	13.8	44.1	7.1	17.1	22.5	33.7	5.1
55 da Ave	508	443	951		536	500	1036	
SE	24.7	28.8	50.3		18.0	32.3	46.2	
67 da Ave	486	431	917	260.5	542	468	1009	302.0
SE	17.1	30.2	35.7	20.7	28.7	31.7	51.7	12.3
79 da Ave	570	577	1147	282.0	661	554	1215	341.2
SE	16.8	20.3	21.4	18.0	30.8	57.3	72.5	13.7
91 da Ave	515	575	1090	343.1	430	597	1027	425.8
SE	33.5	18.3	38.8	15.8	27.4	54.3	72.2	31.2
103 da Ave	538	508	1046		399	502	901	
SE	11.5	40.7	44.5		68.1	83.9	137.5	
115 da Ave	493	509	1002	383.6	330	317	647	500.5
SE	21.6	44.8	50.5	39.8	83.2	105.9	187.0	43.8
127 da Ave								
SE								

continued .....

TABLE XI (continued)

Time 1968	Date III - 2 lb. US	S	T	Ad	Date III - 3 lb. US	S	T	Ad
19 da Ave	245.6	218.6	464.3		257.6	237.7	495.3	
SE	19.5	7.2	19.5		20.8	18.7	28.9	
31 da Ave	404.7	306.7	711.4		454.3	374.4	828.7	
SE	22.5	25.4	41.4		19.5	29.9	40.4	
43 da Ave	477	517	994		484	591	1075	
SE	19.1	35.8	48.6		30.7	30.7	47.1	
55 da Ave	558	715	1273		448	731	1179	
SE	43.8	42.1	79.8		21.1	25.1	36.6	
67 da Ave	526	762	1288		573	690	1264	
SE	46.8	31.4	56.4		23.9	28.3	30.0	
79 da Ave	596	815	1411		358	628	986	
SE	38.2	35.4	61.8		29.3	32.6	52.0	
91 da Ave	588	713	1301		584	641	1226	
SE	51.3	21.6	48.3		29.2	77.8	88.4	
103 da Ave								
SE								
115 da Ave								
SE								
1969								
19 da Ave	206	234	440	62.8	280	280	559	90.5
SE	12.5	12.9	21.7	4.1	19.7	14.7	21.1	3.7
31 da Ave	351	244	596		392	445	837	
SE	23.1	25.4	37.4		18.7	18.2	31.0	
43 da Ave	390	400	790	146.8	391	499	890	187.0
SE	17.1	34.8	43.1	10.8	18.9	15.2	29.1	7.3
55 da Ave	465	413	878	189.0	524	378	902	262.4
SE	31.5	30.5	28.1	13.6	19.9	28.0	34.3	14.5
67 da Ave	487	569	1056	164.5	508	495	1003	336.1
SE	49.4	21.1	58.1	21.0	30.5	32.6	60.3	15.4
79 da Ave	609	538	1148		527	460	987	
SE	53.2	41.1	78.3		31.8	49.2	70.1	
91 da Ave	509	471	980	426.6	473	477	951	430.6
SE	44.8	42.9	58.3	18.6	37.1	48.6	67	44.9
103 da Ave	532	574	1106	458	512	454.8	967	489.6
SE	48.0	43.5	75.7	22.3	21.6	73.0	78.9	33.0
115 da Ave								
SE								
127 da Ave								
SE								

US - Unsealed Brood S - Sealed Brood T - Total Brood

1) Measurements in square inches Ad - Adults
2) Measurements in 100's of Bees

FIGURE IX - TOTAL BROOD AREAS IN EXPERIMENTAL COLONIES:
DATE I - 1968 AND 1969

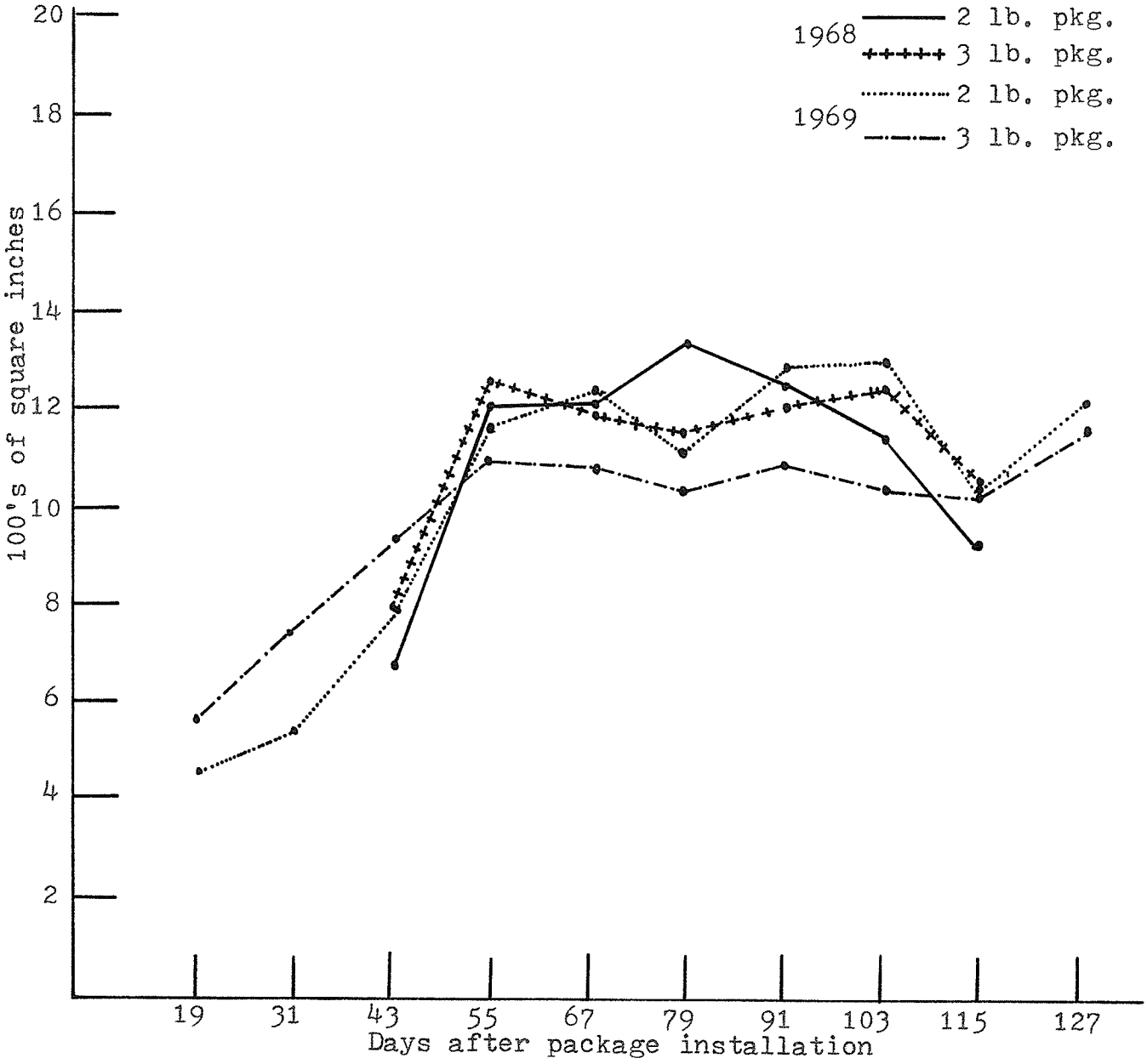


FIGURE X - TOTAL BROOD AREAS IN EXPERIMENTAL COLONIES: DATE II - 1968 AND 1969

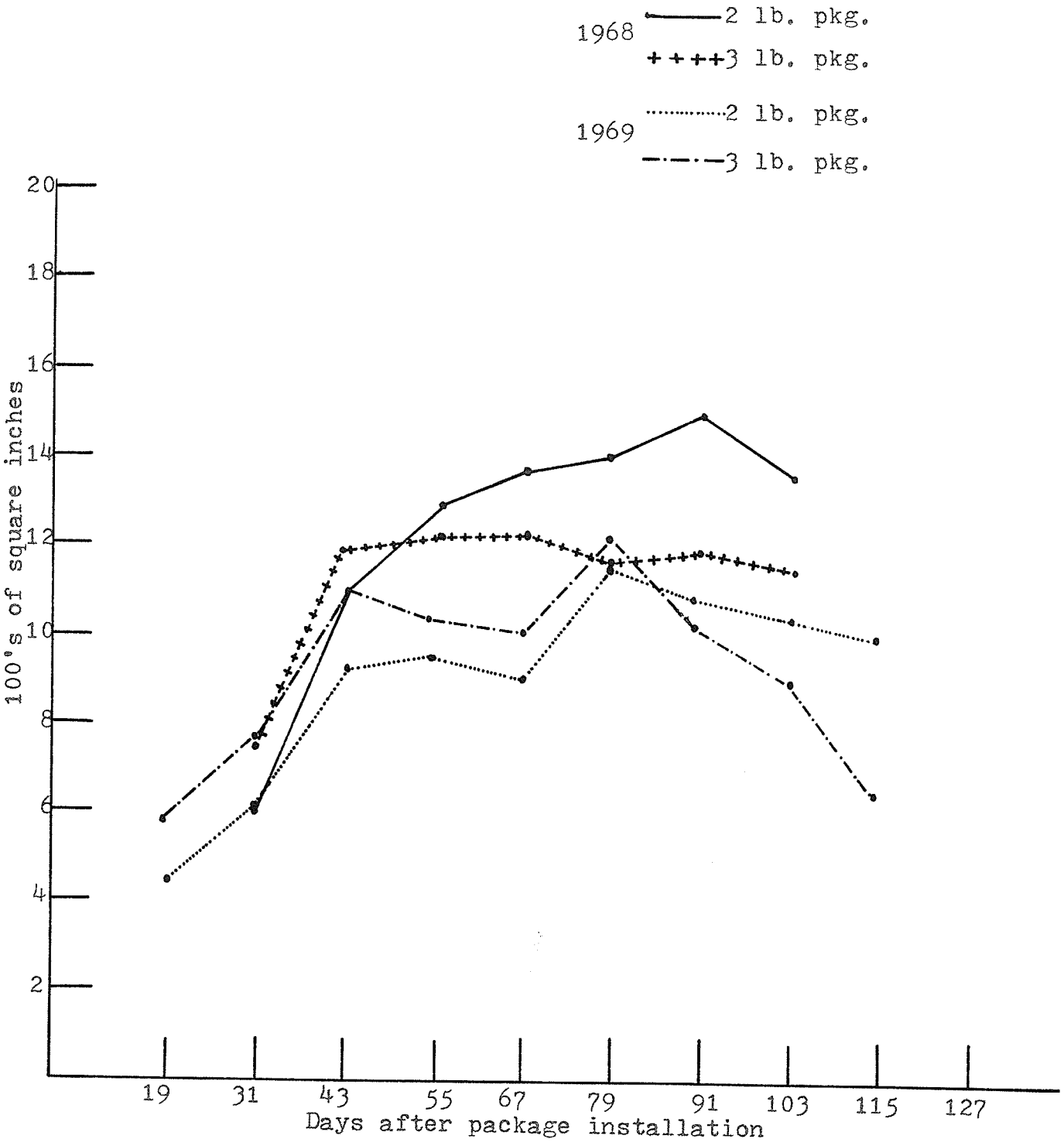


FIGURE XI - TOTAL BROOD AREAS IN EXPERIMENTAL COLONIES: DATE III - 1968 AND 1969

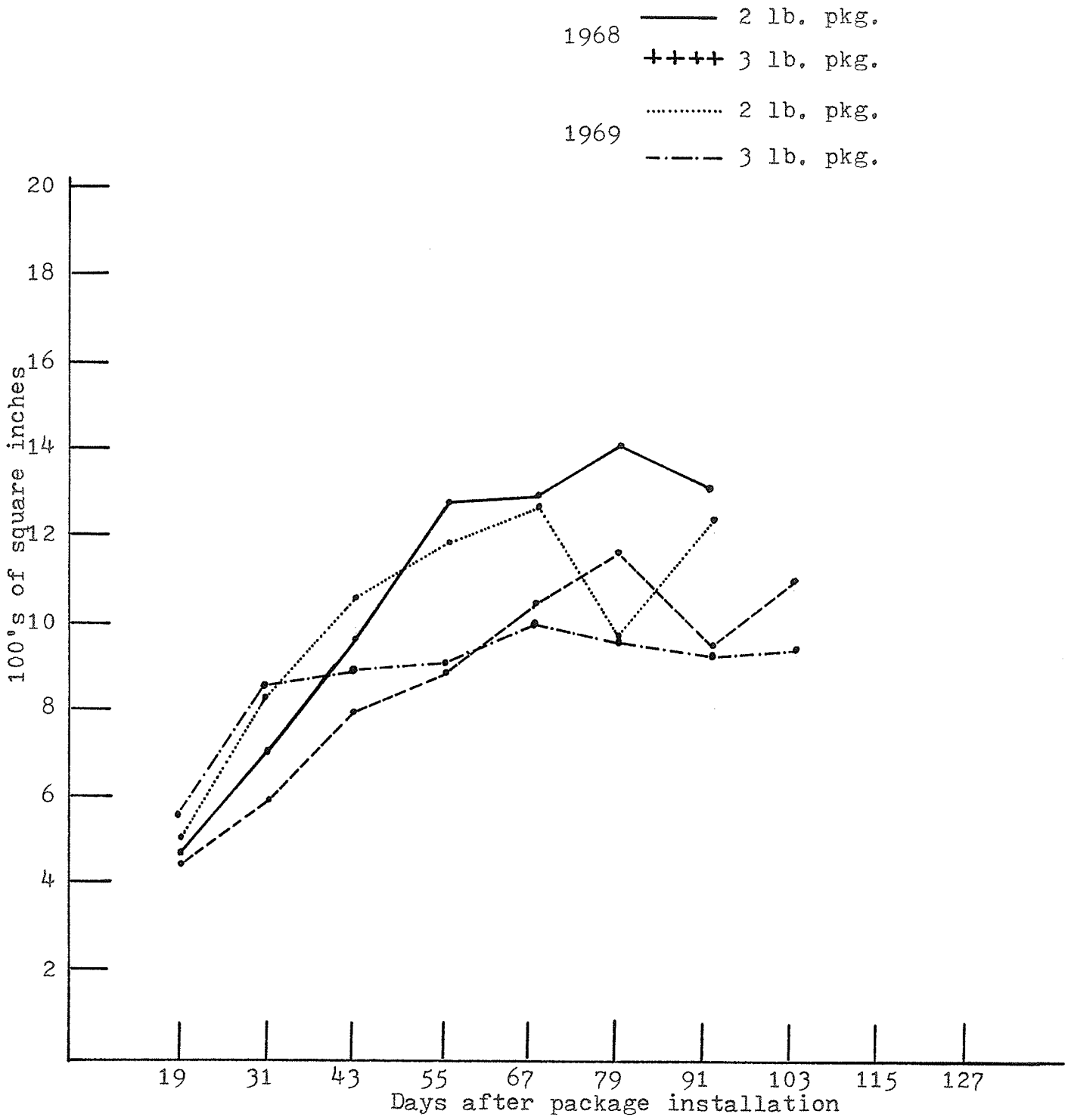


TABLE XII - DIFFERENCES IN ADULT AND BROOD MEASUREMENTS OF EXPERIMENTAL COLONIES FOR 1968 AND 1969

1968 Reading	TOTAL BROOD			SEALED BROOD			UNSEALED BROOD			ADULTS		
	Size[1]	Date[2]	SXD[3]	Size	Date	SXD	Size	Date	SXD	Size	Date	SXD
19 da.	NS											
31 da.												
43 da.	*	**	NS	NS	**	NS	NS	**	NS			
55 da.	NS	NS	NS	NS	NS	NS	NS	NS	NS			
67 da.	NS	NS	NS	NS	NS	NS	NS	NS	NS			
79 da.	**	NS	NS	**	NS	NS	**	NS	NS			
91 da.	*	NS	NS	*	NS	NS	NS	**	NS			
103 da.	NS	NS	NS	NS	NS	NS	NS	NS	NS			
115 da.	NS			NS			NS					
1969 Reading												
19 da.	**	NS	NS	**	*	NS	**	NS	NS	**	*	NS
31 da.	**	*	NS	**	*	NS	*	*	NS			
43 da.	**	**	NS	**	**	NS	**	**	NS	**	NS	NS
55 da.	NS	**	NS	NS	**	NS	NS	NS	NS			
67 da.	NS	**	NS	NS	**	NS	NS	NS	NS	**	NS	NS
79 da.	NS	NS	NS	NS	NS	NS	NS	NS	NS			
91 da.	*	**	NS	NS	NS	NS	*	**	NS	NS	NS	NS
103 da.	**	*	NS	NS	NS	NS	**	**	NS			
115 da.	NS	**	NS	NS	*	*	*	*	NS			
127 da.	NS			NS			NS					

1) Package size, two pound and three pound

2) Date of hiving

3) Package size and date of hiving interaction

* $P \leq 0.05$

** $P \leq 0.01$

NS - Non-significant

TABLE XIII - HIVING DATES RANKED ACCORDING TO BROOD PRODUCTION

Time of Measurement	1968 Total Brood[1]	1968 Sealed Brood[1]	1969 Total Brood	1969 Sealed Brood
19 da.	no measurement		DII > DI > DIII (ns, ns; ns)	DI > DII > DIII (ns, ns; *)
31 da.	no measurement		DIII > DII > DI (ns, ns; *)	DIII > DI > DII (ns, ns; *)
43 da.	DII >* DIII > DI (*[2]; **[3])	DII >* DIII >* DI (**; **)	DII >* DI > DIII (ns; **)	DII >* DIII > DI (ns; **)
55 da.	DII > DIII > DI (ns, ns; ns)	DII > DIII > DI (ns, ns; ns)	DI >* DII >* DIII (**; **)	DI >* DII >* DIII (**; **)
67 da.	DII > DIII > DI (ns, ns; ns)	DII > DI > DIII (ns, ns; ns)	DI >* DIII > DII (ns; **)	DI >* DIII >* DII (**; **)
79 da.	DII > DI > DIII (ns, ns; ns)	DII > DIII > DI (ns, ns; ns)	DII > DI > DIII (ns, ns; ns)	DII > DIII > DI (ns, ns; ns)
91 da.	DII > DIII > DI (ns, ns; *)	DI > DII > DIII (ns, ns; *)	DI > DII > DIII (ns, ns; *)	DII > DI > DIII (ns, ns; *)
103 da.			DI > DIII > DII (ns, ns; *)	DI > DIII > DII (ns, ns; ns)

1) Measured in square inches 2) $P \leq 0.05$ 3) $P \leq 0.01$

colonies occurred at fifty-five days in 1968 and a secondary peak occurred at ninety-one or 103 days in all of the three pound package colonies. The two pound package colonies in 1968 did not peak until seventy-nine to ninety-one days and had only a single peak. In 1969, only the Date I packages were similar to 1968 trends (above). In the Date I two pound group the peak production occurred at seventy-nine days. In Dates II and III the brood production was similar on both sizes; the three pound packages produced more brood, at least during the first six weeks, with peak production at seventy-nine days. The data indicates a tendency for peaks to occur after a set period of growth for a particular package size. Sealed brood production shows a similar pattern to that of total brood (Figures IX, X, XI).

(ii) Sealed Brood

For general trends in sealed brood production for all groups in 1968 and 1969, see Figures XII, XIII, XIV and Table XII.

In the 1968 data, package size had an effect only at seventy-nine and ninety-one days ($P \leq 0.05$, Table XII), when the two pound packages produced more sealed brood than did the three pound ones. The same effect was shown in total brood (See previous section). At nineteen days package size showed no effect on sealed brood area, but the three pound packages had a larger total brood area ($P \leq 0.05$).

In 1968, hiving date showed an effect only at forty-three days. However, nineteen and thirty-one day measurements were not made on all groups (See Table XI), so these may have also been different (See 1969 data following). At ninety-one days, Date I out produced Date III ($P \leq 0.05$). At forty-three days the effect parallelled that of total brood measurements (Table XIII). The effect at ninety-one days differed from that of total brood (Table XIII).

During the 1968 season, Date II produced the most sealed brood in five of six measurements, but only at nineteen days was the difference significant ($P \leq 0.05$) (Table XIII).

In 1969, the three pound packages produced more sealed brood at the nineteen, thirty-one and forty-three day measurements ($P \leq 0.01$). The two pound packages did not produce more sealed brood at seventy-nine and ninety-one days as they did total brood (Table XII).

The effect of date on sealed brood production showed no consistent pattern in 1969. Relative positions of the three dates varied as to the measurement time (Table XIII). The comparison between the three Dates showed twenty-one comparisons to be significant ($P \leq 0.05$). Date II at forty-three days produced more brood than did Date I and Date III ($P \leq 0.05$), and at ninety-one days more than Date III ($P \leq 0.05$, Table XIII).

The 1969 differences between the sealed brood quantities of the three dates showed a similar pattern to that of

total brood quantities (Table XII). However, a difference between sealed brood and total brood relationships (i.e. significance between groups) were shown at ninety-one days and one hundred and three days ($P \leq 0.01$ and $P \leq 0.05$) respectively; sealed brood showed no significant difference. The differences between the two measurements originate in the differences in unsealed brood quantities between the groups at ninety-one days and one hundred and three days ($P \leq 0.01$) (Table XII).

No one hiving date in 1969 showed a clear advantage in sealed brood production as was shown in 1968. The reasons for this situation appear to be related to the several environmental factors which existed in 1969.

In 1969 flood conditions in the apiary site used in 1968 necessitated moving to a site which proved to be poor in nectar and pollen supplies during the spring and early summer. A supplementary pollen material had to be fed to colonies (See Chapter III, method). Figures XIII and XIV show a depression in the amount of sealed brood during the June period. In the Date II groups and the Date III, three pound colonies, this depression is very plain. In addition to nutritional problems, weather conditions appeared to have provided approximately the same environment for each hiving date (See Chapter V, Table XXX). Normally cooler weather conditions probably retard brood-rearing at Date I and perhaps Date II. (Geiger,

1967). The cool temperatures may cause brood mortality by chilling if the brood next is too large. In addition the adult bees are prevented from foraging for fresh nectar, and pollen supplies, which is believed to stimulate brood rearing (Free, 1968).

As both weather and forage conditions varied between 1968 and 1969, only a general comparison of colony development in these two years would seem useful.

In 1968, all groups were producing 700 square inches of sealed brood by 3 July. In 1969, only Date I groups had produced or were producing five hundred square inches of sealed brood (Figure XII).

The 1967 and 1968 data indicate that the best brood production was by the Date II packages but in 1969, the Date I packages were the best. Spring weather conditions and food supplies have important effects on the development of the packages hived on a certain date in any one year.

(iii) Sealed Brood Production by Experimental Colonies During Specified Periods.

Sealed brood areas were recorded every twelve days during the study period each year, and these areas provided the total worker bee production for a colony for a specific period (i.e. if the measurements were taken on the first, the twelfth and the twenty-fourth of June, when the sum of the three areas is multiplied by twenty-five, the total number of

FIGURE XII - SEALED BROOD AREAS IN EXPERIMENTAL COLONIES:

DATE I - 1968 AND 1969

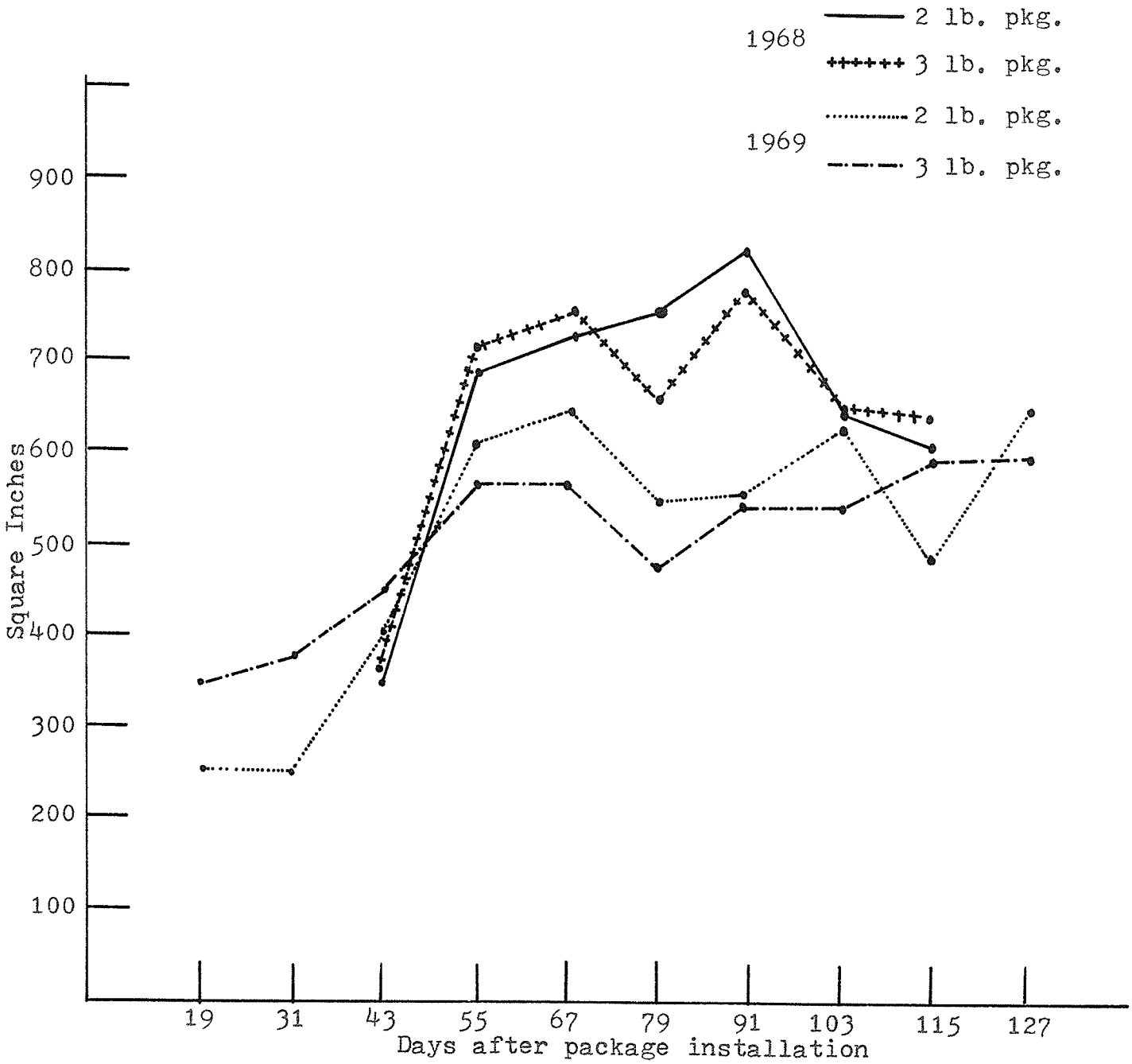


FIGURE XIII - SEALED BROOD AREAS IN EXPERIMENTAL COLONIES:

DATE II - 1968 AND 1969

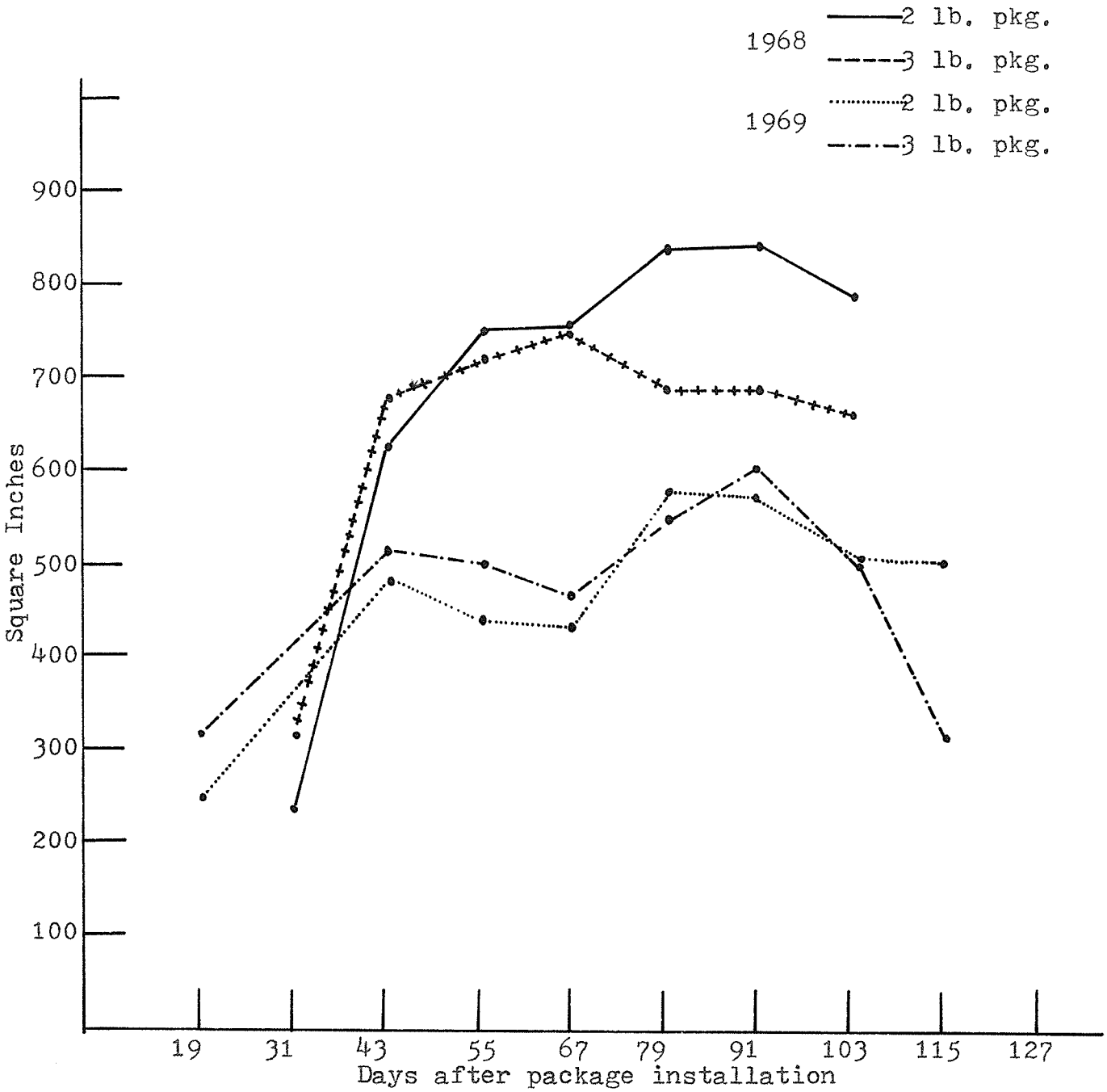
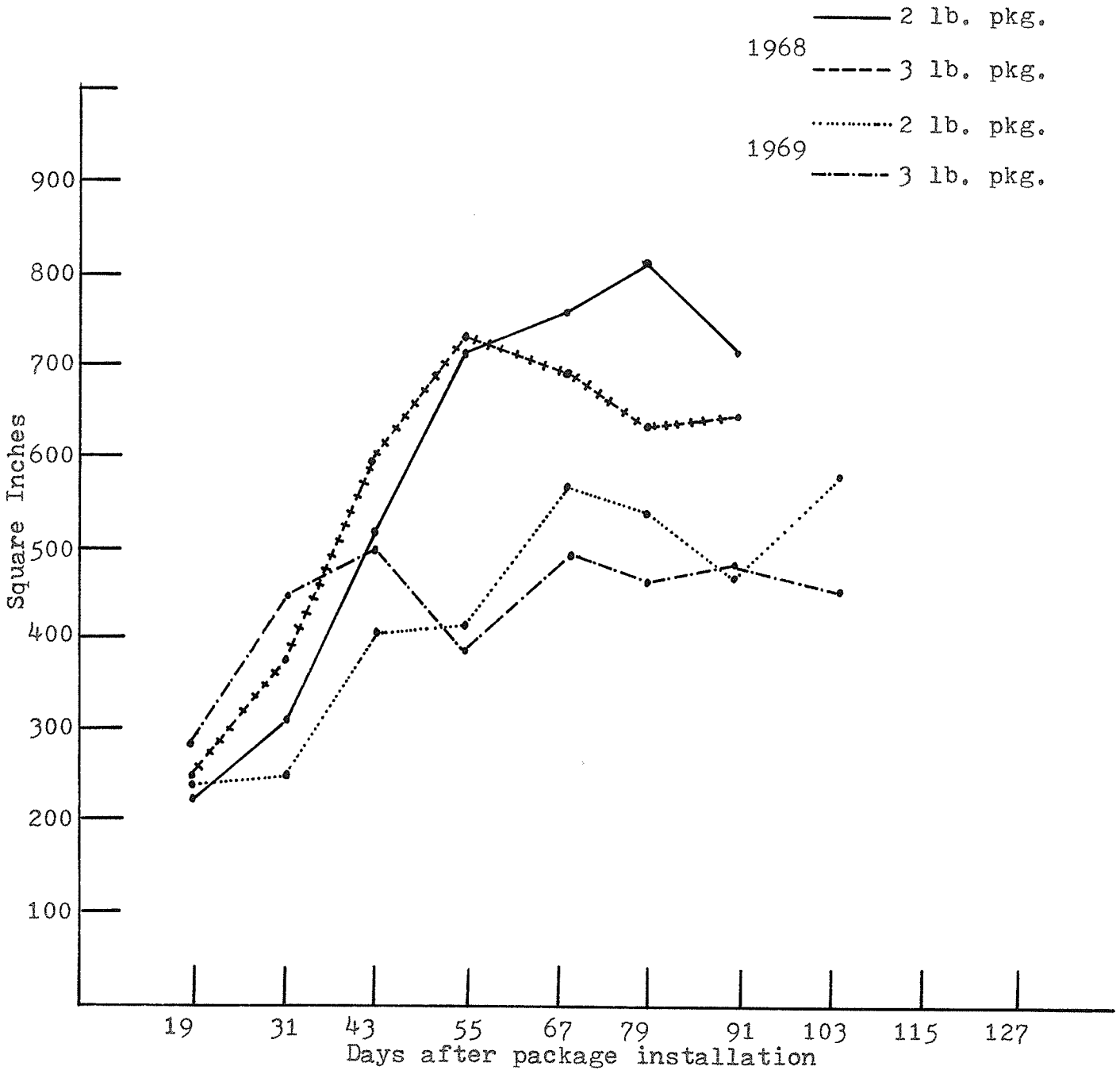


FIGURE XIV - SEALED BROOD AREAS IN EXPERIMENTAL COLONIES: DATE III - 1968 AND 1969



young bees hatched between June first and July sixth is obtained). In the measurements, the periods used did not exactly coincide with the monthly periods due to the dates when the actual measurements were made.

The sealed brood produced during June should hatch and provide foragers for the July honey flow, while July sealed brood should provide foragers for the August flow. Large quantities of sealed brood, produced during the active season would be expected to produce large adult populations and hence large crops of honey (Farrar, 1937).

Comparison of the six groups in 1968 (Table XIV) showed that there was no significant difference between the sealed brood produced by the two pound and the three pound packages in June or July or the period first of June to eighth of August. In August the two pound packages, in two of the three dates, produced more sealed brood than did the three pound packages ($P \leq 0.05$). This partial reversal of the package size effect was significant in date-size interaction ($P \leq 0.05$).

Date of hiving affected the sealed brood production in June as follows: Date I > Date II > Date III; the differences of Date I vs. Date III and Date II vs. Date III were significant ($P \leq 0.05$) (Table XIV). During August sealed brood production ranked as follows: Date II > Date III > Date I with Date II significantly greater than Date I ($P \leq 0.05$).

In 1969 the three pound packages produced more sealed

brood than did the two pound ones during the May and June periods ($P \leq 0.01$) (See Table XV).

Colonies, from packages, hived on various dates produced differences ($P \leq 0.01$) in the total amounts of sealed brood produced during 1969 in the periods of May, June, first of June to eighth of August, and the total spring and summer period. In the May period, Date I Date II or Date III ($P \leq 0.01$); for the June period, Date I > Date II > Date III ($P \leq 0.05$); for the 1 June to 8 August period, Date I > Date II > Date III ($P \leq 0.05$); for total of the season's brood, Date I > Date II > Date III ($P \leq 0.05$).

Package size did not affect the total brood produced in the July period of either year. The June period of 1968 showed no difference between the two pound packages and three pound ones while June of 1969 did ($P \leq 0.01$). In 1969 the environmental conditions (Chapter lV B-1-(b)) appear to have retarded sealed brood production, particularly in the Date II and Date III packages. This effect was not noted in 1968 and the two pound packages were not significantly different than the three pound ones in sealed brood production during the June period.

In ten of the twelve July and August measurements made in the two years the two pound packages out produced, in sealed brood areas, the three pound packages which were hived on the same dates. This vigorous growth and development of

the two pound packages should affect the foraging and honey production (Free, 1968); this was observed in the nearly equal performance of the two and three pound packages although the three pound packages had larger populations (Chapter IV-4).

The sealed brood production in the 1 June to 8 August period should indicate the foraging potential of a particular experimental group. In 1968 no significant difference was shown between either package size or any of the three hiving dates. During the 1 June to 8 August (1969) period, only hiving date affected the sealed brood production with Date I Date II or Date III ($P \leq 0.01$).

The two Date I groups in 1969 produced more honey than did the Date II or Date III groups ($P \leq 0.01$). Sealed brood production was greater for these two former groups. However, in Date I the two pound group outproduced the three pound group (Chapter IV -5-(b)), although sealed brood production was similar (Table XV). This condition may have resulted from the small number of hives used in each group's average.

2. Results and Discussion of Adult Population Measurements

The six groups of colonies were compared in two ways; first by plotting population measurements at various spring and summer dates (Figure XV); and second by directly compar-

TABLE XIV - PRODUCTION OF SEALED BROOD FOR PERIODS IN 1968

		Measurement Period			
Hiving Date	Package Size	June	July	August	May 31-Aug8
1	2 lb.	1756	1567	1232	4490
1	3 lb.	1815	1538	1403	4878
11	2 lb.	1597	1597	1642	4836
11	3 lb.	1712	1277	1381	4356
111	2 lb.	1118	1477	1530	4123
111	3 lb.	1316	1421	1240	4046
Sig. Size		N.S.	N.S.	*	N.S.
Sig. Date		**	N.S.	*	N.S.
Sig. Size-Date		N.S.	N.S.	**	N.S.

* $P \leq 0.05$

** $P \leq 0.01$

TABLE XV - PRODUCTION OF SEALED BROOD FOR PERIODS IN 1969

		Measurement Period					
Hiving Date	Package Size	May	June	July	August	May 31-Aug. 8	Total
1	2 lb.	481	1648	1101	1759	3844	4946
1	3 lb.	715	1574	1005	1703	3663	4932
11	2 lb.	245	1152	969	1587	3172	3863
11	3 lb.	312	1356	1017	1397	3504	4129
111	2 lb.		878	980	1590	2835	3439
111	3 lb.		1224	873	1539	3121	3643
Sig. Size		**	**	N.S.	N.S.	N.S.	N.S.
Sig. Date		**	**	N.S.	N.S.	**	**
Sig. Size-Date		**	**	N.S.	N.S.	*	N.S.

Key: * - $P \leq 0.05$

** - $P \leq 0.01$

ing groups after the passage of a certain development period, (Figures XVI and XVII; Figure XVIII; Table XII).

Figure XV shows that the average rates of population growth and population levels attained by the six groups up to July, 1969 were similar. After the beginning of July, the Date II, two pound group developed abnormally. Figures XIII shows the low level of sealed brood produced by this group during June, which in turn would be expected to depress the July adult population. However, the Date II three pound group also had a low sealed brood production in the same period but not a marked decrease in July's adult population. The August 22 adult estimations were done on group samples; three hives were used for the Date II, two pound group, and therefore this reading is not wholly reliable. The similar condition is true for the August 22 reading of the Date III, two pound group.

The groups of colonies tended to merge in adult population numbers during August (Figure XV). Five of the six groups reached adult population levels of 45 to 52 thousand by 22 August. Differences in average populations between the groups was not significant (Table XII).

The population level attained at a certain time during the season should affect the nectar gathering (i.e. nectar flow, Chapter IV - A-(3)) or pollinating potential of a colony; Table XVI shows the average populations of the six

FIGURE XV - ADULT BEE ESTIMATIONS OF PACKAGE SIZE - HIVING DATE GROUPS DURING THE 1969 SEASON

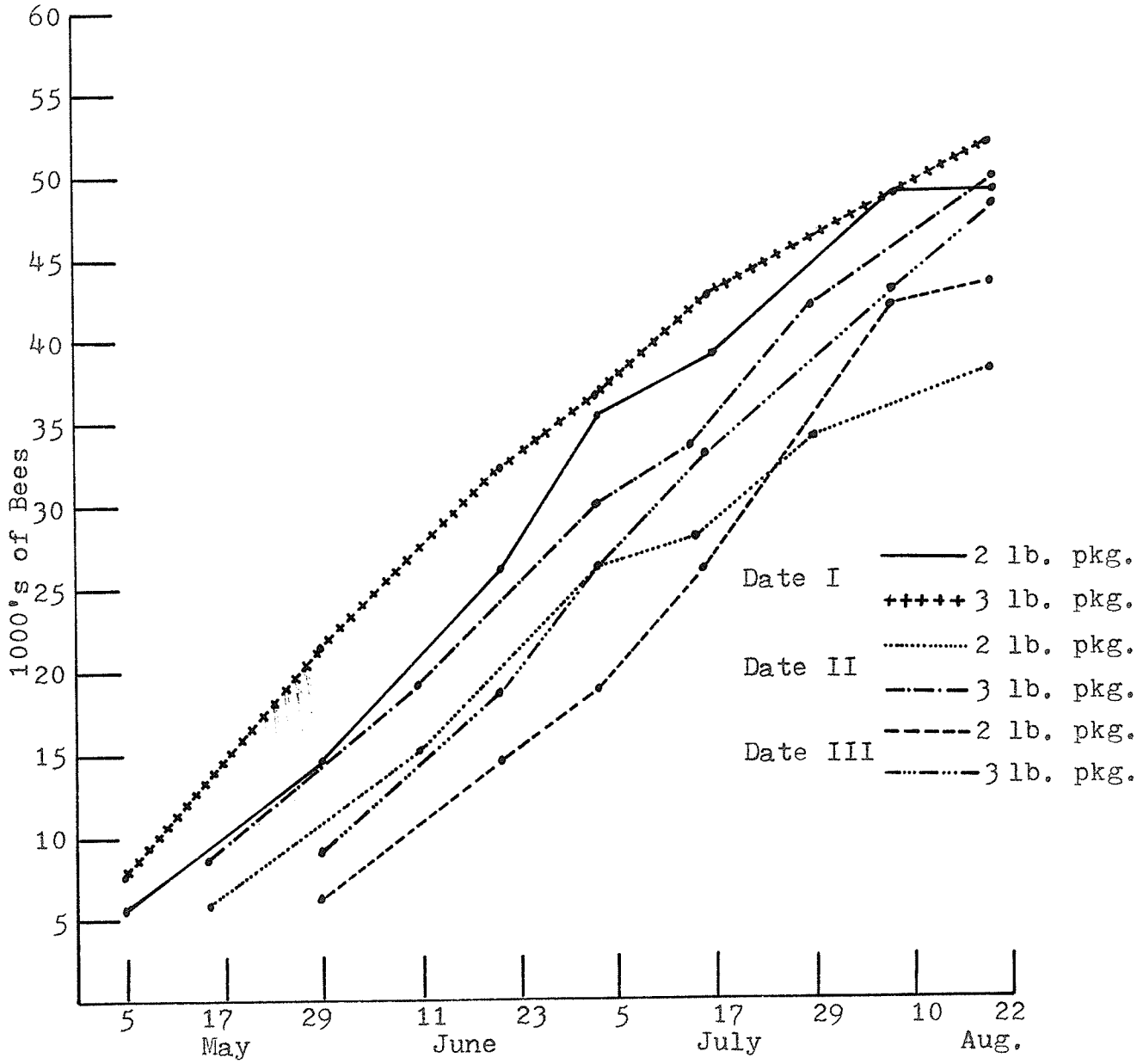


FIGURE XVI - ADULT BEE POPULATIONS SHOWING THE EFFECT OF HIVING DATE ON TWO POUND PACKAGES - 1969

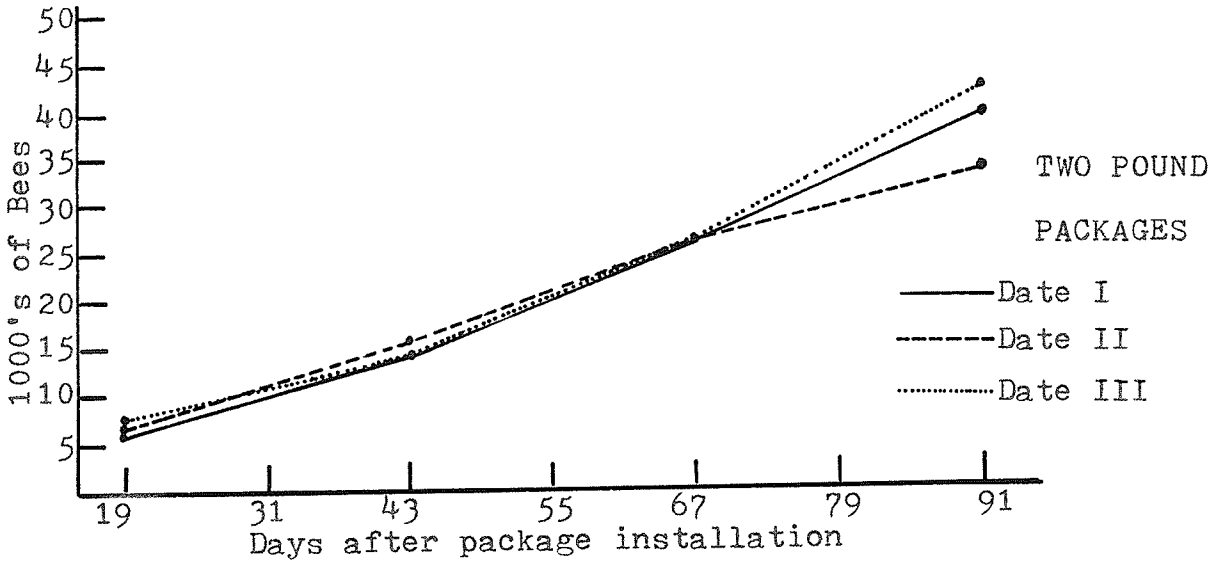


FIGURE XV11 - ADULT BEE POPULATIONS SHOWING THE EFFECT OF HIVING DATE ON THREE POUND PACKAGES - 1969

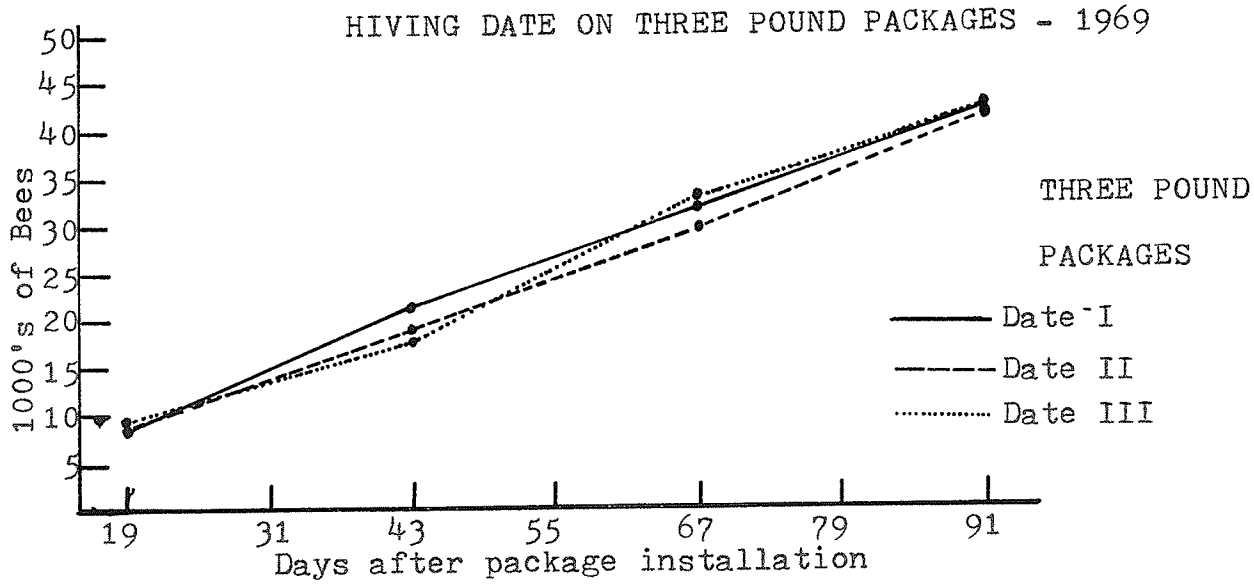


FIGURE XVIII - THE EFFECT OF PACKAGE SIZE ON ADULT BEE POPULATIONS AT THREE HIVING DATES - 1969

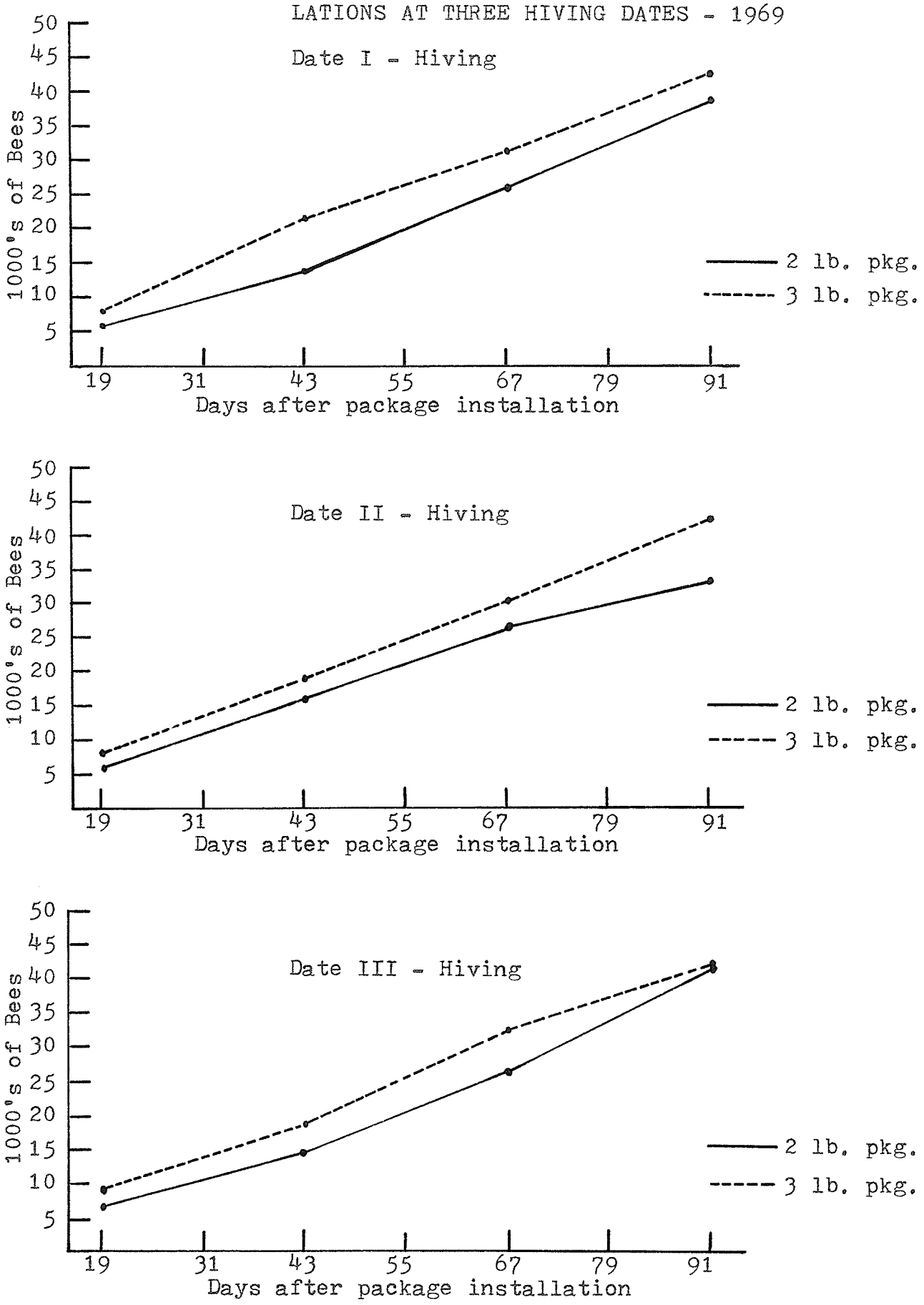


TABLE XVI - ADULT POPULATIONS OF THE 1969 EXPERIMENTAL COLONY GROUPS AT TWO SUMMER DATES

Size	Date I 2 lb.	Date I 3 lb.	Date II 2 lb.	Date II 3 lb.	Date III 2 lb.	Date III 3 lb.
July 3[1]	357	[3] 369	261	[3] 302	189	[1] 262
July 17[1]	395	[3] 430	282	[2] 341	265	[2] 336

1) $P \leq 0.01$ 2) $P \leq 0.05$

3) Non significant

TABLE XVII - RANKING OF HIVING DATE ACCORDING TO ADULT BEE PRODUCTION AT TWO SUMMER DATES

July 3	$D_1 > D_2 > D_3$
July 17	$D_1 > D_2 > D_3$

groups of colonies at 3rd July and 17th July, and the average group populations based on sampling each group at 22nd August.

At 3rd July, the Date III, three pound packages produced more adults than did the two pound packages ($P \leq 0.01$). The 17th July measurements showed that three pound packages produced more adults than did the two pound packages in the Date II or the Date III groups ($P \leq 0.05$). As previously discussed in this part, the Date II, two pound colonies appear to be abnormal during July.

The date of hiving produced the population ranking as shown in Table XVII. The population level was directly affected by the length of time a group had been established. At July 17th the three dates were closer in population than at 3rd July ($P \leq 0.05$ at 17th July versus $P \leq 0.01$ at 3rd July). In more favorable June conditions this difference in population would probably have been less (See 1967 results Chapter IV-B-1-a).

A direct comparison of development time for the six groups for 1969 shows the advantage of the three pound package up to ninety-one days (Figure XVIII); this difference was significant up to sixty-seven days ($P \leq 0.01$; Table XII).

The date of hiving of either a two or three pound package resulted in a difference in adult population only at nineteen days ($P \leq 0.05$) (Table XII-1969). Figure XVIII shows the parallel development of the three dates of two and three

pound packages. At nineteen days the ranking of the three dates was Date III > Date II > Date I with significance only between Date III and Date I ($P \leq 0.05$).

3. Population Relationships During the Season

The adult population and brood area measurements made in 1969 allow for calculations of colony brood rearing efficiency (Farrar, 1931; Michener, 1964). The efficiency of brood production is a control on the rate of colony growth.

Table XVIII shows the decline in the ratio of total and sealed brood to adult bees as the adult populations of the colonies increased. The relationship is an inverse linear one (Figures XIX, XX, XXI). Deviations at sixty-seven and seventy-nine days in Date II colonies and fifty-five days for Date III colonies were related to nutritional problems (Chapter IV-A-1 and Figures XIII and XIV). Figure XXI and Table XIX show that changes in the brood to adult ratios did have a seasonal pattern in certain groups. The level of development of a group (i.e. the latter June Date III, three pound group was vigorously expanding while Date I, two pound group already had a large population), and the food required by a group (i.e. Date III three pound would require more food than the Date III, two pound one) are two factors which would influence the brood levels and hence the brood to adult ratios.

The highest efficiency occurred when the colonies were smallest (i.e. at nineteen days). There was no increase

TABLE XVIII - THE RATIO OF BROOD CELLS TO ADULT BEES IN THE EXPERIMENTAL COLONIES AT SPECIFIED PERIODS AFTER HIVING, 1969

Comb	TOTAL BROOD						SEALED BROOD					
	DI-2	DI-3	DII-2	DII-3	DIII-2	DIII-3	DI-2	DI-3	DII-2	DII-3	DIII-2	DIII-3
Reading												
19 da	2.02	1.79	1.88	1.72	1.77	1.56	1.13	1.07	1.04	0.90	0.93	0.77
31 da												
43 da	1.39	1.24	1.55	1.47	1.37	1.22	0.68	0.52	0.77	0.66	0.68	0.67
55 da					1.20	0.89					0.55	0.36
67 da	1.24	0.88	0.93	0.89	1.06	0.82	0.63	0.43	0.41	0.39	0.54	0.36
79 da	0.82	0.77	1.18	0.97			0.38	0.32	0.51	0.41		
91 da	0.74	0.69	0.87	0.65	0.61	0.60	0.35	0.31	0.42	0.35	0.28	0.28
103 da					0.66	0.53					.32	.23
115 da	0.57	0.58	0.71	0.34			0.25	0.30	0.33	0.16		
127 da	0.64	0.60					0.33	0.28				

TABLE XIX - THE RATIOS OF BROOD CELLS TO ADULT BEES IN THE EXPERIMENTAL COLONIES AT CERTAIN DATES DURING THE 1969 SEASON

Comb	TOTAL BROOD						SEALED BROOD					
	DI-2	DI-3	DII-2	DII-3	DIII-2	DIII-3	DI-2	DI-3	DII-2	DII-3	DIII-2	DIII-3
Reading												
May 5	2.02	1.79					1.13	1.07				
May 15			1.88	1.72					1.04	0.90		
May 28	1.39	1.24			1.77	1.56	0.68	0.52			0.93	0.77
June 9			1.55	1.47					0.77	0.66		
June 20	1.24	0.75			1.37	1.22	0.63	0.43			0.68	0.67
July 3	0.82	0.77	0.93	0.89	1.20	0.89	0.38	0.32	0.41	0.39	0.55	0.36
July 16	0.74	0.69	1.18	0.97	1.06	0.82	0.35	0.31	0.51	0.41	0.54	0.36
July 30			0.87	0.65					0.42	0.35		
Aug. 8	0.57	0.58			0.61	0.60	0.25	0.30			0.28	0.28
Aug. 20	0.64	0.60	0.71	0.34	0.66	0.53	0.33	0.28	0.33	0.16	0.32	0.23

FIGURE XIX - BROOD-ADULT POPULATION RATIOS AT INTERVALS AFTER HIVING - 1969

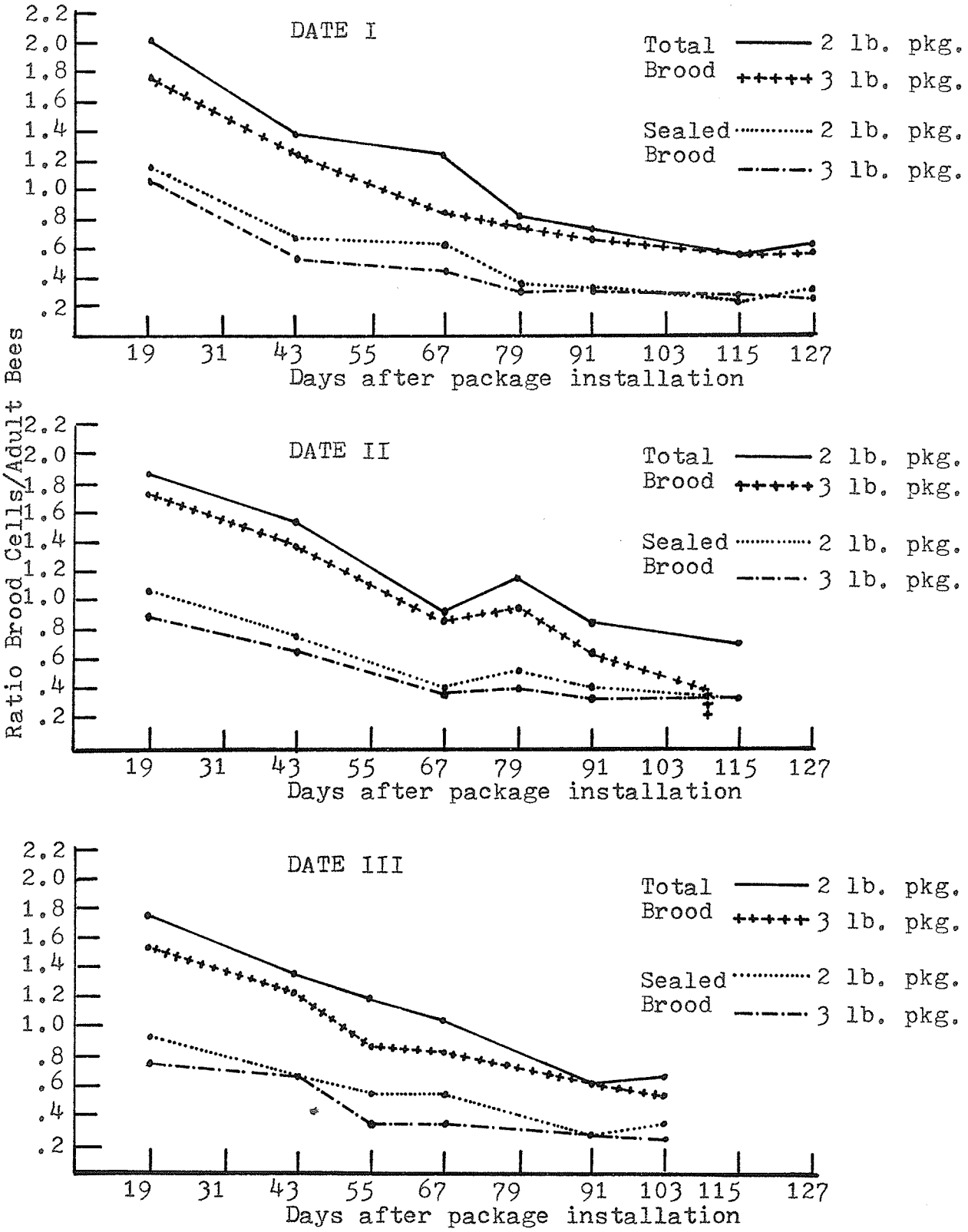
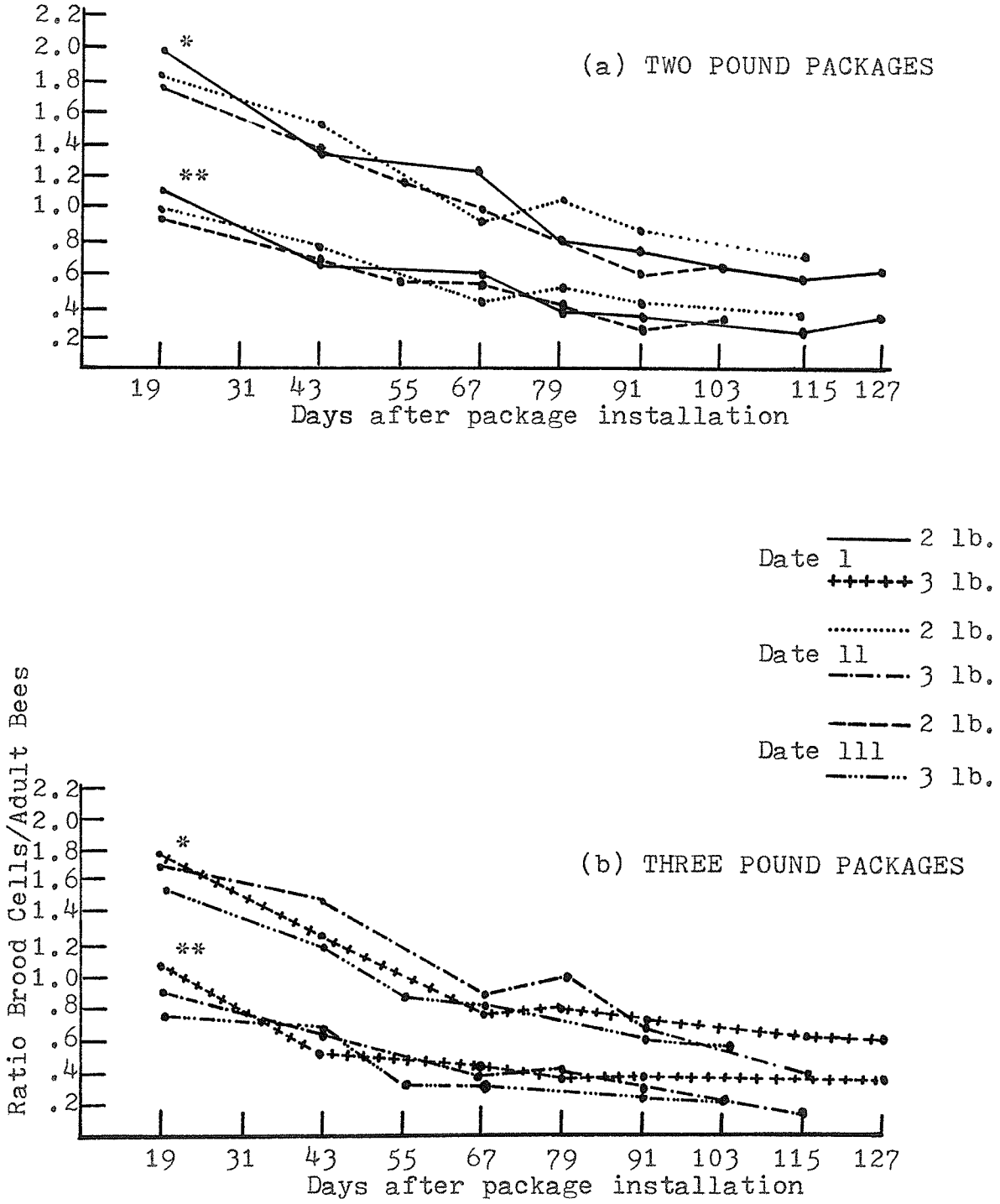


FIGURE XX - A COMPARISON BY PACKAGE SIZE OF BROOD TO ADULT RATIO - 1969



* total brood

** sealed brood

FIGURE XXI - BROOD TO ADULT RATIOS OF TWO POUND PACKAGE SIZES AT VARIOUS SUMMER DATES - 1969

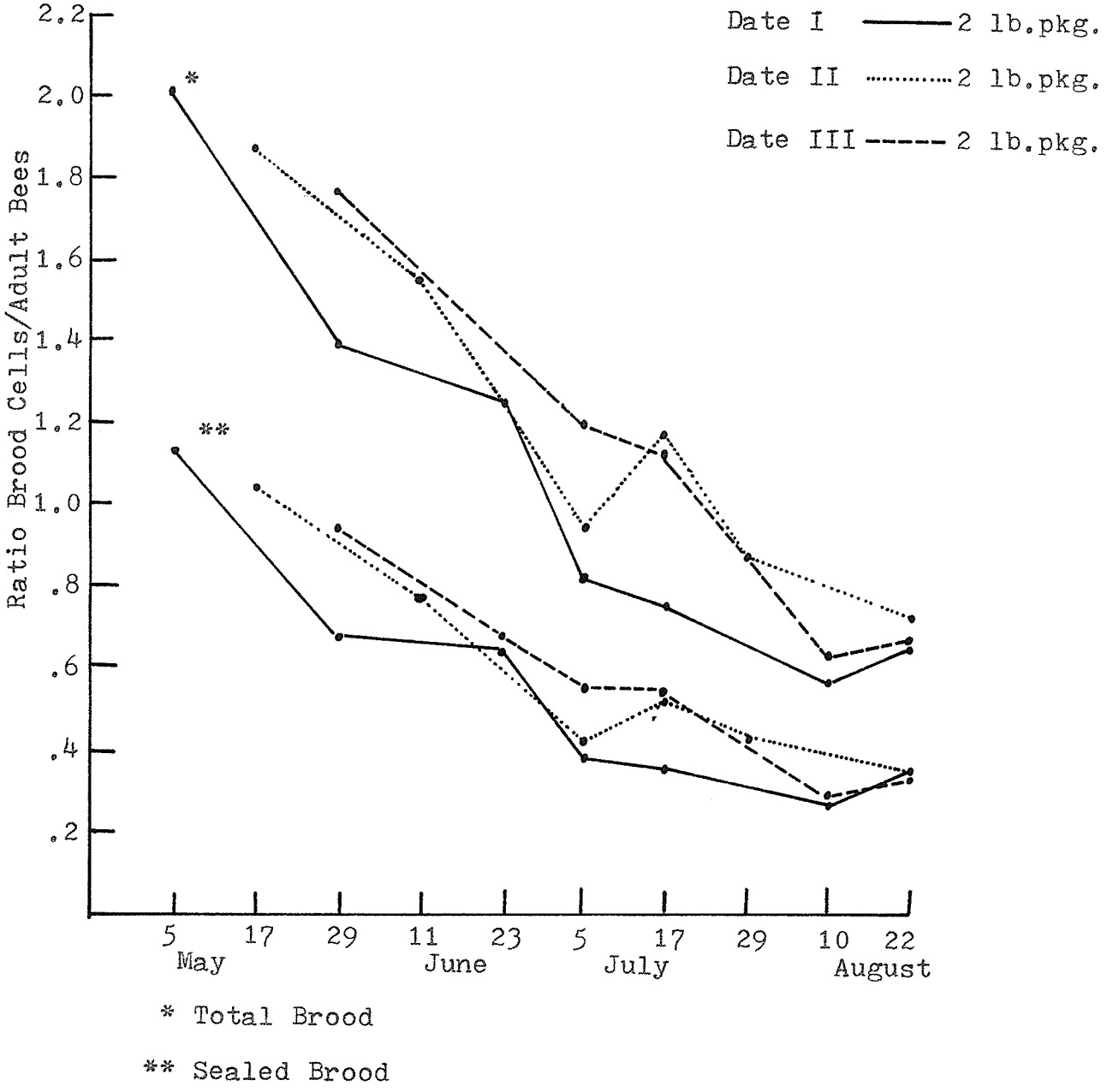
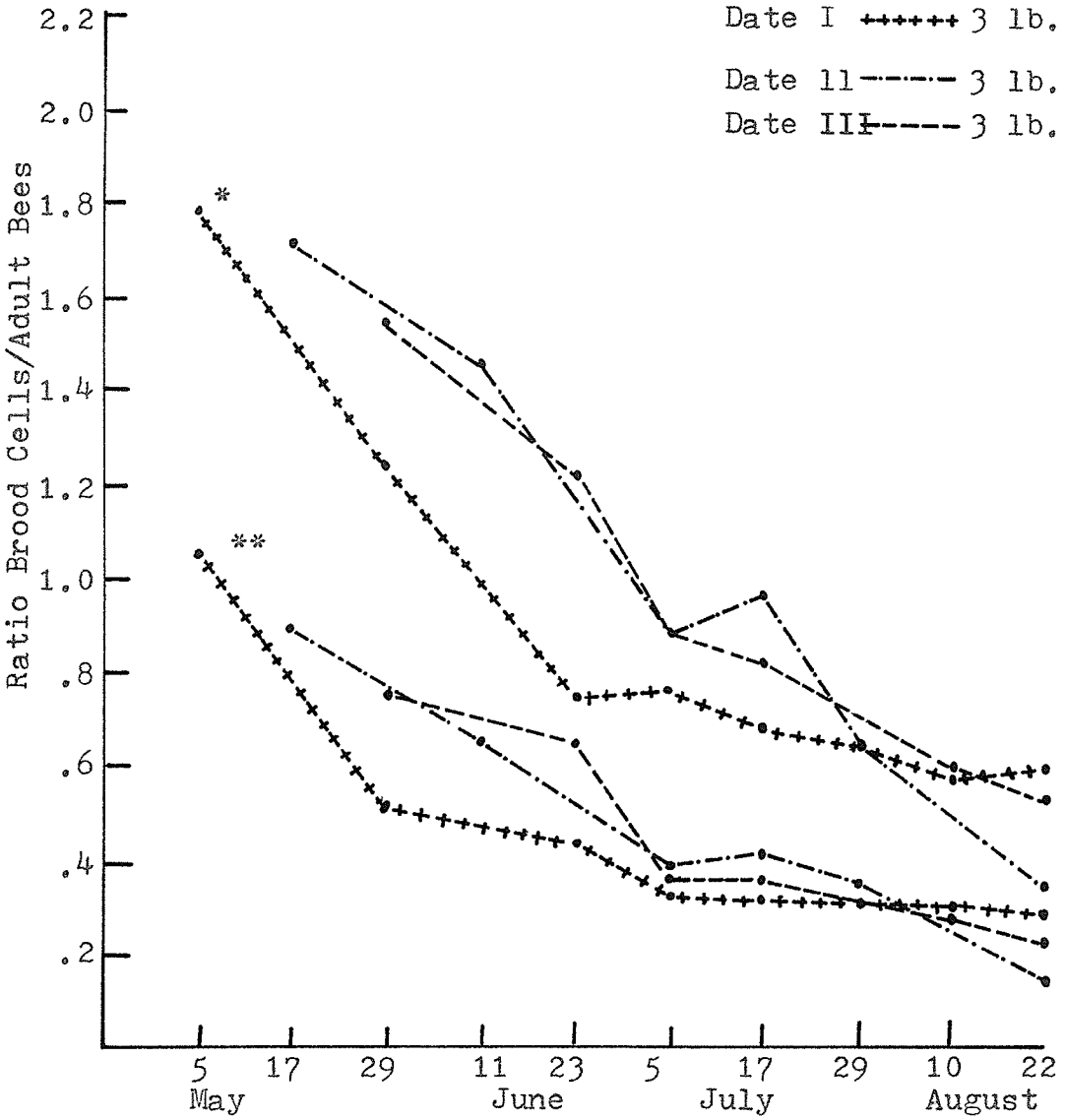


FIGURE XXI - (continued) - BROOD TO ADULT RATIOS OF THREE POUND PACKAGE SIZES AT VARIOUS SUMMER DATES - 1969



* Total Brood

** Sealed Brood

in efficiency of brood rearing by the two later hiving dates (Table XVII). The increase in efficiency of later hived packages would be expected, according to the results of the 1967 experiments (Figure VIII).

The two pound packages were more efficient at brood rearing than were the three pound packages up to ninety-one days (or longer) in the six groups. (Figure XIX). However, more absolute total and sealed brood were produced by the three pound packages due to the larger brood area which they supported (Table XI).

Brood to adult ratios of the three dates of hiving were compared directly for two and three pound packages (Figure XX). The colonies hived at any one date, from the two or three pound packages, appear to be equally efficient in producing brood. However, as previously noted, the two pound are more efficient than the three pound packages.

Total and sealed brood to adult ratios are similar in trend. Sealed brood is considered to be most invulnerable, and hence this ratio is probably most useful for indications of the actual growth trends in a colony.

During May and June, in Manitoba, the beekeeper should be developing a large population of bees to prepare for the July nectar flow. The more quickly this can be accomplished the later the date when the packages can be installed and thus utilize the better temperature and forage conditions.

The higher the brood to adult ratio, the more bees that can be produced in a short period. In the 1969 studies there was little difference in the ratios of total, or sealed, brood to adult bees produced for individual groups (Figure XX). The colonies tended to start at a similar efficiency level and decrease at each successive measurement (Figure XX). Preliminary work in 1967 indicated that the later the hiving date the greater would be the brood rearing efficiency. This was not supported in the 1969 experiments. The 1969 data indicates that the forage availability was probably an important factor influencing the brood rearing efficiency. Increasing the rate of colony growth, therefore, is dependent on the discovery and modification of certain important factors influencing colony development.

4. Results and Discussion of Entrance Activity Counts

Table XX and Figure XXII show the results for the 1969 experimental groups. Table XXI shows comparisons between forager activity and other hive measurement parameters. The index values are found by expressing each group value for a parameter as a fraction of the lowest value.

The results obtained on the three July and four August sampling dates were pooled for each month.

The traps captured returning bees which were assumed to be foragers returning from the field. The counts were

made during the honey flow in order to determine the effectiveness of each colony in fielding a nectar gathering force.

July collections showed no differences between pollen gatherers from the six groups, while the foragers not gathering pollen were different (P 0.01). Package size difference was due to the hiving date; Date I> Date II>Date III; (significant differences occurred between Date I and Date II, as well as between Date I and Date III ($P \leq 0.05$). There was no significant difference between the two package sizes.

Numbers of bees foraging for pollen in July differed numerically between the groups (i.e. 11.2 to 17.9) which was 11.8 to 20.0 per cent of the total foragers. Date I had the lowest percentage of pollen foragers which may have resulted in a higher nectar gathering force and hence a higher honey production occurred in the Date I group as compared to that of the Date II or Date III ones ($P \leq 0.01$).

Foragers not collecting pollen during the month of July were not significantly affected by size of package. The equalizing tendency of two and three pound packages in development in July has been noted in both the sealed brood production levels and the amounts of sealed brood produced in a given period. Date of hiving produced a larger non-pollen collecting foraging population in Date I than in Date II ($P \leq 0.05$) or Date III ($P \leq 0.01$); Date II and Date III forager populations were not significantly different. The longer

TABLE XX - FORAGING ACTIVITY OF THE EXPERIMENTAL COLONIES DURING JULY AND AUGUST 1969

Group	DI - 2		DI - 3		DII - 2		DII - 3		DIII - 2		DIII - 3	
Class	PG *	NPG**	PG	NPG	PG	NPG	PG	NPG	PG	NPG	PG	NPG
Date Rep.												
July 1	23.1	97.5	25.3	127.6	14.8	41.7	14.3	93.7	12.6	57.0	16.5	54.0
" 2	27.8	94.1	25.6	115.4	26.3	71.0	23.3	57.9	17.0	56.7	29.1	64.6
" 3	10.8	180.5	15.5	143.7	14.9	96.6	15.4	110.1	9.6	73.5	12.6	75.0
" Average	17.9	134.3	18.7	123.2	17.3	71.5	18.2	103.7	11.2	64.7	16.0[1]	64.0[2]
" Standard Error	±2.7	±14.7	±3.1	±22.0	±0.8	±8.0	±3.3	±11.8	±1.8	±4.9	±4.2	±3.9
% PG of Total Foragers	11.8%		13.2%		19.5%		14.9%		14.8%		20%	
Aug. 1	13.9	111.4	19.3	162.3	16.4	102.4	16.0	162.2	12.0	89.9	19.9	126.3
" 2	8.3	171.2	9.6	140.4	6.8	164.1	5.9	122.9	7.2	120.7	12.3	92.0
" 3	22.3	116.1	13.7	85.6	10.8	54.8	9.4	63.2	9.7	73.4	17.6	52.3
" 4	5.0	222.0	7.6	157.1	3.5	130.2	0.9	92.1	4.5	146.6	4.5	110.3
" Average	13.6	159.2	15.2	139.2	8.0	116.1	6.4	97.9	7.9	106.8	13.5[3]	92.2[4]
" Standard Error	±1.2	±4.9	±27.0	±18.8	±5.9	±17.7	±1.0	±19.6	±1.7	±16.7	±2.7	±9.5
% PG of Total Foragers	7.9%		9.9%		6.5%		6.2%		6.9%		12.8%	

* Pollen Gatherers

** Non Pollen Gatherers

1) Not significant

2) $P \leq 0.01$ (6 groups)

3) $P \leq 0.05$ (6 groups)

4) $P \leq 0.05$ (6 groups)

TABLE XXI - RELATIONSHIPS BETWEEN FORAGER ACTIVITY, HIVE POPULATION, AND HONEY PRODUCTION (1969)

JULY Group	Period of Activity	Bee[1] Activity	Pop'n Estimation	% of[2] Foragers	Pop'n Index	Forager Index	Honey Prod. Index
DI-2 lb	July 22-31	152	41400	.367	1.36	2.00	1.54
DI-3 lb	July 22.31	142	44500	.319	1.46	1.87	1.28
DII-2 lb	July 22-31	89	31300	.284	1.03	1.17	1.00
DII-3 lb	July 22-31	122	38400	.318	1.26	1.61	1.05
DIII-2 lb	July 22-31	76	30500	.249	1.00	1.00	1.00
DIII-3 lb	July 22-31	80	36000	.222	1.18	1.05	1.02

1) No. of Bees Captured in 30 seconds

2) % of Foragers Captured in 30 seconds

continued.....

TABLE XXI (continued)

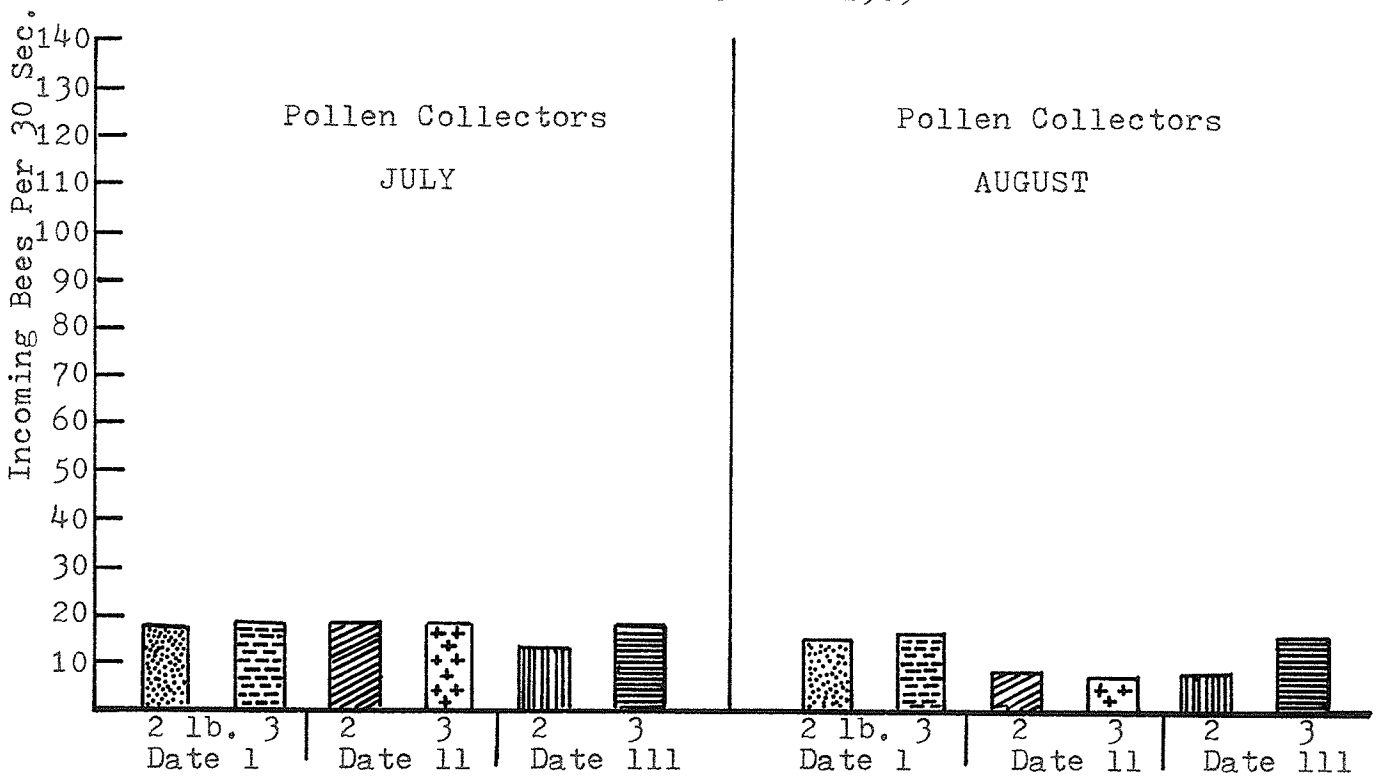
(AUGUST) Group	Period of Activity	Bee[1] Activity	Pop'n Estimation	% of[2] Foragers	Pop'n Index	Summer Ave[3] Pop'n Index	For-ager Index	Summer Ave. Forager Index	Honey Prod. Index
DI-2 lb.	Aug.1-18	173	49200	.352	1.36	1.36	1.66	1.83	1.54
DI-3 lb.	Aug.1-18	144	49100	.293	1.35	1.41	1.38	1.63	1.28
DII-2 lb.	Aug.1-18	124	36300	.342	1.00	1.02	1.19	1.18	1.00
DII-3 lb.	Aug.1-18	104	46300	.225	1.27	1.27	1.00	1.31	1.05
DIII-2 lb.	Aug.1-18	115	42700	.269	1.18	1.09	1.11	1.06	1.00
DIII-3 lb.	Aug.1-18	106	43100	.245	1.19	1.19	1.02	1.04	1.02

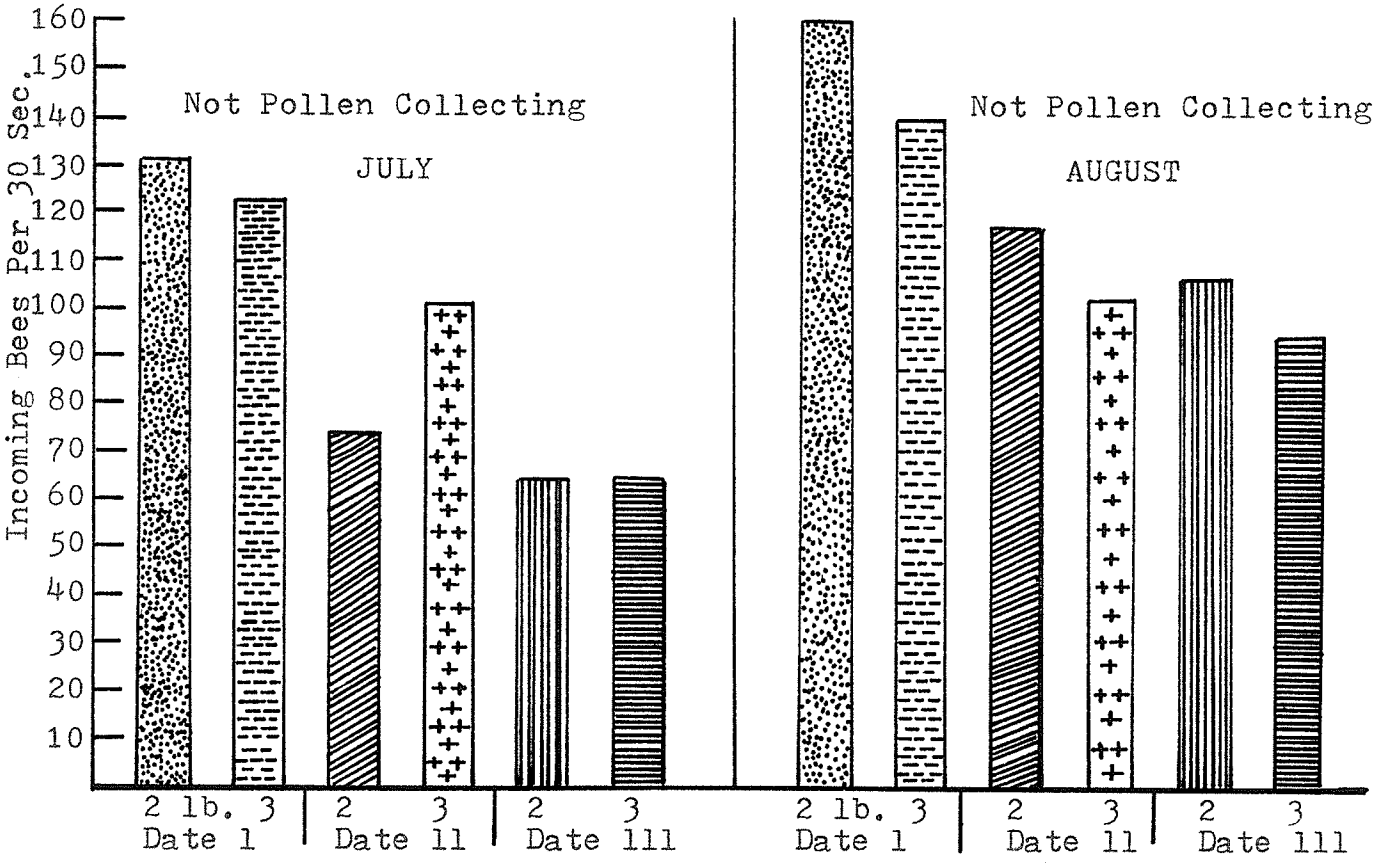
1) No. of Bees Captured in 30 seconds

2) % of Foragers Captured in 30 seconds

3) Summer Ave. = $\frac{\text{July} + \text{August}}{2}$

FIGURE XXII - FORAGING ACTIVITY OF THE EXPERIMENTAL COLONIES DURING JULY AND AUGUST 1969





development period of the Date 1 packages and to a lesser extent the Date 11 packages allowed more bees to be reared and this would affect foraging numbers (Farrar, 1937).

The August pollen gatherer counts analysis showed the package size produced no significant effect. Analysis of date of hiving showed that Date 1 colonies yielded more pollen foragers than did Date 11 (P 0.05).

Numbers of bees not collecting pollen in August were not affected by package size. Date of hiving allowed the Date 1 hiving date to outproduce Date 11 and also Date 111 (P 0.05). Date 11 and Date 111 forager differences were not significant.

The similar numbers of pollen collectors in the six groups during July may have influenced the constant unsealed brood quantities observed in the six groups during the 55, 67 and 79 day measurements as well as the constant quantities of sealed brood measured at 79, 91 and 103 days (Table X11-1969). The amount of pollen used by a hive will have an important bearing on the amount of brood reared.

Table XX1 shows a system of index numbers to compare the population and foraging levels of the six groups.

The lowest value for a parameter (i.e. adult population estimate) is given the value one (1.0) and all other values are expressed as a ratio of this value. In July, the Date 1 colonies had the largest percentage of foragers, popu-

lation levels and forager activity. During the season this Date produced the greatest honey crop.

The August values (Table XXI) show a pattern similar to that of July in the ranking of the three hiving dates in percentage of foragers, population levels, and forager numbers.

In the work, occasional problems associated with the entrance traps were: a "reluctance" of bees to enter the trap, entering and then leaving the trap, and the loss of forager pollen baskets before counting was completed on some August samples. However, these problems did not appear to significantly affect the results.

5. Results and Discussion of Honey Production Measurements in the Experimental Colonies.

(a) Use of Scale Colonies.

1967:

Two Date 11 scale colonies were used in the experimental apiary, one from a two pound and one from a three pound package (Table XXII, Figure XXIII). The largest percentage of the summer's honey yield occurred in July with July 14-18 giving the greatest five day gain. During August a heavy secondary flow also occurred. This August flow allowed the packages in the Date II and Date III (especially the two pound size) to make large gains because by August the populations of most groups tended to equalize (Chapter IV

-B-2 for 1969 results). The equalizing effect was noted in the results of the Commercial Honey Production Studies (Chapter IV, A-2).

1968:

Three scales were used, one for each date of the two pound packages (Table XXII, Figure XXIV). Highest honey production by two of the three colonies was in August with the greatest gain in a five day period occurring during August 8 to 12.

1969:

The gains from one colony from each experimental group are shown in Table XXII and Figure XXV. During July the pattern of the five day gains of the six groups varied only in quantity of honey gathered, but in August the pattern of gains varied considerably among groups (Figure XXV). This variation was probably due to differences in population levels attained by the various scale colonies and a more diversified forage in August than in July when sweet clover (Melilotus officinalis) appeared to provide for most of the forage.

(b) Total Honey Produced (1969)

Table XXIII shows the honey production of the six groups. Date I was the best producer; there was little variation between the four Date II and Date III groups.

Considerable variation occurred in the amount of honey

produced by individual hives in a group (L'Arrivee and Geiger, 1966; Kelty, 1948, and Moeller, 1961). The two pound packages in Date I and Date II showed the most uniform production by individual hives (See Standard Error, Table XXIII).

Package size did not produce a significant difference in honey yield. Date of hiving showed that Date I produced more honey than did Dates II or III ($P \leq 0.01$).

The apiary location probably was important in both variation in the yield of individual hives and in the low honey yields because forage sources were scarce for honey production. The diversity of the available forage gave different yields by the colonies (Moeller, 1961).

(c) The Relationship of Sealed Brood to Honey Production

As sealed brood quantities should indicate the population in a hive, and as honey production is related to adult population (Farrar, 1937), then the sealed brood production should relate to the honey production of a colony. Table XXIV lists the correlations between the amount of sealed brood produced in a period (i.e. month of June) and the honey the colony produced. While this correlation was significant for all three periods when based on all six groups, each Date of hiving and package size combination was different. Date 1 groups showed no correlation between June sealed brood and honey production, while Date II and Date III showed correla-

TABLE XXII - FIVE DAY GAINS OF EXPERIMENTAL SCALE COLONIES 1967-69

	1967		1968			1969					
	DII-2	DII-3	DI-2	DII-2	DIII-2	DI-2	DI-3	DII-2	DII-3	DIII-2	DIII-3
June 14-18	.5[1]	1.75				-5.5	-5.6	2.0	-3.0	-2.5	-2.0
19-23	-2.5	-3.75				-7.0	-3.5	-6.0	-3.0	-4.0	-2.0
24-28	-2.5	-2				-2.0	-2.5	0.0	-2.5	-0.5	0.0
29-July3	30	26				-10.5	-8.0	-2.5	-3.0	-3.5	-2.5
June Gains	25.5	22.0				-25.0	-19.6	-6.5	-11.5	-10.5	-6.5
July 4-8	26.5	19.2				3.0	2.0	-2.0	2.0	-0.5	0.0
9-13	24.5	36.8	-7.3	13.0	4.0	42.0	37.5	23.0	29.5	21.0	28.0
14-18	36.5	59.5	3.0	7.0	4.0	16.0	21.5	21.5	17.5	15.5	13.5
19-23	25.0	45	6.5	10.0	6.0	7.0	17.5	10.0	9.0	6.0	8.5
24-28	28	11	18.5	21.0	15.0	11.5	13.0	10.5	11.5	4.5	5.5
29-Aug.2	10	7.5	11.0	17.5	11.0	20.5	26.5	15.0	13.5	8.0	19.0
July Gains	150.5	179	31.7	68.5	40.0	100.0	118.0	78.0	83.0	54.5	74.5
Aug. 3-7	16.5	16.5	20.5	29.5	27.0	31.5	30.0	21.5	20.5	28.5	18.0
8-12	24.5	17.5	22.0	31	29.0	38.5	27.5	25.0	20.0	17.5	19.0
13-17	46.5	30	-1.5	-2.5	-1.5	-10.5	-3.0	-2.0	-8.5	-2.5	-6.5
18-22	37	36.5	-1.5	-2.5	-1.0		8.5	12.0	0.0	3.0	-1.0
23-27			.5	-0.5	3.5		.5	-3.0	-5.5	-1.5	-5.5
28-Sept1							-2.0	-1.0	-1.0	-1.5	-3.0
August Gains	124.5	100.5	40.0	55.0	57.0	59.5	61.5	52.5	25.5	43.5	21.0

1) lb. gain in five day period

FIGURE XXIII - NECTAR FLOWS RECORDED BY TWO 1967 EXPERIMENTAL COLONIES

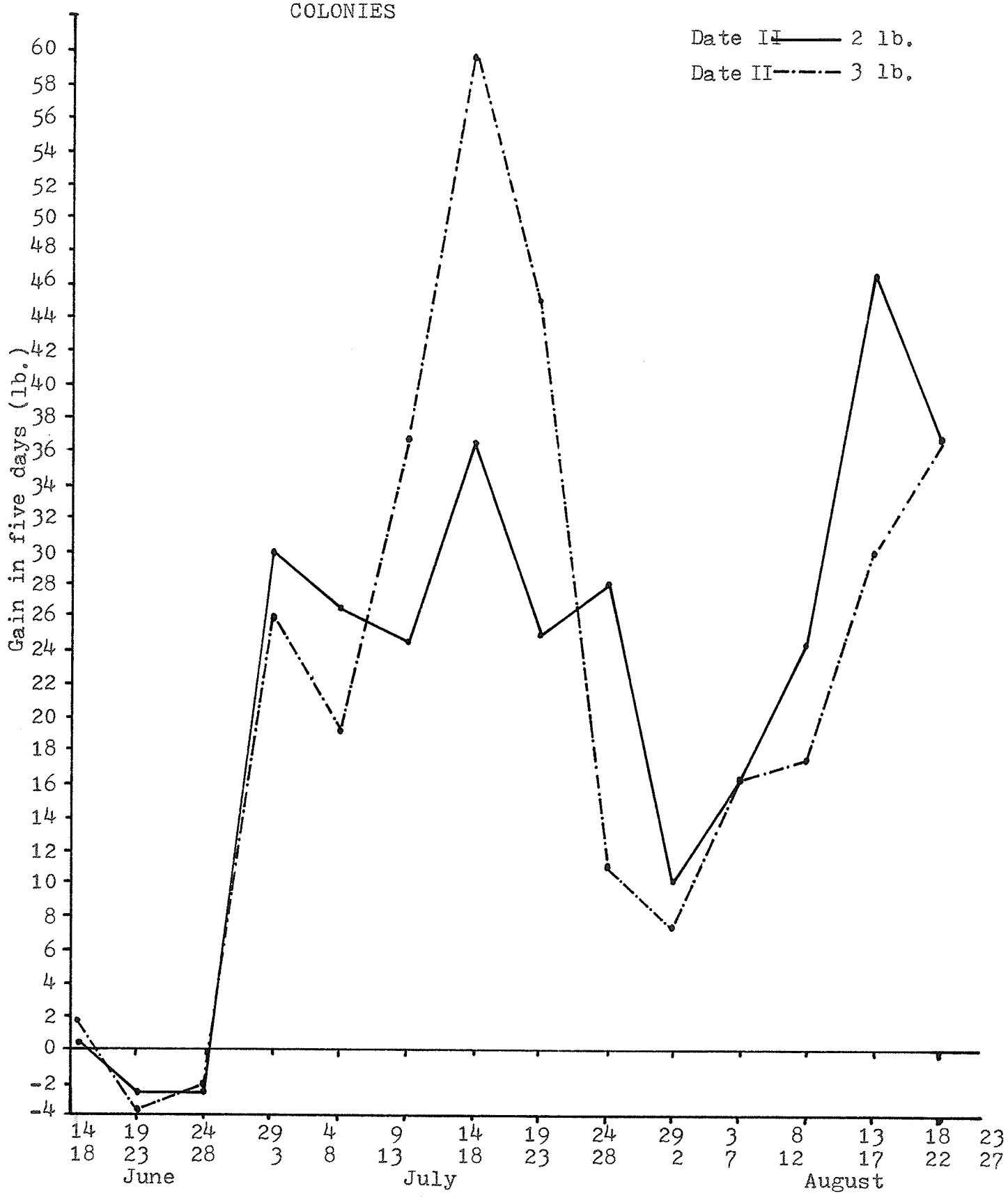
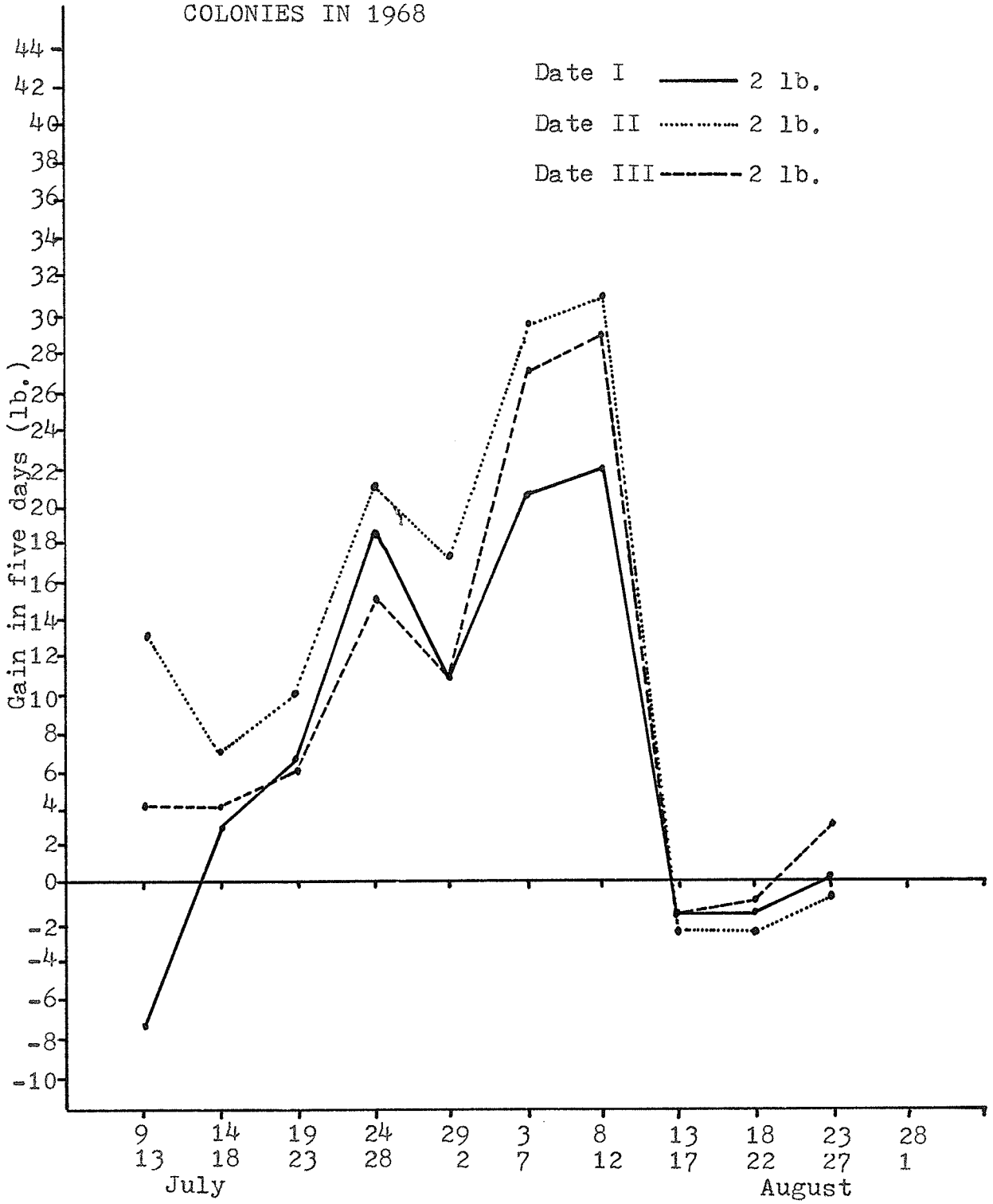


FIGURE XXIV - NECTAR FLOWS RECORDED BY THREE EXPERIMENTAL COLONIES IN 1968



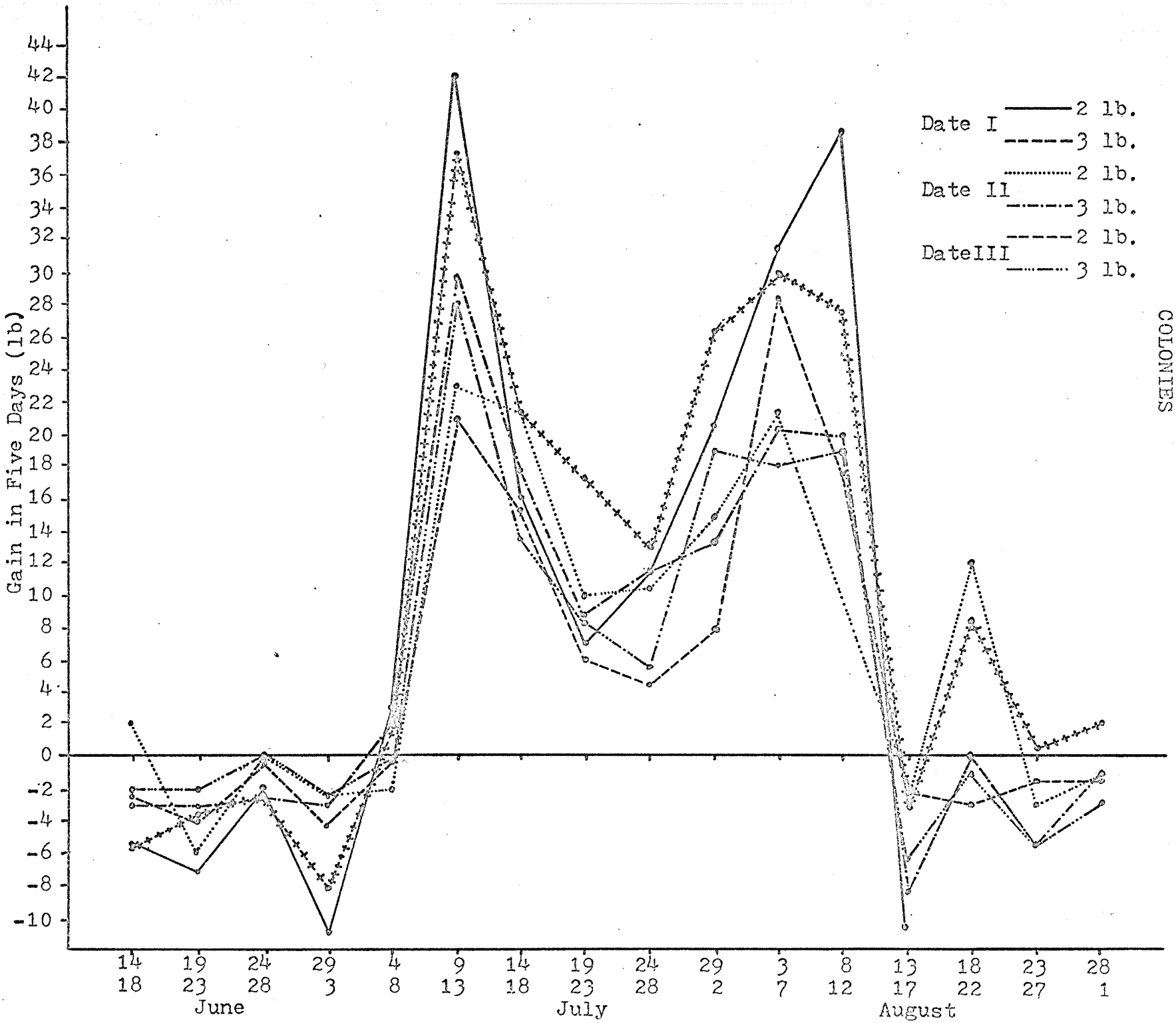


FIGURE XXV - NECTAR FLOWS RECORDED BY SIX 1969 EXPERIMENTAL COLONIES

TABLE XXIII - HONEY PRODUCTION (IB) IN THE EXPERIMENTAL COLONIES (1969)

	Date I	Date II	Date III
Two Pound Package	143 ± 4.7[1]	93 ± 5.3	93 ± 10.9
Three Pound Package	119 ± 11.9	98 ± 19.7	95 ± 10.2

1) S.E. - standard error

TABLE XXIV - THE RELATIONSHIP OF SEALED BROOD TO HONEY PRODUCTION

Period	Group	Significance
June	All groups	0.01
June 10 - July 20	" "	0.01
July	" "	0.02
June	Date I - 2 lb.	n.s.
June 10 - July 20	" "	n.s.
July	" "	-0.1
June	Date I - 3 lb.	-0.05
June 10 - July 20	" "	n.s.
July	" "	0.1
June	Date II - 2 lb.	0.02
June 10 - July 20	" "	n.s.
July	" "	0.1
June	Date II - 3 lb.	0.1
June 10 - July 20	" "	n.s.
July	" "	n.s.
June	Date III - 2 lb.	0.05
June 10 - July 20	" "	0.1
July	" "	n.s.
June	Date III - 3 lb.	0.1
June 10 - July 20	" "	0.01
July	" "	n.s.

tion ($P \leq .05$ to .1). The 10 June to 20 July period of sealed brood production was only significant in the Date III groups.

6. General Discussion of University Studies

An attempt was made in this study to measure various indicators of the development and growth of a honey bee colony.

The month of June appears to be very important in hive development. In 1968 rapid development was noted in total and sealed brood areas in all three hiving dates. In 1969 the Date II and Date II groups developed sealed brood areas slowly in June; the reason probably being mainly a nutritional one. Statistical analyses showed that the amounts of sealed brood produced in June by the Date II and the late Date III groups were correlated with their total honey production. This effect was not shown in the Date I groups. However, the Date I groups made the best gains on the July honey flow (Table XIV) and the large quantities of sealed brood present (Figure XII) must have provided bees for the July flow.

The three pound package had a significant effect up to seventy days in the amount of sealed and total brood which a colony supported. The larger amount of brood supported by the three pound colonies was most evident at nineteen and thirty-one days after hiving. The three pound packages

were less efficient in raising brood than were the two pound packages when cells of brood supported per adult bee were measured. The brood area growth pattern of the two pound packages usually increased progressively to a peak above that of the three pound package colonies. The three pound package colonies tended to reach an early peak and then remain constant or decrease and reach a second peak in brood areas (Figures IX to XIV).

The tendency of the two pound packages to steadily increase brood production may be an "incentive" for the colony to forage and thus produce honey (Free, 1968). This is especially true during July when populations are much lower than the 60,000 adult bee population, which is considered to be an efficient honey gathering unit (Farrar, 1937).

Date of hiving was significant in the development of the different groups of colonies. This is largely a function of differing environmental conditions. The 1967 Date II and Date III groups produced larger quantities of sealed brood during the initial periods than did the Date I groups (Figures VII and VIII). Temperatures in the period following Date I hiving were colder than either of those following Date II or Date III hivings. In 1968, although Date I and Date II did not have a complete set of measurements, a significant difference in brood production occurred at forty-three days (Table XII).

In 1968 Date II consistently produced larger brood areas than did Date I or Date III. The 1969 brood measurements showed date of hiving as being significant in all but two readings. Spring temperatures were more consistent in 1968 and 1969 than in 1967 (Table XXIX).

The adult populations were significantly different ($P \leq 0.01$) on 3rd July and 17th July; the nectar flow began between these two dates. The significance levels varied between package size according to hiving date (Table XVI). At 20 August, differences in adult population between the six groups were not found significant. The greater adult population of the Date I groups probably gave a greater forager force and eventually a greater honey crop than did the Date II or Date III groups. It was observed that the larger populated colonies provided more nectar collecting, but approximately the same number of pollen gathering bees. The larger population colonies also showed that a higher percentage of the adult population was engaged in foraging.

In the three experimental years Date II appears to have provided the most consistent results. Package size appears to have much less influence in the overall colony development and honey producing performance than does the date of hiving, within those dates used in this study (Chapter IV - Table XII).

CHAPTER V

MISCELLANEOUS STUDIES AND OBSERVATIONS

A. Abnormal Colonies in the University Studies

During the three years of the experiments certain colonies developed abnormalities. These abnormalities were due to queen loss or failure, swarming, and in 1969 some European foulbrood infection. In this analysis only the 1969 data are analysed (Table I).

1. Results and Discussion

The abnormal conditions will be classified as (a) queen problems, (b) queen failure or supersedure, (c) swarming, and (d) disease.

(a) Queen problems.

Queen loss sometimes occurred after an adult and brood measurement had been taken, indicating that the queen was lost during the operation or killed by the disturbed bees.

In the Date I, two pound colony #4 lost two queens which was replaced on 10 June and 30 June. The last queen which was introduced did not appear to perform well until 30 July reading. Its highest population of bees was 31,000 on 8 August. The group average surpassed this colony after 22

June. The low population contributed to its low fifty-eight pound honey production.

Colony #6 in this group lost a queen during the 5 May brood measurement. Introduction of the new queen was delayed, resulting in reduced brood rearing early in the season. The introduced queen was above average in brood production from 3 July to 8 August. The honey production indicates active development during the honey flow, which gave a honey production equalling the other hives with higher populations in the group, entering the honey flow. The high rate of brood production resulted in a large adult population at the end of the season.

Date I, three pound colony #4 lost its queen at the end of July. This colony probably had a poorly performing queen.

Date II three pound colony #5 had a queen replaced on 6 May and lost this queen on approximately 30 July. Its highest population was below 40,000 bees and its below average honey yield probably is a reflection of its low population early in the season.

Date III two pound colony #2 lost its queen about 8 August. Previous to this loss, the queen had been performing normally and therefore the fifty-eight pound honey production was probably not connected with queen loss.

Date III three pound colony #4 lost its queen about

3 July. Queen cells were introduced into the colony but no laying queen was reared. Although the maximum recorded population was only 23,500 in this colony 28 pounds of honey were produced.

(b) Queen Failure or Supersedure

This type of queen loss is difficult to analyse. Mother and daughter queens may lay together for a time period. Abnormal changes in brood quantities, which may originate from other than queen problems, are used as a criteria in this analysis. This results in a certain degree of speculation.

Date II three pound colony #8 showed a marked decline in brood production from 17 July to 30 July. The large decline in brood at the 8 August measurement probably indicates queen supersedure, or possibly swarming, as queen cells were present between July 16 and August 8. The unusual decline of the population in the summer was probably due to drifting of bees after the entrance traps were fitted to the hive in mid-July. The sixty-five pound honey crop was quite good, when the poor brood and adult population levels are considered.

Date III three pound colony #2 had a large reduction in sealed brood at about 3 July. Supersedure may have occurred although no queen cells were recorded. At mid-July a population redistribution probably caused the decline in adult numbers. Subsequently the brood production equalled or

exceeded the group average; however, the adult population did not exceed 35,000. This was approximately two thirds of the group average and the sixty-six pound honey crop was approximately two-thirds of the group average.

(c) Swarming

Queen cells, at all stages of active development, were removed during the summer. However, four of the experimental colonies did swarm.

Date I three pound colony #7 swarmed at the end of July. Up to this time the colony had performed well; both brood and adult production. The swarm was returned to the colony, but the queen was injured and no replacement queen was reared. The population remained high for much of the season but a negligible amount of honey was produced after swarming occurred.

Date II two pound colony #1 swarmed on 29 July. This swarm was lost and although the colony was performing above the group average in brood and adult production to this point, the honey crop was approximately one-third of the average of the normal hives in the group.

In Date II three pound colonies #1 and #4 swarmed. Colony #1 performed at an average level up to mid-July, when due to entrance trap disturbance, this colony gained bees from other colonies in the group. The excess population appears to have induced queen cell production (Table XXVIII),

and subsequent swarming. The honey crop of seventy-eight pounds was gathered in the latter half of July when the large population appeared to be very effective. Colony #4 performed above average in brood production until it swarmed on 28 July. The swarm was not captured. However, the high population recorded on 20 August indicates that the swarm must have returned to the hive. The colony produced no brood and little or no honey after the swarm emerged.

(d) Disease.

Preventive Terramycin treatments were given to all colonies during the spring development period. However, visual signs of European foulbrood were detected in hives on 3 July. These colonies were again treated with Terramycin.

In Date I two pound colony #5, brood production was poor until the end of July. The low July populations were probably responsible for the low honey yield. Date I three pound colony #4 had low brood production during late June and July; the queen was lost or killed in early August. Although a population of 28,700 was recorded on 3 July, no surplus honey was produced by this colony.

2. Summary.

As the number of abnormal colonies were limited, only general conclusions are warranted. In all but one of the abnormal cases noted, honey production was depressed below the group average of the colonies considered as normal. It

TABLE XXV - PERFORMANCE OF ABNORMAL COLONIES IN 1969

Group		Measurement	19da	31da	43da	55da	67da	79da	91da	103da	115da	127da	Honey Prod.	Problem	Entrance Activity etc.
DI 2 lb	4	TB	459	552	851	531	483	468	630	1050	1055		58 lb.	Q.loss J10+J30 Poor Queen	
		WSB	225	249	422	426	297	283	166	509	530				
		Ad	4800	-	13800	-	29100	24275	23600	-	31300				
	5	TB	365	514	690	892	737	462	810	1191	1188	1003	32 lb.	Poor Queen SomeEFB	
		WSB	265	196	343	428	429	178	257	602	606	464			
		Ad	5300	-	13000		21100	28700	29300		36700	42300			
	6	TB	447	239	416	891	1061	1207	1264	1418	1338	-		Q.loss	
		WSB	281	239	32	449	545	609	642	671	757	-	144 lb.		
		Ad	4200	-	15800	-	20000	30400	-	-	55700	54800			
	Group Ave.	TB	451	553	797	1171	1236	1108	1271	1285	1056	1205	143 lb.		
		WSB	251	248	400	599	654	540	548	623	489	647			
		Ad	5700	-	14700	-	26000	35700	39500	-	49200	50100			
DI 3 lb.	4	TB	414	706	697	1106	814	830	851	619	195		0lb.	PoorEFB Queen Q loss	
		WSB	315	283	329	509	388	322	354	294	-				
		Ad	8400	-	14300	-	20600	28700	33100	-	23700				
	7	TB	688	848	1011	1246	1199	1179	1425	1099	467	-	80 lb.	Swarmed July 29	
		WSB	402	472	455	628	599	527	607	474	418	-			
		Ad	7900	-	23100	-	36200	37700	43700	-	58500	52800			
	Group Ave.	TB	564	733	928	1099	1081	1059	1084	1060	1057	1160	119 lb.		
		WSB	341	375	449	566	559	473	531	529	585	567			
		Ad	7900	-	21700	-	32500	36900	43000	-	49100	52100			

TB - Total brood
WSB - Sealed worker brood
Ad - Adult bees

continued.....

TABLE XXV -(continued)

Group		Measurement	19da	31da	43da	55da	67da	79da	91da	103da	115da	127da	Honey Prod.	Problem	Entrance Activity Etc.
DII 2 lb.	1	TB	521	685	1125	1264	1164	1328	822	284	-			Swarmed July	
		WSB	289	256	536	581	611	673	566	0	-		34 lb.	July 29	92/30 sec.
		Ad	6200	-	17500	-	38700	37000	45700	-	29000				
	Group Ave.	TB	442	608	939	951	917	1147	1090	1046	1002		93 lb.		89/30 sec.
		WSB	245	229	480	443	431	577	575	508	509				
		Ad	5900	-	15600	-	26100	28200	34300	45800	38400				
DII 3 lb.	1	TB	631	849	1094	1181	1101	1049	378	64	-		78 lb.	Swarmed July 29	
		WSB	301	389	466	538	473	486	255	60	-				
		Ad	10400	-	21000	-	32000	49200	53200	-	40400				
	4	TB	678	789	1249	1312	1318	1363	1284	470	-		41.5 lb.	Swarmed July 29	
		WSB	328	423	577	629	613	401	673	434	-				
		Ad	8700	-	19900	-	29100	36300	40100	-	46050				
	5	TB	134	519	796	805	986	1212	1339	518	-		61.5 lb.	Q.loss July 30	
		WSB	114	183	451	340	444	595	624	474	-				
		Ad	9200	-	10000	-	21900	30500	39500	-	-				
	8	TB	570	809	1259	989	920	1180	800	395	630		65 lb.	Q.failing Possible supersedure	
		WSB	323	343	553	415	349	532	585	230	584				
		Ad	8200	-	17700	-	24400	19500	28400	-	-				
	Group Ave.	TB	589	757	1094	1036	1009	1215	1027	901	647		98 lb.		
		WSB	312	350	513	500	468	554	597	502	317				
		Ad	8700	-	19400	-	30200	34100	42600	49000	50100				

continued.....

TABLE XXV - (continued)

Group		Measurement	19da	31da	43da	55da	67da	79da	91da	103da	115da	127da	Honey Prod.	Problem
DIII 2 lb.	2	TB	405	541	720	932	991	1237	1052	343			58 lb.	
		WSB	232	209	397	388	521	475	558	310				
		Ad	5700	-	13000	16300	21600	-	40900	45400				
	Group Ave	TB	440	596	790	878	1056	1148	980	1106			93 lb.	
		WSB	234	244	400	413	569	538	471	574				
		Ad	6300	-	14700	18900	26500	-	42700	45800				
DIII 3 lb.	2	TB	511	779	839	463	840	1059	928	1010			66 lb.	Poor Q-possible supersedure
		WSB	302	383	497	99	315	412	521	510				
		Ad	9300	-	18400	24200	21300		33000	34900				
	4	TB	564	938	934	964	214	-	-	-			28 lb.	Q. loss
		WSB	261	539	442	382	176	-	-	-				
		Ad	8200	-	19400	22000	23800	-	18300	16700				
	Group Ave	TB	560	837	890	902	1003	987	950	967			95 lb.	
		WSB	280	392	391	524	508	527	473	512				
		Ad	9100	-	18700	22600	33600	-	43100	49000				

should be noted however that there was considerable variation in the honey production of the colonies considered as normal.

Queen loss had no effect on the honey production of one hive, but severely depressed it in the other three. A late season queen loss, whether by accident or failure to re-queen after swarming, appears to severely depress honey production of a colony regardless of hive adult population.

Any factor which tends to depress the rate of brood rearing, or hold the brood rearing at a low level, will binder colony development and performance. The association between hive population, as well as increasing brood production, on honey production has already been discussed and these principles appear applicable to the colonies classified as abnormal.

B. Drone Brood and Queen Cell Production

1. Introduction

The quantities of drone brood in colonies have been shown to be significantly affected by the time of the season and the amount of drone comb available (Allen, 1963; 1965) (Free, 1967).

Allen (1965) showed that the summer increases the quantities of drone brood and queen cells were synchronized in seasonal production but that the two quantities were not necessarily correlated.

Allen (1963; 1965) found no significant difference in worker brood production and honey production between control and treated hives in which the amount of drone brood had been artificially encouraged and was significantly greater than in the control colonies. No correlation between swarming tendency and drone production was observed.

Mitchener (1949), using a sample of 1087 swarms over a twenty year period, set the peak of the swarming season in Manitoba during the first week in July, and the swarming season from June first to mid-August.

2. Method

As the quantities of drone brood may vary according to the drone comb present, and this drone brood represents a part of the brood output of a colony, the quantities of drone brood were included in the brood measurements in 1958. In the 1969 work, drone brood was included in the total measurements of brood, but not in the sealed and unsealed measurements. Drone brood production was recorded separately. A record of queen cells which contained any developmental stage of a queen was taken at each brood measurement and also on 24 July. At each recording of the queen cells, the cells were destroyed to discourage swarming.

3. Results and Discussion

In four of the six groups maximum production of total drone brood occurred at the end of July (Table XXVI). All

dates of the three pound colonies were maximal at this date; this was also true of the Date II, two pound group. Date I, two pound group had a definite peak on 17 July, and the Date III, two pound measurement of 17 July was slightly above that of 30 July or 10 August.

Peak production of sealed drone cells occurred in all groups at the end of July. The two groups having maximal seasonal drone brood amounts on 17 July, also had considerable amounts of unsealed drone brood. This unsealed brood is reflected in the 30 July sealed amounts. The presence of the honey flow probably caused a high survival rate of unsealed drone brood at this time.

In all groups, regardless of the date of hiving or size of package, the maximum drone brood production occurred in the latter half of July which indicates a seasonal regulation in this production. Maximum brood production occurred in the Date I and Date II groups on 17 July. This seasonal decline in brood productivity in latter July was noted by L'Arrivee and Geiger (1966) and about 7 July by Geiger (1967). In this study the maximum total brood and total brood production in general coincided.

Queen cells were noted from 3 July to 22 August. Maximum queen cell production occurred on 25 July in Date I, two pound and Date II, two pound colonies. In Date II, three pound and Date III, two and three pound colonies, the maximum

TABLE XXVI - AMOUNTS OF DRONE BROOD AND NUMBERS OF QUEEN CELLS PRESENT IN THE 1969 EXPERIMENTAL COLONIES

SIZE	DATE	MEASURE	June20	July3	July17	Check July25	July30	Aug8
D I	2 lb.	TD[1]	4.5[4]	4.0	8.4		7.4	6.1
		SD[2]	3.3[5]	3.0	3.2		6.0	4.2
		QC[3]	0.0[6]	0.0	41.0	33.0	17	6
D I	3 lb.	TD	5.4	7.0	8.0		9.7	7.2
		SD	3.7	3.9	5.6		7.6	4.3
		QC	1	4	34	18	21	6
D II	2 lb.	TD	2.5	5.4	7.8		8.5	6.4
		SD	1.4	2.0	5.0		6.4	4.6
		QC	0	1	39	38	23	0
D II	3 lb.	TD	4.5	5.5	8.8		9.3	4.0
		SD	2.2	2.7	5.7		8.0	3.8
		QC	0	2	125	80	92	103
D III	2 lb.	TD	2.2	2.6	6.4		6.3	6.2
		SD	1.2	1.0	4.0		4.8	4.4
		QC	0	0	27	27	19	5
D III	3 lb.	TD	3.1	3.1	10.4		11.5	6.2
		SD	2.4	1.5	7.5	9.7	9.7	5.9
		QC	0	0	72	53	8	23

1) Total drone

2) Sealed drone

3) Queen cells

4) As a percentage of the total brood in the group

5) As a percentage of the sealed worker brood

6) Total queen cells in the group

TABLE XXVII - TERCILES OF DRONE BROOD PRODUCTION IN THE 1969 EXPERIMENTAL COLONIES

#1 Drone Brood	#1 Queen Cells	#1 Honey	#2 Drone Brood	#2 Queen Cells	#2 Honey	#3 Drone Brood	#3 Queen Cells	#3 Honey
123.0[1]	25	153[2]	60.1	6	102	47.1	0	141
86.7	13	115	59.6	7	84	44.3	32	72
83.0	91	121	58.0	16	139	44.1	71	88
80.3	1	127	56.9	2	90	43.0	26	124
73.3	11	127	55.4	5	106	41.6	74	134
69.1	8	107	53.9	13	151	41.3	31	153
68.1	3	88	53.5	18	96	39.8	42	97
66.4	5	86	52.1	29	47	38.5	0	104
64.3	20	75	50.1	11	117	38.0	10	144
61.3	15	115	50.1	26	116	37.5	8	58
60.4	1	68	47.7	2	132	35.0	1	82
60.3	13	70	47.4	5	61	33.1	0	63
74.4	17.2	104.3	53.7	11.7	103.4	40.3^{**}[3]	24.6^{ns}	105.1^{ns}

1) In square inches

2) In pounds

3) Comparison of three groups

** - $P \leq 0.01$

ns - non significant

TABLE XXVIII - COMPARATIVE MEASUREMENTS ON COLONIES SWARMING DURING THE 1969 SEASON

Hive	Date	Capped Drone	Capped Drone Group Ave.	Queen Cells	Group Ave. Queen Cells
D I 3 lb. hive 7	July 3	6.6[1]	3.9	0	0.50
D II 2 lb. hive 1		0.6	2.0	1	0.13
D III 3 lb. hive 1		4.9	2.7	2	0.25
D II 3 lb. hive 4		2.0	2.7	0	0.25
D I 3 lb. hive 7	July 17	6.8	5.6	8	4.25
D II 2 lb. hive 1		4.4	5.0	13	4.75
D II 3 lb. hive 1		7.0	5.7	47	15.6
D II 3 lb. hive 4		15.5	5.7	22	15.6
D I 3 lb. hive 7	July 30	7.1	7.6	22	5.4
D II 2 lb. hive 1		1.8	6.4	12	2.9
D II 3 lb. hive 1		12.9	8.0	12	11.5
D II 3 lb. hive 4		6.6	8.0	27	11.5

1) Percent of total brood

occurred on 17 July, and in Date I, three pound colonies on 30 July.

Thus queen cell production coincides with the period of maximum production of worker and drone brood. Table XXVII indicates the relationship between drone brood, queen cells and honey production. The quantity of drone brood in the thirty-six "normal" hives is divided into three groups. Numbers of queen cells and quantity of honey produced is also entered on the table. Statistical analysis reveals that the variation between drone brood quantity of each group was highly significant ($P \leq 0.01$) while the queen cell production and honey production between the three groups was not significantly different.

The colonies which swarmed exhibited a higher queen cell production than did the group averages at 3 July and 17 July, but not capped drone brood production in all cases (Table XXVII).

In general the present study supports that of Allen (1965) in the coincidence of maximum worker and drone brood areas, and the lack of correlation between colony drone brood areas, honey production and swarming.

C. An Analysis of Spring Temperatures for the Years 1967 to 1969.

1. Introduction

Spring temperatures may influence the rate of development of a honey bee colony (Pankiw, 1968; Geiger, 1967). Low temperatures can at least restrict the brood areas. This is because colony populations will be restricted in the area which they can maintain at brood rearing temperature (i.e. 90-95 degrees Fahrenheit). Low temperatures will also prevent the bees from foraging for nectar and pollen. This may in turn directly or indirectly, affect brood rearing because of low food supplies (Free, 1968).

2. Results and Discussion

During the months of April, May and June in the years 1967, 1968 and 1969, an analysis of springtime temperatures in the experimental areas was done. Table XXIX shows the average temperatures for the last half of April and the months of May and June. In 1967 there was a progressive increase in temperature in each of the periods calculated. Thus those colonies in the last two hiving dates had the advantage of a better temperature regime during their initial growth periods. A progressive increase in the amount of sealed brood supported at the first two measurements is shown in Figure V11.

A comparison of 1968 and 1967 temperatures shows that the month of April, 1968 had a nine degree increase over April, 1967; May and June averages were similar to those in 1967. However, at the forty-three day measurement the Date I

groups had the lowest amount of sealed brood. This may be because the better May and June conditions provided forage for the rapid growth of Date I and Date II packages. The average temperature values were most similar in 1969, when the last part of April was warmer than 1967 or 1968, with the June 1969 period having the lowest temperature average of the three years. During 1969 no one date was consistently superior in temperature. The high average for April should have stimulated brood production while the relatively low averages in June would retard brood production by preventing brood nest expansion and also confining bees to the hive.

Table XXX shows the number of hours within a series of temperature ranges at ten degree increments during the initial nineteen day period of each hiving date.

It is well known that bee flight begins at about 60 degrees Fahrenheit. In 1967, the Date III packages had much better flying weather than did the Date I or Date II ones. This may explain the higher initial quantities of brood attained by Date III packages (Figure VII, Chapter IV). Date I in 1967 experienced more temperatures in the range of ten to thirty degrees than did Date II or Date III.

In 1968, the Date II and Date III groups had similar temperature patterns. Date I had fewer hours in flying, and had more hours below thirty degrees than did Date II or Date III.

In the initial 19 days in 1969 Date I had more hours of over 60 degree weather for flying than did Date II. Date III had the most flying hours. In general the high number of flying hours for Date 1 in 1969 is not usual in most years, and may have contributed to the good growth of this group in 1969.

TABLE XXIX - MEAN OF THE AVERAGE TEMPERATURES FOR THREE DAY PERIODS IN APRIL, MAY AND JUNE OF 1967, 1968 AND 1969

Period	APRIL			MAY			JUNE		
	1967	1968	1969	1967	1968	1969	1967	1968	1969
1-3				24	52	49	67	63	48
4-6				43	42	57	53	62	56
7-9				41	44	45	57	56	59
10-12				38	45	42	63	57	48
13-15				42	56	55	62	55	52
16-18	30	41	44	53	38	46	65	60	53
19-21	38	44	52	43	45	41	57	63	50
22-24	24	34	48	58	51	51	50	58	62
25-27	39	41	44	51	56	66	65	61	60
28-31	39	55	44	63	59	77	68	63	55
Average	34	43	46.4	45.6	48.8	52.9	60.7	59.8	54.3

TABLE XXX - TEMPERATURE RANGE CLASSIFIED BY TEN DEGREES, DURING THE NINETEEN DAY PERIODS AFTER HIVING

Year	Temp. Range	Period I*	Period II**	Period III***
	10-20	43	20	
	21-30	174	82	26
	31-40	148	148	111
1967	41-50	77	121	101
	51-60	16	14	104
	61-70		6	78
	71-80			34
	81-90			2
	10-20	4	3	
	21-30	49	22	14
	31-40	122	72	54
1968	41-50	134	151	162
	51-60	94	122	129
	61-70	38	64	82
	71-80	15	22	15
	81-90			
	10-20			
	21-30	25	10	14
	31-40	85	81	93
1969	41-50	176	193	128
	51-60	114	130	118
	61-70	56	34	69
	71-80		5	21
	81-90		3	13

* Period I - approximately April 16 to May 14

** Period II - approximately April 27 to May 17

*** Period III - approximately May 2 to May 28

CHAPTER VI

GENERAL SUMMARY

This investigation was designed to determine the development and performance of honey producing bee colonies in Manitoba when the colonies were established at different dates during the spring season and by using different sizes of packages.

Chapter III

The program was divided into two areas: (1) an extensive study using colonies owned and operated by commercial beekeepers and, (2) an study at the University of Manitoba of various parameters indicating growth and development of the colony.

The extensive study was designed to provide data on the populations of the different developmental stages in a colony during the course of the spring and summer; the effect of hiving two and three pound packages on 15-18 April and 8-9 May on the honey crop produced. The usual pattern of nectar flow during the summer month also determined.

The University studies were designed to measure the quantities of sealed brood (1967, 1968 and 1969), unsealed brood (1968 and 1969), adult population 1969, forager activity

1969, and honey production (1969). Brood measurements were done by tracing brood patterns on glass sheets ruled in one inch squares and adult numbers were estimated by comparing each frame with bees to a calibrated photograph.

Chapter IV

The extensive survey over the years 1966 to 1968 showed hive populations about 6000 adult bees at 19 days after hiving, 22,500 at the end of June and 47,500 at the end of August.

The honey production study based on approximately 200 hives per year over the period 1967 to 1969, indicated that the three pound packages hived about mid-April produced the best crop; the two pound packages hived about 9th May produced the smallest crop. The different in the three year average yields for the two above groups was 23 pounds.

Analysis of nectar flow records, from scale colonies located throughout the province of Manitoba, indicated that the months of July and August provide the nectar flow; July being the most important. The flow begins by the first week in July.

The extensive University studies indicated that the three pound packages produced more brood than the two pound packages, for the initial forty-three or more days after installation. The two pound packages tended to equate their

brood production with that of the three pound packages by fifty-five days after installation, and in some instances the two pound packages surpassed the three pound packages in quantity of brood produced during mid-summer brood measurements.

The date at which the colonies were hived affected their growth up to 43 days in 1968 and up to 67 days in 1969. In 1968 the packages hived on 26 April showed the best growth, but in 1969 no one date of hiving was consistently superior.

Peak brood production occurred in most colonies from 15 to 30 July during 1968 and 1969.

The adult populations during 1969, showed the 15 April hiving date to lead in population numbers during the spring and summer seasons; however each package size produced approximately the same population after a certain period of development regardless of the date on which each size was hived. Populations of the groups tended to merge about 20 August at a level of 45-50,000 adult bees.

Entrance activity showed that the first hived packages had the greatest flight activity of bees not gathering pollen (123 to 134 per thirty second period in July and 139 to 159 in August). During August the second and third hiving dates had similar forces of non pollen gathering foragers. The pollen foragers were 11.8 to 20.0% of the total foragers

in July and 6.2 to 12.8% of the forager force in August. During July the earliest hived packages had larger populations and a higher percentage of the total population was foraging.

Honey production was highest in the packages hived earliest and appeared directly related to the higher adult populations and higher percentage of the population which was engaged in foraging.

Chapter V

Abnormalities in the colonies during 1969 were a result of queen loss or supersedure, swarming and European foul brood. Of the twelve abnormal colonies investigated, only one which had temporarily lost a queen, produced a honey crop equal to the average of "normal hives" of the size of package and date of hiving group in which it was included. Queen loss by accidental loss or swarming and failure to requeen, resulted in little or no honey being stored after the time queen loss occurred.

Drone brood production was maximum at the end of July. No correlation was shown between drone brood amounts and honey production or queen cell production. Queen cell production maximums coincided with drone brood maximums.

Temperatures generally became progressively more favourable for each later date of hiving. However in 1969 the first hived packages had better temperature conditions,

and in general there was little different in temperature conditions for the initial development of the three hiving dates.

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APPENDIX TABLE I - MANITOBA NECTAR FLOWS*, 1955-1969

	April		May				June			
Year	30-4	5-9	10-14	15-19	20-24	25-29	30-3	4-8	9-13	14-18
1955	-1.5	-1.0	-0.5	0.0	-0.2	-0.2	1.0	-1.0	-0.5	2.0
1956	-0.9	-2.2	-1.4	-0.8	-0.3	1.7	1.1	1.8	2.8	3.4
1957	-0.4	-0.2	-0.5	0.0	-0.3	0.8	3.4	1.0	-0.3	-0.2
1958	-0.8	-1.0	-1.0	-0.4	-0.6	0.6	0.5	-0.3	-0.6	-0.1
1959	0.6	-0.7	-1.0	0.7	-0.6	0.3	1.4	5.0	0.9	0.0
Ave.	-0.6	-1.0	-0.9	0.1	-0.4	0.6	1.5	1.3	0.5	1.0
1960	-1.5	-2.5	-1.0	0.0	-0.5	0.0	-0.5	0.5	1.5	-0.5
1961	-1.6	-1.3	-1.1	-1.6	2.6	1.4	3.2	4.4	2.4	0.3
1962	0.0	-1.0	-1.0	-0.3	-1.5	0.0	-0.3	4.5	5.8	5.8
1963	-2.0	-1.0	0.0	0.0	-2.0	0.0	1.5	1.0	0.5	0.0
1964	-0.5	-1.0	-2.0	-0.5	0.5	0.3	-0.3	0.3	0.0	-0.3
Ave.	-1.1	-1.4	-1.0	-0.5	-0.2	0.3	00.7	2.2	2.0	1.1
1965	-1.0	-0.5	0.0	-1.0	0.0	-1.0	-1.0	2.0	1.8	1.0
1966	-0.5	-1.3	-1.0	-1.0	-1.3	-1.0	-1.5	-0.8	0.0	2.5
1967	0.2	-0.3	-1.4	-1.3	-0.2	1.4	0.9	6.4	3.1	-0.5
1968	0.0	1.0	0.0	-1.0	-1.0	0.0	0.7	1.9	0.5	-2.0
1969		-1.3	0.5	-0.5	1.8	-1.3	-1.3	2.3	-1.8	-2.1
Ave.		-0.9	-0.6	-1.0	-0.1	-0.4	0.2	2.4	0.7	0.2

* Records of 9-23 beekeepers

continued.....

APPENDIX TABLE I (continued)

Year	July 19-23	24-28	29-3	4-8	9-13	14-18	19-23	24-28	29-2	3-7	8-12
1955	2.0	10.7	23.5	21.5	23.5	46.0	34.0	17.0	19.5	9.5	8.5
1956	2.9	3.6	11.6	17.1	40.5	24.7	30.0	10.0	20.8	27.9	20.9
1957	1.0	2.0	10.5	14.5	20.5	29.5	31.5	29.5	22.0	18.0	10.0
1958	-0.1	4.3	8.0	6.9	22.4	18.1	36.3	13.7	23.1	18.0	21.3
1959	0.5	3.8	10.8	14.7	24.9	28.3	20.6	25.6	15.6	21.1	13.6
Ave.	1.3	4.9	12.9	14.9	28.2	29.3	30.5	19.2	20.2	18.9	14.9
1960	1.0	7.0	12.0	33.0	35.5	32.0	32.0	19.5	15.5	14.5	13.5
1961	2.5	13.3	13.4	30.2	19.2	15.5	11.5	13.6	16.0	15.1	10.5
1962	8.5	16.0	20.5	19.0	29.0	28.0	20.5	12.0	7.0	6.0	11.0
1963	0.5	3.5	10.5	26.5	23.5	35.0	46.6	32 0	19.0	31.0	19.5
1964	0.0	9.3	15.3	25.8	41.0	30.0	29.5	24.5	24.5	13.5	5.0
Ave.	2.5	9.8	14.2	26.9	29.6	28.1	27.9	20.3	16.4	16.0	11.9
1965	0.0	3.5	6.0	26.0	21.0	25.5	17.8	22.5	25.0	26.8	29.0
1966	2.3	1.0	7.8	16.5	35.5	36.5	25.5	20.0	20.0	10.8	5.8
1967	-0.3	6.5	4.6	21.8	22.5	41.5	31.4	30.5	15.9	14.7	13.5
1968	-0.8	-0.9	4.6	14.8	21.7	23.0	15.8	20.8	16.6	22.3	13.2
1969	-2.7	0.0	-0.9	2.2	37.5	26.8	23.1	22.4	26.7	21.8	31.4
Ave.	-0.3	2.0	4.4	16.3	27.6	30.7	22.7	23.2	20.8	19.3	18.6

continued.....

APPENDIX TABLE I (continued)

Year	August 13-17	18-22	23-27	28-1	September 2-6	7-11	12-16	17-21	22-26	27-1
1955	11.0	8.0	9.5	1.5	-4.5	-2.0	-2.0	-2.0	-2.0	-1.5
1956	13.0	0.9	3.3	-0.6	-3.5	-4.1	-3.0	-1.8	-0.6	-1.5
1957	3.5	6.5	0.5	0.5						
1958	13.3	7.3	3.7	1.0	-0.4	-0.1	-1.0	0.0	-2.0	-2.5
1959	7.1	2.4	3.6	2.7	0.1	1.1	-1.1	-0.1	0.5	-0.3
Ave.	9.6	5.0	4.1	1.0	-2.1	-1.3	-1.8	-1.0	-1.0	-1.5
1960	9.5	4.0	2.5	-0.5	4.0	-1.5	-2.5	-1.0	-2.0	-1.5
1961	13.3	4.1	1.1	4.5	0.0	1.0	-2.0	0.3	-2.3	0.0
1962	8.3	5.3	1.0	2.3	-2.0					
1963	7.5	7.5	3.0	-1.0	-0.5	1.0	-1.5	-1.0	-1.5	-0.5
1964	2.0	0.0	-2.5	-2.5	-1.5	0.0	-2.5	-4.5	-1.0	-1.0
Ave.	8.1	4.2	2.0	0.6	0.0	0.1	-2.1	-1.7	-1.7	-0.8
1965	10.0	2.0	-2.0	-0.3	-2.0	-2.5	-1.5	-1.0	-1.5	-1.0
1966	4.0	2.3	5.0	2.3						
1967	21.1	10.4	8.2	3.5	2.8	-1.7	0.0	-3.2		
1968	1.7	1.0	1.4	2.3	-2.0	-2.0	-3.0	-1.5	0.5	
1969	2.8	15.9	7.9	1.7	7.0	4.0	4.5	-2.5	0.5	-1.0
Ave.	7.9	6.3	4.5	1.9	1.2	-0.6	0.0	-2.1	-0.1	-1.0

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES

DATE I - 2 1B.

Hive No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	1V Sealed Brood	1V Total Brood	1V Adult Est.
1968												
19 da.												
31 da.												
43 da.	380	551		374	720		375	546		270	524	
55 da.	614	614		776	1238		504	1116		667	1061	
67 da.	78	78		836	1344		666	1065		596	997	
79 da.	339	1112		735	1194		649	1169		758	1354	
91 da.	588	1100		666	1119		790	1232		691	1043	
103 da.	535	969		543	1230		741	1136		588	952	
115 da.	530	928		717	1089		657	1014		593	668	
1969												
19 da.	294	510	56	278	452	59	197	460	64	225	459	48
31 da.	264	574		228	599		309	575		249	552	
43 da.	405	754	179	440	923	161	400	883	125	422	851	139
55 da.	596	1150		634	1308		608	1248		426	531	
67 da.	618	1294	285	706	1397	248	688	1314	310	297	483	291
79 da.	533	1106	368	520	1184	347	586	1136	410	283	468	243
91 da.	626	1406	468	597	1632	363	603	1230	417	166	630	236
103 da.	711	1494		745	1660		565	1239		509	1050	
115 da.	519	1357	509	396	877	519	596	1211	490	530	1055	313
127 da.	685	1401	580	630	1255	470	667	1281	491	no reading		370

1) After this point the colony was not considered normal.

continued.....

APPENDIX TABLE II - (continued)

DATE I - 2 1B.

Hive No. Reading	V Sealed Brood	V Total Brood	V Adult Est.	VI Sealed Brood	VI Total Brood	VI Adult Est.	VII Sealed Brood	VII Total Brood	VII Adult Est.	VIII Sealed Brood	VIII Total Brood	VIII Adult Est.
1968												
19 da.												
31 da.												
43 da.	370	873		255	677		299	564		456	753	
55 da.	683	1318		743	1304		807	1393		623	995	
67 da.	735	1227		778	1354		826	1498		652	955	
79 da.	589	1117		999	1894		860	1418		640	1335	
91 da.	835	1256		957	1512		967	1428		825	995	
103 da.	783	824		755	1570		**********			528	886	
115 da.				427	715					611	1105	
1969	**********											
19 da.	265	365	53	281	447	42	255	424	56	230	404	57
31 da.	196	514		239	239		214	489		225	551	
43 da.	343	690	130	32	416	158	340	679	141	392	808	136
55 da.	428	892		449	891		611	1146		545	1220	
67 da.	429	737	211	545	1061	200	598	1142	238	661	1328	220
79 da.	178	462	287	609	1207	304	486	1007	340	575	1395	319
91 da.	257	810	293	642	1264		586	1226	360	327	1615	367
103 da.	602	1191		671	1418		466	1101		628	1487	
115 da.	606	1188	367	757	1338	557	447	1022	494	487	1132	446
127 da.	464	1003	423	no reading		548	628	1037		627	1373	436

continued.....

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES (continued)

DATE I - 3 1B.

Hive No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	IV Sealed Brood	IV Total Brood	IV Adult Est.
1968												
19 da.												
31 da.												
43 da.	418	828		195	628		358	785		329	642	
55 da.	608	1027		636	1573		763	1101		542	1455	
67 da.	564	1092		761	1120		767	1388		641	994	
79 da.	572	1042		642	1126		685	1286		607	1065	
91 da.	667	1035		854	1322		746	1329		799	1090	
103 da.	639	1405		548	958		794	1320		536	1192	
115 da.	758	1263					740	1249		523	937	
1969												
19 da.	360	560	7125	256	426	9225	390	665	7275	**********	**********	**********
31 da.	385	781		348	693		396	670		315	414	8375
43 da.	451	1078	23725	447	903	20800	415	872	19650	283	706	
55 da.	567	1195		505	1050		529	1010		329	697	14275
67 da.	502	1108	35050	612	1397	28600	416	806	33725	509	1106	
79 da.	439	993	34850	560	1256	36125	430	1026	42900	388	814	20600
91 da.	641	1360	40375	369	974	39525	538	1211	46250	322	830	28650
103 da.	458	1120		519	1221		529	1221		354	851	33100
115 da.	502	1184	49900	706	1291	48500	451	905	50850		619	
127 da.	633	1249		570	1306		559	1180	60100		217	

Brood is recorded in Square Inches

continued.....

APPENDIX TABLE II - (continued)

DATE I - 3 1B.

Hive No. Reading	V Sealed Brood	V Total Brood	V Adult Est.	VI Sealed Brood	VI Total Brood	VI Adult Est.	VII Sealed Brood	VII Total Brood	VII Adult Est.	VIII Sealed Brood	VIII Total Brood	VIII Adult Est.
1968												
19 da.												
31 da.												
43 da.	449	881		518	1095		263	629		50	234	
55 da.	789	977		1044	1505		562	1113		344	650	
67 da.	781	1271		1073	1522		642	1082		535	976	
79 da.	739	1238		983	1534		396	779		689	1202	
91 da.	853	1314		1021	1481		473	827		883	1321	
103 da.	854	1604		783	1633		252	508		681	1310	
115 da.	774	1294		613	845		331	765		671	1222	
1969												
19 da.	351	560	8150	306	546	8100	402	688	7850	319	526	7600
31 da.	327	638		367	801		472	848		328	762	
43 da.	493	968	23100	522	969	21050	455	1011	23075	359	896	20200
55 da.	608	1130		528	1207		628	1246		597	1244	
67 da.	636	1143	35100	581	1147	33650	599	1199	36150	570	1211	28200
79 da.	546	1158	38150	313	1051	34825	527	1179	37700	498	1295	33500
91 da.	595	1197	49175	375	879	38800	607	1425	43650	595	1206	
103 da.	459	980		563	1187		474	1099		701	1386	
115 da.	480	937		703	1297	39250	**********			592	1193	47500
127 da.	489	1001	48700	572	1339	42500				656	1423	56600

continued.....

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES (continued)

DATE II - 2 IB.

Hive No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	IV Sealed Brood	IV Total Brood	IV Adult Est.
1968												
19 da.												
31 da.	121	335		270	785		298	633		126	541	
43 da.	358	671		711	1357		628	1150		439	775	
55 da.	541	1155		960	1546		633	1125		672	1206	
67 da.	368	735		972	1637		629	1150		888	1355	
79 da.	587	1274		1012	1444		611	1144		893	1383	
91 da.	781	1481		951	1667		767	1373		809	1602	
103 da.	809	1427		922	1526		629	1243		704	1297	
115 da.												
1969												
19 da.	289	521	6225	225	381	4350	284	489	6100	280	484	5550
31 da.	256	685		203	551		229	679		277	582	
43 da.	536	1125	17450	457	877	12950	519	1055	18025	450	1096	17975
55 da.	581	1264		454	957		400	881		405	933	
67 da.	611	1164	38650	439	1047	25500	477	946	27100	395	983	21550
79 da.	673	1328	36950	538	1225	22400	605	1325	30100	514	1167	33375
91 da.	**********	822	45675	544	1015	36950	521	1188	42025	524	1276	32350
103 da.	284	295	29000	469	1122		618	1262		398	968	
115 da.				468	966	37350				435	1006	32000
127 da.												

Brood is recorded in Square Inches

continued.....

APPENDIX TABLE II (continued)

DATE II - 2 1B.

Hive No. Reading	V Sealed Brood	V Total Brood	V Adult Est.	VI Sealed Brood	VI Total Brood	VI Adult Est.	VII Sealed Brood	VII Total Brood	VII Adult Est.	VIII Sealed Brood	VIII Total Brood	VIII Adult Est.
1968												
19 da.												
31 da.	242	628		271	699		257	621		259	556	
43 da.	585	1025		773	1328		636	1234		826	1316	
55 da.	601	998		899	1393		749	1309		921	1600	
67 da.	510	1046		850	1580		772	1423		1034	1804	
79 da.	828	1380		983	1331		910	1586		927	1580	
91 da.	794	1406		927	1508		801	1457		943	1562	
103 da.	690	1314		899	1265		834	1299		878	1472	
115 da.												
1969												
19 da.	217	455	6325	224	409	6150	243	470	6525	200	345	6025
31 da.	178	632		242	598		229	700		216	584	
43 da.	459	892	13550	491	790	14600	509	991	15450	423	894	14200
55 da.	342	831		533	1126		461	917		368	886	
67 da.	379	943	22150	390	907	28200	430	913	24750	326	847	19750
79 da.	617	1244	41525	524	1273	28800	614	1216	23600	533	1182	24725
91 da.	586	1328	31150	640	1298	33800	576	1081	34475	632	1217	29275
103 da.	461	1040		411	1066	45650	511	1131		688	1335	
115 da.	417	1085					575	1125		651	1248	

continued.....

APPENDIX TABLE II (continued)

DATE II - 3 1B.

Hive No.	V			VI			VII			VIII		
Reading	Sealed Brood	Total Brood	Adult Est.	Sealed Brood	Total Brood	Adult Est.	Sealed Brood	Total Brood	Adult Est.	Sealed Brood	Total Brood	Adult Est.
1968												
19 da.												
31 da.	331	658		398	796		289	817		261	688	
43 da.	577	1097		691	1294		623	1204		790	1418	
55 da.	851	1250		885	1394		524	1069		859	1463	
67 da.	645	1049		1003	1602		611	1104		968	1101	
79 da.	723	1118		854	1360		729	1386				
91 da.	695	1329		760	1297		715	1527		41	96	
103 da.	614	1106		748	1305		523	1167				
115 da.												
1969	**********											
19 da.	114	134	9225*	300	529	6975	354	692	8300	323	570	8150
31 da.	183	519		342	741		302	670		343	809	
43 da.	451	796	9950	568	1143	20175	536	1125	17325	553	1259	17650
55 da.	340	805		433	921		419	976		415	989	
67 da.	444	986	21850	393	956	35200	460	1063	30600	349	920	24375
79 da.	595	1212	30475	536	1166	30925	756	1578	38300	**********		
91 da.	624	1339	39500	723	1263	34950	584	1016	51600	532	1180	19525
103 da.	474	518		718	1269		308	649		558	800	28375
115 da.				616	1271	46250	296	602	55900	230	395	
										584	630	

continued.....

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES (continued)

DATE II - 3 1B.

Hive No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	IV Sealed Brood	IV Total Brood	IV Adult Est.
1968												
19 da.												
31 da.	325	750		162	579		386	792		321	708	
43 da.	655	1175		689	1061		644	1121		749	1149	
55 da.	727	1167		588	925		620	1046		754	1486	
67 da.	638	1059		799	1410		638	1117		667	1372	
79 da.	632	1109		636	1119		618	1067		644	1188	
91 da.	670	1020		550	788		743	1242		704	1237	
103 da.							683	1107		719	988	
115 da.												
1969												
19 da.	301	631	10375	294	488	8275	283	582	9900	328	678	8650
31 da.	389	849		295	773		355	771		423	789	
43 da.	466	1094	21000	430	985	19425	458	1097	19975	577	1249	19900
55 da.	538	1181		482	1082		585	1155		629	1312	
67 da.	473	1101	32000	484	1176	29450	502	976	30550	613	1318	29100
79 da.	486	1049	49150	520	1222	32500	558	1311	32600	401	1363	36300
91 da.	255	378	53225	404	910	38050	600	1072	48100	673	1284	40050
103 da.	60	64	40400	495	1074		488	775		434	470	46050
115 da.				235	580	39500	122	305	58400			
127 da.												

continued.....

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES

DATE III - 2 1B.

Hive No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	IV Sealed Brood	IV Total Brood	IV Adult Est.
1968												
19 da.	229	529		231	527		190	465		230	419	
31 da.	327	773		445	983		353	870		359	756	
43 da.	383	777		575	1086		440	992		614	1078	
55 da.	586	1027		798	1573		607	1101		874	1455	
67 da.	731	1390		792	1350		748	1499		722	1151	
79 da.	797	1475		752	1392		968	1672		743	990	
91 da.	683	1391		716	1434		795	1279		85	85	
103 da.												
115 da.												
1969												
19 da.	294	538	8700	232	405	5675	233	495	7025	244	466	5445
31 da.	352	758		209	541		166	629		222	500	
43 da.	472	905	19955	397	720	12950	452	883	16025	276	723	14850
55 da.	376	914	25950	388	932	15300	411	823	20850	277	877	16050
67 da.	552	1230	33975	521	991	21550	491	881	28000	566	1401	21900
79 da.				475	1237		378	883		624	1542	
91 da.	528	1168	45100	558	1052	40900	327	777	36350	416	1228	
103 da.	450	1084	5375	310	343	45400	409	815	45700	594	1399	
115 da.												
127 da.												

continued .....

APPENDIX TABLE II (continued)

DATE III - 2 1B.

Hive No. Reading	V Sealed Brood	V Total Brood	V Adult Est.	VI Sealed Brood	VI Total Brood	VI Adult Est.	VII Sealed Brood	VII Total Brood	VII Adult Est.	VIII Sealed Brood	VIII Total Brood	VIII Adult Est.
1968												
19 da.	246	458		199	454		197	434		227	368	
31 da.	336	731		438	750		489	1003		316	662	
43 da.	385	801		586	1062		630	1161		521	992	
55 da.	558	977		805	1505		699	1240		793	1304	
67 da.	656	997		769	1308		718	1216		958	1390	
79 da.	200	200		721	1272		848	1394		803	1261	
91 da.				693	1204		676	1196				
103 da.												
115 da.												
1969												
19 da.	238	456	6075	223	376	6250	250	464	6175	161	356	4910
31 da.	226	645		275	597		340	712		164	442	
43 da.	447	878	14475	397	744	12975	522	976	16550	234	614	9450
55 da.	531	1011	20200	434	818	17750	532	986	20525	356	903	13350
67 da.	690	1256	35000	584	1104	29000	601	1094	22850	547	1053	19175
79 da.	644	1442		428	1184		593	1135		627	1206	
91 da.	433	1088	48950	614	1151		295	829	45075	597	1039	39450
103 da.	693	1314	51025	647	1161	42150	529	1059	33070	697	1336	38400
115 da.												
127 da.												

continued .....

APPENDIX TABLE II - BROOD COUNTS AND ADULT ESTIMATIONS FOR THE 1968 AND 1969 EXPERIMENTAL COLONIES (continued)

DATE III - 3 1B.

Hive. No. Reading	I Sealed Brood	I Total Brood	I Adult Est.	II Sealed Brood	II Total Brood	II Adult Est.	III Sealed Brood	III Total Brood	III Adult Est.	IV Sealed Brood	IV Total Brood	IV Adult Est.
1968	**********	**********	**********	**********	**********	**********						
19 da.	191	401		240	412		295	568		228	570	
31 da.	326	326		136	136		472	916		442	895	
43 da.	3	41		91	349		563	1107		618	1137	
55 da.	26	192		361	722		677	1147		778	1260	
67 da.	461	832		714	1189		753	1240		659	1215	
79 da.	400	400		768	1267		602	902		524	867	
91 da.				732	1377		784	1356		516	1057	
103 da.												
115 da.												
1969												
19 da.	287	671	10100	302	511	9270	253	493	9175	261	564	8200
31 da.	449	944		383	779		402	781		539	938	
43 da.	540	1018	23000	497	834	18375	440	791	16500	442	934	19350
55 da.	396	970	26925	**********	**********	**********	310	820	21675	382	964	21950
67 da.	588	1202	39450	315	840	21250	483	1101	28950	**********	**********	**********
79 da.	620	1295		412	1059		403	1154		176	214	23775
91 da.	517	1197	55250	521	928	32950	504	1141	26150	0	269	18300
103 da.	575	1259	59625	510	1010	34850	557	1098	39350			16700
115 da.												

All brood is recorded in Square Inches

continued .....

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APPENDIX TABLE II (continued)

DATE III - 3 1B.

Hive No. Reading	V Sealed Brood	V Total Brood	V Adult Est.	VI Sealed Brood	VI Total Brood	VI Adult Est.	VII Sealed Brood	VII Total Brood	VII Adult Est.	VIII Sealed Brood	VIII Total Brood	VIII Adult Est.
1968												
19 da.	302	574		167	452		241	488		145	145	
31 da.	564	987		425	801		491	926		99	189	
43 da.	556	1078		521	895		697	1160				
55 da.	748	1242		666	1056		785	1191		2	2	
67 da.	762	1379		620	1221		658	1264		212	441	
79 da.	671	1140		717	1073		624	946		310	607	
91 da.	624	1264		326	326		364	364				
103 da.												
115 da.												
1969												
19 da.	294	614	10450	325	551	8500	197	520	9400	319	607	7200
31 da.	447	842		482	957		460	884		395	744	
43 da.	541	952	19800	547	1015	17725	510	934	17950	478	846	16825
55 da.	359	868	30300	350	1029	26900	531	1068	31550	318	823	24300
67 da.	503	1067	32900	378	992	35950	577	1288	33675	443	946	30625
79 da.	533	1211		284	830		522	1108		399	1051	
91 da.	492	1076	36900	254	754	53700	614	1071	39875	483	947	46400
103 da.	571	1147	47750	119	678	46550	521	1120	51350	386	1009	
115 da.												