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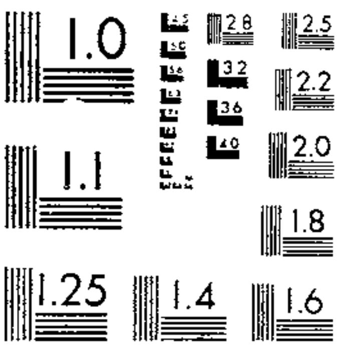

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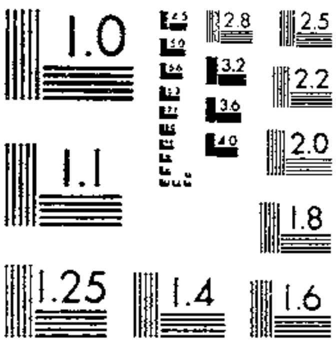

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TECHNICAL BULLETIN No. 309 — JUNE, 1932

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THE DEVELOPMENT OF PACKAGE-BEE COLONIES

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INTRODUCTION

The package bee has brought many new problems of apiary management to the beekeeper. To obtain more definite information on pertinent factors underlying these problems, particularly on the rate of development of packages of various sizes, work on package bees was undertaken in 1926 in the division of bee culture of the Bureau of Entomology. A knowledge of the rate of development of package colonies is of special importance to the beekeeper in many of his uses of the package bee if he is to choose the size of package which will best suit his purpose and if he is to know the proper time to obtain those packages.

Although in the United States bees have been shipped in combless packages for more than 40 years, only within the last 15 has the package-bee business assumed special importance. During these years it has increased by leaps and bounds. Recent statistics (*38*)[1] from the State of Alabama, which has become the center of the package-bee as well as of the queen-bee industry (*25*), well illustrate this

[1] Italic numbers in parentheses refer to Literature Cited, p. 42.

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point. According to these statistics, in the two years from 1924 to 1926 the sales of package bees in Alabama more than doubled, 40,000 packages being sold in 1926 as against only 18,000 in 1924.

So far the commercial use of combless package colonies in honey production has been confined almost exclusively to the United States and Canada. It is only within recent years that the question of the practicability of combless packages under European conditions has been seriously raised in European bee journals. For a long time, however, there has been some traffic in colonies of bees between France and the British Isles, and also between the Netherlands and the British Isles. Within the last few years there has even been a beginning attempt to sell in the British Isles package bees produced in France. Russia, a country possessing vast extent and wide range of climatic conditions as well as immense beekeeping possibilities, seems to offer a big field for this phase of the beekeeping industry.[2]

In the past the production of package bees in North America has been practically limited to the United States, since Canada has depended for its supply on this country. The exact number of packages used in either country is not known, but Floyd (*9*) in 1929 estimated that, in Manitoba alone, 10,000 packages are needed to supply the annual demand.

Thus far the package-bee business has been confined largely to contiguous areas served by rail transportation. It has not figured in transoceanic shipments, no doubt partly because the conditions for successfully shipping bees in confinement for the long period necessary in such a case are not yet known. The importance of determining the proper conditions for shipping package bees successfully was one of the reasons for the establishment of the Southern States bee culture laboratory at Baton Rouge, La. Air transportation would appear the best means so far as the bees in the package are concerned, but resort to this method is not yet feasible.[3]

Package bees are bought, for the most part, for the purpose of building up new colonies in time for the honey flow, or of strengthening overwintered weak colonies so that they, too, may build up to sufficient strength to gather surplus. Recently Hutson (*14*) has advocated the procuring of packages in early spring for the purpose of having them build up to colonies strong enough for pollination work in orchards instead of relying on overwintered colonies.[4]

The results obtained in the last few years from the use of package bees to build up into new colonies for the honey flow, especially in some of the newer western and northern beekeeping regions, have often been surprising and may well explain the rapid development of

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[2] Since the foregoing was written, the use of package bees under conditions in the Union of Socialist Soviet Republics has become the subject of investigation there, one of the leaders in the movement being W. W. Alpatov, director of the biological laboratory at the zoological museum of the University of Moscow, who was a research fellow of the International Education Board at Johns Hopkins University in 1926–1928. As a matter of fact, as pointed out by the writer (*28a*) in a recent article, The Shipment of Package Bees in the U. S. A., which was translated into Russian by Alpatov and published in Kollektivnoe Pchelovodnoye Delo for March, 1931, the Union of Socialist Soviet Republics seems the only country of beekeeping importance at present which embraces sufficient climatic range and contiguous territory for the development of a package-bee industry entirely within its own borders comparable to that now found in the United States. In The Bee Kingdom for July, 1931, A. Z. Abushady (*1*) reported the shipment of package bees from Jugoslavia to Egypt.

[3] Since the above was written advertisements offering for sale package bees shipped by air from France to England have appeared. (Cf. Scottish Beekeeper, April, 1931.)

[4] Since the original completion of the manuscript for this bulletin in 1929, Hutson (*15*) has described an "orchard package" to be used primarily for pollinating purposes. At this date (1931) several producers of package bees are advertising "orchard packages" for sale. The bees arriving in such packages are those depended upon to accomplish pollination, and they are permitted to fly directly from their original shipping container without being transferred to a hive.

this phase of the beekeeping industry. For instance, among some exceptional examples, it was reported *(36)* that 1-pound packages in Ontario in 1916 built up sufficiently to gather an average of 100 pounds of surplus honey in one season. In the sweetclover region of the North a 290-pound crop was reported *(16)* as the 1924 total from a 2-pound package installed in North Dakota on May 22 of that year. This particular region is marked by high colony yields because natural conditions make possible both exceptionally high daily gains and an exceedingly long period during which nectar is available. Sweetclover may bloom for about three months in North Dakota. A 3-pound package received in that State on June 5, 1922, was reported *(5)* to have gathered a honey crop of 485 pounds before the end of the same season.

It is not to be assumed from the foregoing examples that a direct relationship exists between the size of the package installed and the size of the honey crop obtained. Other factors which govern the total number of field bees on hand for the honey flow enter in as well. Among these are the relative rapidity with which packages of various sizes build up, the length of time between the receipt of the bees and beginning of the main honey flow, the age of the bees when put into the package, the queen bee herself, and whether the worker bees in the original package prove of field use in the main honey flow if obtained late enough or whether their energy is all expended in rearing brood to replace themselves. The division of labor in the honeybee is also a governing factor since, as summarized by the writer on another occasion *(26)*, it has long been common knowledge that under normal conditions the worker honeybee spends the forepart of its life in various activities which it has been the custom to group under the heading of hive duties, while the latter part of its life is devoted to field duties such as gathering nectar, pollen, water, and propolis. On the other hand, when compelled to do so, bees may go to the field earlier than they would normally, or to a limited extent old bees may perform hive duties.

Recent research by Rösch *(37)* has placed our knowledge of the division of labor on a more scientific basis than heretofore and has brought out new facts as well. The work of Soudek *(39)* on the glands of the worker honeybee is also an important contribution toward the solution of this problem.

PREVIOUS DATA ON DEVELOPMENT OF PACKAGE-BEE COLONIES

Few data from any direct study of the factors governing the development of package colonies have been published. Most of our ideas on the subject have been obtained incidentally from casual observations made by beekeepers while using package bees in their apiaries. From the scientific side the most comprehensive work on the problem published thus far is by Merrill *(19)*, who presented data showing the average population and amount of brood at intervals varying from 22 to 24 days throughout the season of 1923 in four colonies started from packages on April 30 of that year. The population was apparently determined each time by taking the weight of the bees in pounds and then multiplying this by 5,000, the commonly accepted number *(34, p. 760)* of bees in a pound. Merrill *(22)* later published some other results obtained with package bees, but these seem to represent abnormal conditions and need not be discussed here.

There might be objection to deriving population from weights by using some constant conversion factor like 5,000 bees per pound instead of the average weight of a representative sample of bees obtained at each weighing of the whole colony. Such an objection is not invalid when it is remembered that the average weight of an individual bee varies, depending on the load carried in its honey sac. Furthermore, since Alpatov and Tjunin (*2, pp. 2–7; 3, p. 99*) have found the body dimensions of the honeybee to vary somewhat with the colony, and since Mikhailoff (*23, 24*) states that these dimensions vary even in the same colony at different times of the year, it is only reasonable to suppose that weight may possibly do likewise.

If Merrill's brood counts had included only brood, all or most of which eventually developed into the adult stage, the number of bees which should have been on hand at any time during the active season under any given average length of life for the bees at this period of the year could easily be computed from these counts, and a fair check on his numbers derived by weight could be obtained. Thus, since only 21 days are required for development from egg to adult, if brood counts are taken every 21 days and, in addition, if the average length of life of the worker bee during the active season is assumed to be six weeks or more, as has been assumed by some writers, such as Pellett (*31, p. 93*), Phillips (*33, p. 136*), the Roots (*34, p. 17*), and Zander (*41, p. 74*), it follows that the total population at the time of any particular brood count would be equivalent to at least the sum of the brood counts on the two preceding dates, provided all the brood develops. If the average life of the worker during the active season is assumed to be about five weeks, the period assumed by other authorities, such as Buttel-Reepen (*4, p. 133*), Dadant (*17, p. 64*), Leuenberger (*18, p. 7*), and Rösch (*37, p. 628*), the total population on any of these dates should be the total brood count on the preceding date plus approximately two-thirds of the total brood count on the second preceding date. The exact fraction to be used in this case depends on the weekly emergence of the brood included in this count.

The use of counts of total brood in computing population, however, may introduce a considerable error in the result, since it is known that not all eggs or unsealed larvæ reach the adult or even the sealed stage. Merrill has published data (*21*), for the same year as his experiments with package colonies, which indicate that sometimes as much as one-third of the unsealed brood in certain colonies investigated did not reach the sealed stage.

Merrill received his packages on April 30, and from his calculations each contained, on an average, 14,000 bees. He states that in his locality the main honey flow for that year (*19*) occurred between June 18 and July 11, but that during the last of August and the first week of September there was another honey flow.

His first determination of brood and population was made on May 26, 26 days after the packages had been received. Since worker bees require an average of 21 days to develop from egg to adult, any bees on hand at this time either survived from the original packages or else had emerged between May 21 and May 26. It does not seem likely that an average of much more than 3,000 bees had emerged in each colony by May 26, since the total number of cells of brood found then, 13,000 cells, indicates a daily egg-laying rate, or a subsequent daily emergence rate, of only 619. Merrill's data show an average of 10,200 bees in each package colony, a large number of which, therefore, must have survived from the original number received.

The second determination was made on June 18, seven weeks after the packages were received. It may be assumed that practically all the bees from the original packages were dead at this time, whereas all of the worker brood, 13,000 cells, found on May 26 would have had time to emerge and would still be alive, together with whatever bees had emerged as a result of brood-rearing activity before the 21-day period covered by this brood count. As a matter of fact Merrill reports, for June 18, 13,250 bees and 11,000 cells of brood. The sealed brood count represents a daily egg-laying average of only about 500. This decrease in the amount of brood will be commented upon later.

The next reading, on July 11, about 10 weeks after installing the packages, showed 18,000 bees. This is approximately 1.3 times the number computed as in the packages on arrival. The number of cells of brood had increased to 15,200, which means an increase in the egg-laying rate. For the reading three weeks later, August 2, about 13 weeks after the packages were installed, Merrill gives the population as 22,000 and the brood as 17,800 cells. He continued his counts on these colonies throughout the season, but the later counts seem of less value in a study of colony development.

After the decrease shown by the second brood count, the computed daily egg-laying average rose until the maximum, approximately 1,000, was attained, about 16 weeks after the packages were received. That these colonies were laboring under a handicap throughout the season might seem evident from the fact that Merrill (*20*) states elsewhere, in reporting on other colonies in the same apiary in the same year, that the highest daily rate of egg laying in any colony was 2,030 and that this occurred during the nine days previous to June 21. It fell to 1,400 during the next nine days. This highest rate occurred during the period covered by the second count for the package colonies, the interval in which the egg-laying rates of their queens were dropping off. The average given in the same article (*20*) for certain of his colonies in August of that year is a little more than half that of the same colonies for June.

The decrease in brood rearing found by Merrill between May 26 and June 18 is significant of what was taking place in colony population, especially since he (*20*) reports that this was the period of greatest brood-rearing activity in other colonies in the same year. As stated before, on May 26 the population was composed largely of package bees. Toward the end of May these bees must have aged physiologically to the point (Rösch, *37, p. 627;* Soudek, *39, p. 57*) at which their efficiency as nurse bees was becoming impaired. After May 26 these old bees must have died even more rapidly than new bees emerged because they had now been working practically four weeks, to say nothing of their age when put into the packages. With the sudden rapid decrease in field bees, bees normally of hive age would be called upon to go to the field. Consequently, both field and hive activities would seem to have suffered somewhat at this time. Following June 18, the course of brood rearing is clearly upwards.

In studying Merrill's data, it is apparent that by June 18, the beginning of the main honey flow and seven weeks after the packages were installed, brood rearing in these colonies had been only sufficiently active to result in enough new bees to equal approximately the number in the packages originally. It is to be assumed that practically all of the bees contained in the packages were dead at this time. Furthermore, according to Merrill's data the colony population at no time during the season was double that originally in the packages.

It is rather difficult to associate the slow development of these packages and their low maximum population for the season with the astounding performances by packages in other localities mentioned earlier in this bulletin. It may be well to bear in mind that Merrill's data are based on averages from four packages, and that the data from his best package might indicate a much greater possible rapidity of increase in population. Moreover, no information is given as to the apparent age or condition of the bees on arrival, nor whether they were shipped and installed in inclement weather.

Few scientific data obtained by other investigators of the development of package colonies are available, although Wilson (*40*), in 1920, endeavored to obtain data on the relative merits of 2 and 3 pound packages. His experiment, however, was interfered with by cold weather during the time of shipping some of the packages. Other packages, whose size he does not state, but which were received by him on May 1, built up so strongly by July 1, a little more than eight weeks, that he says it was impossible to prevent their swarming. Because of this he holds that packages should not be received too early, at least in Wisconsin.

Farrar (*10*) in 1927 published some observations on package colonies in North Dakota. The highest effective daily egg-laying average given in his data is only 900, and was first attained about six and one-half weeks after the package was installed. This is derived from sealed-brood counts. He also reports that the package was storing surplus honey on the sixth day after being installed. He further states that not all the original package bees were dead 10 weeks after installing the package.

PACKAGE-BEE INVESTIGATIONS AT THE BEE-CULTURE LABORATORY

It was in view of the scantiness of information on the development of package colonies that the investigation in this field was begun in 1926 at the bee-culture laboratory of the Bureau of Entomology at Somerset, Md. During this year the development of a package colony founded from a single package, of a package colony formed by uniting three packages, and of an overwintered colony reinforced by a package, were studied. Even this meager work, however, gave certain leads which showed the advisability of further investigations, and so in 1927 the experiment was continued on a much larger scale.

GENERAL METHOD OF OBTAINING AND WORKING UP DATA

At the present time a package of bees is obtained more for the purpose of starting a new colony or of strengthening a weakened one than for any honey which may be stored by the bees in the package, or for its direct use in pollination. Under these conditions its value to the beekeeper, other things being equal, may be gaged by the rate at which it builds up; in other words, the rate of addition of new bees. Inasmuch as sealed brood represents the last stage before the emergence of the adult bees and under normal conditions practically all will emerge, the rate at which new bees will be added to the colony throughout the season can be more accurately determined by computations based on sealed-brood counts made at least every 12 days than by any other method, except counting the bees as they emerge. For the package-bee investigation, therefore, counts of sealed brood made by photographic means, as described elsewhere (*28, pp. 4–6*), were used.

The daily rate of sealing worker brood, for purposes of calculation, may be assumed to be equivalent to the rate of emergence 12 days later, or to the effective egg-laying rate (*27*) nine days earlier. It will be well to describe the method by which the average daily rates of sealing were worked out by the writer for the data discussed here.

If it is assumed that worker brood remains sealed for an average of 12 days, any single count of the sealed brood in a hive will cover all the brood sealed during a 12-day period ending at the time of the count. It is quite obvious, therefore, that in case of two successive brood counts made less than 12 days apart, the brood sealed during the latter part of the 12-day period represented by the first count will be included in the total for the second count. In other words, the 12-day period represented by the second count will overlap that represented by the first, the number of days included in the overlapped interval being dependent upon the length of time between the counts. It follows, therefore, that the mathematical difference between two successive counts of sealed brood at any interval of less than 12 days is the difference between the amount of brood sealed in that portion of the 12-day period covered by the first count which is not included in the overlapped interval, and the amount sealed in that portion of the 12-day period covered by the second count which is likewise not included in the overlapped interval.

Take, for instance, two successive counts made on May 12 and 19, respectively. The first count covers all brood sealed from May 1 to 12, inclusive; the second count includes all brood sealed from May 8 to May 19, inclusive, while the overlapped interval, or period covered by both counts, extends from May 8 to May 12, inclusive. The portion of the two counts sealed during these five overlapped days is obviously identical, while the difference between the two counts, if any, represents the difference between the brood sealed from May 13 to 19, inclusive, and that from May 1 to 7, inclusive. If the count on May 19 is larger than that on May 12, the difference between the two will be the difference by which the number of cells sealed from May 13 to 19, inclusive, exceeds the number sealed from May 1 to 7, inclusive. On the other hand, if the count on May 19 is less than that on May 12, this represents the difference by which the number of cells sealed from May 13 to 19, inclusive, is less than the number sealed from May 1 to 7, inclusive.

If under the conditions of the foregoing paragraph a third count is assumed to have been made on May 26, the brood sealed from May 20 to 26, the nonoverlapped portion of the second count, would be equal to the brood sealed in the nonoverlapped portion of the count on May 19 plus or minus the difference between the amount of brood found on May 26 and that on May 19. In this particular case the nonoverlapped portion of each count is seven days. The nonoverlapped portion of the count of May 19 is therefore the period from May 8 to 14. This period includes five days sealing (May 8 to 12, inclusive), at the rate for May 1 to 12, as mentioned in the preceding paragraph, plus two days sealing (May 13 and 14), at the rate for May 13 to 19, as also computed there.

With the foregoing as a basis it is comparatively easy to compute the course of the daily rate of sealing (daily effective egg-laying rate 9 days earlier) from a series of successive sealed-brood counts throughout the active season taken at intervals of less than 12 days. It is necessary only to obtain the differences between successive counts and then in succession to add them to or subtract them from, as the case may be, the total for the corresponding nonoverlapped interval. The daily total for the 12-day period represented by the first of a series of successive counts at intervals of less than 12 days is obtained by assuming a uniform rate of sealing during the 12 days covered by the first count, unless the count was taken less than 12 days after the sealing began. In other words, the daily sealing rate during this period is assumed to be one-twelfth of the total for the 12-day period, or the corresponding fraction if less than 12 days is involved. In ordinary cases the first reading of the year in sealed brood will be so small, if taken in time, as to make little difference whether the exact day on which sealing began is known or not. In the example given in the preceding paragraph, therefore, the daily rate of sealing from May 1 to May 12, inclusive, would be taken as one-twelfth of the total sealed brood found on May 12, while the total sealed brood during the seven days from May 1 to 7, inclusive, would be seven times this daily rate. The brood sealed from May 13 to 19, inclusive, therefore, would be equal to the computed amount of brood sealed from May 1 to 7, inclusive, plus or minus the difference between the counts on May 12 and 19, depending on whether the first count is less or greater than the second.

Having worked out the rate of emergence of any colony throughout the season, it is a simple matter to work out the total colony population and the approximate composition in hive bees and field bees at certain dates. In doing the latter, results obtained by Rösch (*37, pp. 627–628*) may well be followed, because his is the most complete attempt to determine the average age at which worker bees take up successive duties in the colony.

Assuming a 35-day period of life for the worker bee, according to Rösch the first 19 days are devoted to hive duties and the last 16 to field duties. Rösch holds further that the first 2 days of the worker's life are given over to cleaning out cells for egg laying; the next 8 to nursing young bees; the next 9 to intermediate hive duties such as relieving incoming field bees of their loads of nectar, carrying out débris, guarding, and the like; while the last 16 are devoted to field duties. Even under normal conditions it is not to be expected, however, that these time divisions are always hard and fast.

The only objection to Rösch's data is that he worked on an observation colony and consequently his bees, through being unduly active, may have been more short-lived that those in colonies under apiary conditions. However, for the purpose of this bulletin it will be better to use too low a figure rather than one too high. Soudek's results, moreover, are quite in accord with those of Rösch as to the nursing period, on the basis of the anatomical and physiological development of the pharyngeal glands of the worker bee. Recent work by Perepelova (*32, p. 557*) in Russia has borne out Rösch in other respects.

In all of the computations of colony population for successive weeks in this bulletin, bees which arrived with the package are disregarded. The computations are based on the number of bees reared after the packages had been installed and assumed to be still alive at the end of the various weekly periods.

EXPERIMENTS IN 1926

Although in 1926 only one of the packages investigated (No. 301) was allowed to build up independently, its development was quite equal to any of those investigated in the succeeding year and would at least seem to be equal if not superior to the minimum which might be expected under optimum conditions. The total weight of the bees in this package was 2½ pounds when received by express from a southern producer on April 23, 1926. It was hived on drawn combs on the day of arrival, having been on the road two days. The package already contained an introduced queen bee, but this queen was accidentally lost on June 16. The record of its sealed brood and the computed emergence for this colony are contained in Table 1.

TABLE 1.—*Record of sealed brood and computed emergence of workers in package colony No. 301*

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package on Apr. 23	Emergence of workers	Average daily emergence
May 7 [1]	6, 850	12	22–26	6, 859	1, 371. 8
May 12	14, 079	35	27–31	7, 220	1, 444. 0
May 18	15, 751	74	32–37	7, 159	1, 193. 2
May 25	15, 208	99	38–44	9, 302	1, 328. 9
May 29	15, 963	189	45–48	5, 468	1, 367. 0
June 8	16, 587	284	49–58	13, 853	1, 385. 3
June 16	16, 441	257	59–66	10, 899	1, 362. 4
June 21	10, 745	146	67–71	7, 208	1, 441. 6

[1] May 3 marks first sealed worker brood.

The main honey flow at Somerset was on in force three weeks after the package was received, and was over before the end of May. Its source was the tuliptree (*Liriodendron tulipifera*). Black locust (*Robinia pseudo-acacia*) also yielded abundantly just before and during the beginning of the tuliptree nectar flow. June was marked by nectar flows from both white clover (*Trifolium repens*) and white sweetclover (*Melilotus alba*), and exceptionally from basswood. These nectar flows were at least sufficient for stimulating brood rearing.

Of the other two colonies used in 1926, No. 201 was started on March 25 by hiving on drawn combs a 3-pound queenless package shipped from the South. Two more 3-pound packages were added to this new colony on April 1. The total live weight of the bees in the three packages, however, due in part to the mortality in two of the packages while being shipped, was not over 8½ pounds. Table 2 gives data on the brood counts and emergence of workers in this colony.

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TABLE 2.—*Record of sealed brood and computed emergence of workers in package colony No. 201*

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing last 2 packages	Emergence of workers	Average daily emergence
Apr. 19 [1]	6,819		26–30	6,819	1,363.8
Apr. 24	11,865	36	31–35	5,046	1,009.2
Apr. 30	13,602	350	36–41	7,282	1,213.7
May 7	15,317	656	42–48	9,249	1,321.3
May 12	16,394	399	49–53	7,145	1,429.0
May 18	15,625	147	54–59	7,159	1,193.2
May 24	15,280	390	60–65	8,130	1,355.0
May 29	15,557	493	66–70	6,234	1,246.8
June 8	14,024	168	71–80	12,431	1,243.1
June 14	14,481	180	81–86	7,023	1,170.5
June 21	12,369	263	87–93	6,517	931.0

[1] Apr. 15 marks first sealed worker brood.

Colony No. 302 had been wintered in the apiary, and was reinforced on March 25 by a 3-pound queenless package shipped from the South. Before the package was added to it, the colony contained 3.3 pounds of bees. Table 3 gives the records of sealed-brood counts and the computed emergence of workers in this colony.

TABLE 3.—*Record of sealed brood and computed emergence of workers in package colony No. 302*

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 12 [1]	4,522	123	26–30	4,522	904.4
Apr. 19	12,749	476	31–37	8,227	1,175.3
Apr. 24	14,829	431	38–42	6,602	1,320.4
Apr. 30	16,177	419	43–48	8,400	1,400.0
May 7	16,945	591	49–55	9,945	1,420.7
May 12	17,459	383	56–60	7,514	1,502.8
May 18	18,780	189	61–66	9,845	1,640.8
May 25	17,506	394	67–73	9,302	1,328.9
June 2	16,721	492	74–81	11,406	1,425.8
June 9	15,392	978	82–88	8,264	1,180.6

[1] Apr. 8 marks first sealed worker brood.

Fewer than 600 sealed drone cells were found in any of the three colonies at any one time, except on May 7 when 656 drone cells were found in No. 201, and on June 9 when 978 sealed drone cells occurred in No. 302. The highest number in No. 301 was 284.

The first new worker bees in each of the three colonies emerged during the fourth week after the packages were installed, but for several reasons the number emerging in Nos. 201 and 302 (Table 4) was smaller, according to the calculations, than that in No. 301. In the first place their queen bees did not come with the packages, and to insure their safety they were so caged that the workers did not release them until four days after the packages were hived, whereas in No. 301 the queen was already free among the bees in the package on arrival. Furthermore, in No. 301 brood rearing began in one of the periods of the year most conducive to egg laying in the apiary at Somerset, owing to the abundance of fresh nectar and pollen available, and this fact alone should have caused brood-rearing activity to be more intense at that time than in No. 302 at least, provided the queen bee was in good condition and had sufficient bees and room.

TABLE 4.—*Computed population in successive weeks of worker bees reared after installation of packages used in 1926*

Colony No.	Worker population at end of specified number of weeks								
	4	5	6	7	8	9	10	11	12
201	4,001	11,865	20,408	29,825	39,120	44,029	45,190	45,298	44,352
301	9,747	18,852	27,882	37,303	47,000	46,920	47,674		
302	2,713	10,398	19,351	29,172	39,109	47,420	49,972	50,709	50,133

In colony No. 201 the queen was caged twice, the first time March 25, when the first package was installed, until her release on March 29. Three days later she was again caged, because the two additional packages of bees were installed at that time. By April 5, or four days later, she had again been released by her bees. The first sealing of brood from eggs laid after the queen's second release occurred on April 15, or 14 days after the second lot of bees had been united with the first. A few cells of brood resulting from the activity of the queen during her first release have been disregarded in the computations.

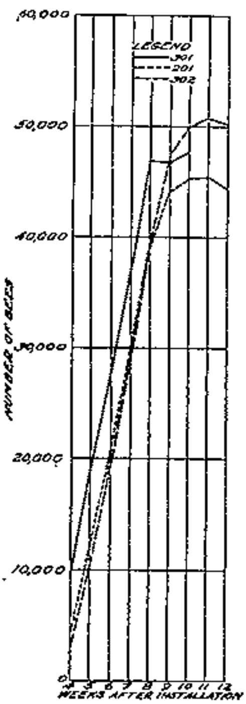

FIGURE 1.—Computed worker populations for successive weeks after installing package colonies used in 1926

In colony No. 302 the first sealing of brood from eggs laid after the package had been united with the original colony occurred on April 8, which was likewise 14 days after the package was installed. In colony No. 301, on the other hand, the first brood was sealed on May 3, or only 10 days after the package was received.

Although the queen in No. 301 started egg laying four days sooner after installation of the package than did the queens in Nos. 201 and 302, their rates of increase until the end of the eighth week are quite similar (fig. 1), notwithstanding the fact that No. 301 was installed three weeks later than the last packages in No. 201, and four weeks later than the package in No. 302. Colony 301 showed little change in population in the eighth and ninth weeks, and, unfortunately, became queenless at such a time that its full performance during the eleventh week could not be calculated. Colonies 201 and 302 made gains in population in the ninth and tenth weeks, but in each case the computed population in the eleventh week shows little increase over that in the tenth. The figures for the twelfth week show a decline.

Comparative numerical data as to the number of bees on hand in each colony at the beginning of the experiment are not available, but, on the basis of the population computations, Nos. 302 and 201 each had 39,000 bees at the end of the eighth week, while No. 301 had slightly more than 47,000. Two weeks later, however, No. 302 had practically reached the 50,000 mark, No. 201 was at 45,000, while No. 301 was still at about the level of the eighth week. The figures for the tenth week represent about the maximum for all three colonies, although Nos. 201 and 302 made minor gains during the next week.

EXPERIMENTS IN 1927

In 1927 the work was continued on a much larger scale, 40 packages being used. These, plus 10 additional packages, were received from the south by express in lots of five. With three exceptions the individual lots arrived at intervals of one week over a period of 10 weeks beginning March 16. The exceptions were lots 3 and 5, which were received one day behind their schedule, and lot 6, which arrived one day early. Each shipment consisted of a 1-pound, a 2-pound, a 3-pound, a 4-pound, and a 5-pound package. They were all on the road from two to three days. Sugar sirup from an inverted tin can fastened in the top of the cage provided food on the journey in addition to any honey the bees may have had in their honey sacs when shaken into the cages. A cloth wick extending through a small hole punched in the can enabled the bees to get at the sirup.

SOURCE OF THE BEES

The packages were all furnished by the same producer to insure uniformity in stock and in age so far as any particular breeder emphasizes these points. If they had been ordered from several different shippers, there would have been the risk of receiving packages put up under widely different conditions both as regards age of the bees and other factors. The producer from whom the bees were ordered was not informed of the purpose for which they were being purchased. Thus, in putting them up he had no occasion for using care other than that taken regularly.

All the queen bees used in this experiment were introduced after the packages had been installed in the hives. In no case did a package arrive with a queen bee already introduced into it. In nearly every case the queen bee was in a mailing cage suspended by fine wire inside the package. In some instances these mailing cages were nailed to the outside of the shipping cage. The queen bees used for the first three lots, however, were obtained from a producer other than the one furnishing the bees, so that these lots were shipped altogether queenless, while the queens came by mail. The queen bees for the last two lots also came by mail, while the packages were shipped queenless by express.

HANDLING THE PACKAGE

Before a shipment was received a hive was prepared for each package. A 10-frame hive body filled with empty drawn combs was used in each case and above this hive body an empty half-depth super was placed, and then the inner cover and the outer cover. The entrance was closed down to a bee space when the package was hived, and later was opened wider when necessary. A Boardman feeder block with a 2-quart glass can was provided at the rear of each hive. The feeder block was shoved through an opening cut in the bottom board.

Each of the shipping cages had two holes in its cover, one being stopped by the food can and its tin flange and the other by a thin piece of wood. When the package was installed, the food can and the piece of wood were removed from the container, thus providing ample exits. The cage was then placed on its side within the half-depth super, resting immediately upon the top bars of the frames. No special attempt was made to get the bees out of the package at this time, but in most cases they were all out by the following morning. The shipping cages and the half-depth supers were then removed, after shaking out any bees which might still be lingering in the shipping cages. This method of installing the packages proved highly convenient during the experiment, since the cages were emptied of bees and were later removed with scarcely any disturbance being caused to the bees themselves. All the lots were received at the bee-culture laboratory in the afternoon, and, with the exception of lot 10, were installed on the day of receipt.

In each hive a Miller introducing cage containing a queen bee was suspended between two of the combs by a bent nail, before the package was installed. The queen bee was placed in this cage without attendants, the exit hole being stopped solidly with candy. In the first lots the queen was caged "safely" by tacking a narrow tin strip across the candy on the outside of the cage, as described by E. R. Root (*35*) in 1908. In such instances the tin was removed the next day, giving the workers a chance to eat out the candy. Whether the tin was used or not, the candy was eaten and the queen freed usually within 24 hours to 36 hours after the workers had access to the candy. Sometimes in cool weather, before the cage with its queen bee was hung between the frames, it was thrust into the package cage for a minute or so until a handful of bees clustered on it.

In order to determine the number of drones in the various packages, excluders were placed between the hive bodies and the half-depth supers used in preparing the hives for all the lots except the first two. The workers, of course, quite readily passed through the excluder to the comb below, where the queen was already caged, while any drones were trapped above in the half-depth super. In most cases they were clustered the next morning. The highest number found in any package did not exceed 75.

Since the main purpose of this experiment was to see how rapidly packages of various sizes build up, and since packages were received over a period of 10 weeks, during which time any nectar flow would normally be subject to variation, feeding was resorted to continuously for all packages to insure that each was under the same conditions as to abundance of food supplies at all times. It is to be remembered that the packages were installed on drawn combs, all of which were empty except for a cupful of the sirup poured into one of them just before installation. The queen in her cage was placed next to this sirup.

The sirup given consisted of 5 parts of sugar to 3 of water. This, of course, approaches a winter sirup rather than one for stimulative feeding. The object in using sirup of this thickness was to reduce the activity of the bees in driving off the excess water. The relative quantities of sirup used per day by the various colonies could readily be gaged by measuring in inches how much the level of the sirup in each can was lowered. These were replenished as soon as empty.

In all lots the net weight of living bees on hand was determined for each package on arrival. A sample, usually of 50 to 100 workers, was then taken from each package in each lot except the first, and the average weight of the individuals in the sample was determined. This was used as the average weight of individuals in the whole package in computing their total number from the weight of live bees in the package. These data will be presented in tables and will be discussed later.

The last numeral in the numbers designating the various colonies used in 1927 denotes the size of the packages in pounds as billed by the producer. Thus No. 402 represents a 2-pound package, while No. 424 represents a 4-pound package.

It should be noted further that lot No. 1 includes package colonies Nos. 401 to 405, lot No. 2, colonies Nos. 411 to 415, and so on through the series to lot No. 10 which includes colonies Nos. 491 to 495.

FLORAL AND WEATHER CONDITIONS

Ordinarily in the vicinity of Somerset, Md., pollen from the field becomes available as early as March in sufficient quantities to supply normal brood-rearing requirements. This held true in 1927, and all the package bees had an abundant pollen supply from the time they were hived, with the possible exception in some instances of a few days of cool or rainy weather. A sufficient supply of sirup or honey and of pollen was, therefore, available practically at all times. The main nectar flow, that from the tuliptree, was on in full force by May 17 and lasted until the first week in June. Some nectar was available from sweetclover in the remainder of June.

In spite of any endeavor to secure bees of a uniform stock and age, or to provide an abundance of food, weather conditions remain a variable factor. During this particular experiment it was unseasonably cold on seven of the last nine days in March; during two 5-day intervals, one 4-day interval, and one 3-day interval in April; and for a 7-day interval in the middle of May. (Fig. 2.) From the day after the beginning of the experiment, March 17, until April 5 the maximum temperature ranged below 55° F. except on March 30 and 31, when the temperature reached 56° and 62°, respectively. On April 6 it reached 68°, but on the morning of April 9 the ground was white with snow. On April 12 the temperature reached 74° during the day. At that time apple trees were in bloom, and much pollen was carried in. On April 17 a scale colony registered a gain of 1 kilogram. The last nine days in April were cool, the temperature being 46° or lower every morning except one when it was 50°. May saw much warmer weather, although from the 12th to the 18th the temperature ranged between 45° and 53° in the morning. By obtaining the bees over a period of weeks, however, instead of all at once, there was less chance of having the whole experiment too seriously affected by any adverse weather, and a better opportunity was given to study the time of arrival of the package in relation to the main honey flow.

BROOD REARING OF THE PACKAGE COLONIES

A complete history of each individual colony used in 1927, with particular reference to its brood rearing, would involve much repetition of detail which often varies little from colony to colony. Consequently the colonies will only be discussed collectively in connection with the general facts brought out by the experiment as a whole. The reader will be able, however, to trace readily the brood-rearing record of any individual colony from the data on sealed brood contained in Table 5. The emergence rates computed for various successive periods are also included in that table.

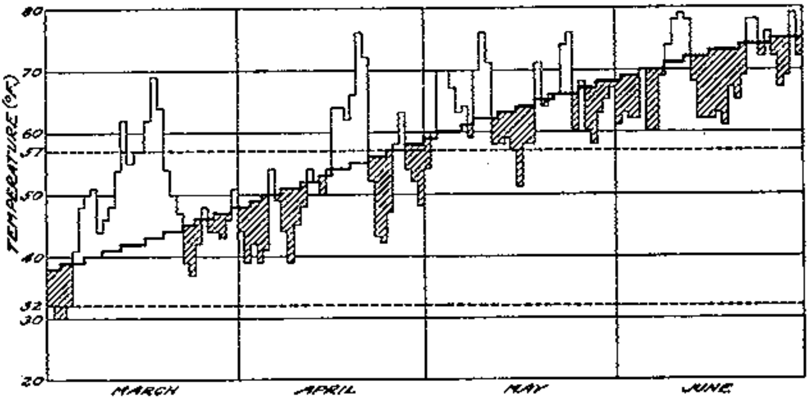

FIGURE 2.—Departure of mean daily temperature from normal mean from March to June, 1927, inclusive. Heavy line represents normal mean temperature, with mean daily departure above it shown by unshaded graph and mean daily departure below it by shaded graph. (Data taken from Monthly Meteorological Summary for Washington, D. C., published by the Weather Bureau, U. S. Department of Agriculture, for the month in question)

TABLE 5.—*Record of sealed brood and computed emergence of workers in package colonies at Somerset, Md., 1927*

COLONY NO. 401

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Mar. 28[1]	128	0	23–24	128	64.0
31	166	285	25–27	38	12.6
Apr. 6	886	640	28–33	720	120.0
11	2,104	398	34–38	1,371	274.2
16	3,131	250	39–43	1,520	304.0
25	6,040	67	44–52	5,128	569.8
May 3	5,527	42	53–60	3,248	406.0
11	3,038	28	61–68	1,414	176.7
20	1,133	109	69–77	603	67.0
28	637	289	78–85	369	46.1

COLONY NO. 402

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Mar. 28[1]	445	0	23–24	445	222.5
31	1,165	0	25–27	720	240.0
Apr. 6	1,981	0	28–33	816	136.0
11	1,611	-------	34–38	555	111.0
16	2,658	-------	39–43	1,831	366.2
25	6,329	1	44–52	5,230	581.1
May 3	5,633	0	53–60	4,308	538.5
11	6,827	38	61–68	4,673	584.1
20	10,074	154	69–77	8,322	924.7
28	11,231	623	78–85	7,532	941.5

[1] Sealing began on the preceding day.

TABLE 5.—*Record of sealed brood and computed emergence of workers in package colonies at Somerset, Md., 1927*—Continued

COLONY NO. 403

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Mar. 28[1]	674	--------	23–24	674	337.0
31	2,094	--------	25–27	1,420	473.3
Apr. 6	4,623	--------	28–33	2,529	421.5
11	4,465	--------	34–38	1,463	292.6
16	6,112	16	39–43	3,806	761.2
25	12,860	331	44–52	10,576	1,175.1
May 3	14,031	224	53–60	9,330	1,166.3
11	12,935	94	61–68	8,270	1,033.75
20	12,021	751	69–77	8,920	991.1
28	13,822	1,039	78–85	9,858	1,232.25

COLONY NO. 404

Mar. 31[2]	100	0	27	100	100.0
Apr. 6	4,705	0	28–33	4,605	767.5
11	6,825	0	34–38	2,120	424.0
16	7,669	0	39–43	4,014	802.8
25	13,012	347	44–52	10,604	1,178.2
May 3	15,977	622	53–60	11,264	1,408.0
11	16,812	560	61–68	11,180	1,397.5
20	15,055	790	69–77	11,462	1,273.55
28	13,538	779	78–85	8,444	1,055.5

COLONY NO. 405

Mar. 28[1]	544	0	23–24	544	272.0
31	2,473	0	25–27	1,929	643.0
Apr. 6	6,562	0	28–33	4,089	681.5
11	6,732	0	34–38	2,000	400.0
16	7,528	29	39–43	4,165	833.0
25	13,644	370	44–52	11,145	1,238.33
May 3	15,769	451	53–60	10,816	1,352.0
11	16,945	242	61–68	11,537	1,442.1
20	16,260	592	69–77	11,942	1,326.9
28	17,904	568	78–85	12,686	1,585.75

COLONY NO. 411

Apr. 7	20	0	27	20	20.0
11	257	--------	28–31	237	59.2
16	327	--------	32–36	70	14.0
25	899	--------	37–45	857	95.2
May 4	440	--------	46–54	154	17.1
			55–56	[3] 34	[3] 17.0

COLONY NO. 412

Apr. 4	6	0	24	6	6.0
6	87	0	25–26	81	40.5
11	202	--------	27–31	115	23.0
16	491	--------	32–36	295	59.0
25	1,346	1	37–45	1,160	129.0
May 4	710	--------	46–54	320	35.55
11	581	--------	55–61	403	57.55
21	368	--------	62–71	253	25.3
June 2	2,191	--------	72–83	2,191	182.58
			84	[3] 183	[3] 182.58

COLONY NO. 413

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 6[4]	878	0	24–26	878	292.7
11	2,436	--------	27–31	1,558	311.6
16	4,788	--------	32–36	2,645	529.0
25	7,825	44	37–45	6,238	693.11
May 4	6,024	75	46–54	3,945	438.33
11	9,128	105	55–61	6,937	991.0
21	13,154	755	62–71	11,172	1,117.2
June 2	16,391	655	72–83	16,391	1,365.93
			84	[3] 1,366	[3] 1,366.0

COLONY NO. 414

Apr. 6[1]	273	0	25–26	273	136.5
11	2,097	--------	27–31	1,824	364.8
16	4,763	--------	32–36	2,666	533.2
25	8,499	--------	37–45	6,899	766.6
May 4	6,523	1	46–54	4,223	469.2
11	9,984	15	55–61	7,638	1,091.1
21	16,420	97	62–71	14,238	1,423.8
June 2	17,605	333	72–83	17,605	1,467.08
			84	[3] 1,467	[3] 1,467.0

COLONY NO. 415

Apr. 3	103	--------	23	103	103.0
6	1,295	0	24–26	1,192	297.3
11	3,315	0	27–31	2,020	404.0
16	6,735	1	32–36	3,920	784.0
25	11,010	214	37–45	8,658	962.0
May 4	11,907	223	46–54	9,021	1,002.3
11	14,090	164	55–61	9,078	1,296.9
21	14,296	362	62–71	11,702	1,170.2
June 2	15,277	750	72–83	15,277	1,273.1
			84	[3] 1,273	[3] 1,273.0

COLONY NO. 421

Apr. 11	33	--------	23	33	33.0
16	975	--------	24–28	942	188.4
26	5,347	--------	29–38	4,070	407.0
May 5	3,827	2	39–47	2,336	259.55
13	7,509	55	48–55	6,471	808.9
23	12,162	22	56–65	10,545	1,054.5
June 3	13,906	259	66–76	12,942	1,176.54
			77	[3] 1,177	[3] 1,177.0

COLONY NO. 422

Apr. 11	51	--------	23	51	51.0
12	178	--------	24	127	127.0
16	1,274	--------	25–28	1,096	274.0
26	7,439	19	29–38	6,891	689.1
May 5	9,140	32	39–47	7,073	785.85
13	8,555	78	48–55	5,412	676.5
23	11,232	237	56–65	9,879	987.9
June 3	11,293	253	66–76	10,305	936.8
			77	[3] 937	[3] 936.8

[1] Sealing began on the preceding day.
[2] The first date in each section of this table is the first day of sealing, unless otherwise noted.
[3] Estimated.
[4] First sealing occurred 2 days earlier.

TABLE 5.—*Record of sealed brood and computed emergence of workers in package colonies at Somerset, Md., 1927*—Continued

COLONY NO. 423

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	223	--------	28	223	223.0
25	5,517	--------	29–37	5,294	588.2
May 4	8,521	5	38–46	6,756	750.67
13	7,601	46	47–55	5,349	594.3
24	10,674	395	56–66	10,080	916.36
June 3	13,365	672	67–76	11,532	1,153.2
			77	[2] 1,153	[2] 1,153.0

COLONY NO. 424

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 14	34	--------	26	34	34.0
16	576	--------	27–28	542	271.0
26	6,419	232	29–38	5,877	587.7
May 5	8,433	74	39–47	6,670	741.1
13	8,928	295	48–55	5,964	745.5
23	8,965	478	56–65	7,474	747.4
June 3	11,163	457	66–76	10,416	946.9
			77	[2] 947	[2] 946.9

COLONY NO. 425

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 11	31	--------	23	31	31.0
12	45	--------	24	14	14.0
16	2,214	--------	25–28	2,169	542.2
26	9,217	42	29–38	8,133	813.3
May 5	12,740	51	39–47	10,300	1,144.44
13	12,883	230	48–55	8,305	1,038.1
			56	[2] 1,038	1,038.0

COLONY NO. 431

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	131	--------	22	131	131.0
25	3,215	--------	23–31	3,084	342.7
May 5	2,508	2	32–41	1,823	182.3
13	4,688	--------	42–49	3,959	494.9
24	9,202	22	50–60	8,707	791.6
June 3	13,774	201	61–70	12,191	1,219.1

COLONY NO. 432

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	383	--------	22	383	383.0
25	6,260	--------	23–31	5,877	653.0
May 6	4,250	--------	32–42	3,597	327.0
13	6,553	4	43–49	4,948	706.9
24	15,259	168	50–60	14,552	1,322.9
June 3	18,310	394	61–70	15,064	1,506.4

COLONY NO. 433

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	169	--------	22	169	169.0
25	7,343	--------	23–31	7,174	797.1
May 5	6,297	--------	32–41	4,703	470.3
13	8,369	14	42–49	6,428	803.5
24	15,707	434	50–60	14,903	1,354.8
June 3	17,691	516	61–70	14,981	1,498.1

COLONY NO. 434

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	281	--------	22	281	281.0
25	7,687	1	23–31	7,406	822.9
May 5	6,581	5	32–41	4,915	491.5
13	8,619	21	42–49	6,654	831.75
24	15,111	314	50–60	14,280	1,298.2
June 3	16,902	632	61–70	14,306	1,430.6

COLONY NO. 435

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 16	256	--------	22	256	256.0
25	7,220	--------	23–31	6,964	773.78
May 5	6,030	7	32–41	4,482	448.2
13	8,944	66	42–49	7,151	893.9
24	10,901	138	50–60	10,007	909.73
June 3	12,984	194	61–70	11,105	1,110.5

COLONY NO. 441

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 25[3]	770	--------	21–23	770	256.67
May 3	4,271	--------	24–31	3,501	437.6
13	4,771	5	32–41	3,896	389.6
24	7,733	13	42–52	7,343	667.5
June 4	12,249	85	53–63	11,581	1,052.8
16	13,116	362	64–75	13,116	1,093.0
25	14,929	401	76–84	11,650	1,294.4

COLONY NO. 442

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 25[1]	387	--------	22–23	387	193.9
May 3	4,072	--------	24–31	3,685	460.6
13	3,301	11	32–41	2,380	238.0
24	7,558	5	42–52	7,320	665.46
June 4	12,525	197	53–63	11,859	1,078.1
16	13,598	315	64–75	13,598	1,133.14
25	16,735	258	76–84	13,335	1,481.7

COLONY NO. 443

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 25[1]	674	--------	22–23	674	337.0
May 3	6,224	--------	24–31	5,550	693.75
13	6,907	31	32–41	5,520	552.0
24	11,269	64	42–52	10,717	974.3
June 4	15,332	209	53–63	14,355	1,305.3
16	15,493	61	64–75	15,493	1,291.1
25	15,899	139	76–84	12,026	1,336.22

COLONY NO. 444

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 3	682	--------	31	682	682.0
13	8,388	35	32–41	7,706	770.6
24	9,754	421	42–52	8,983	816.63
June 4	13,713	423	53–63	12,896	1,172.36
16	12,284	549	64–75	12,284	1,023.67
25	12,126	710	76–84	9,045	1,005.0

[1] Sealing began on the preceding day.
[2] Estimated.
[3] Only a few sealed worker cells were found on Apr. 23, but in the computations this date marks a full day's sealing.

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TABLE 5.—*Record of sealed brood and computed emergence of workers in package colonies at Somerset, Md., 1927*—Continued

COLONY NO. 445

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 25[1]	637	--------	22–23	637	317.5
May 3	6,394	84	24–31	5,757	719.6
13	8,713	187	32–41	7,274	727.4
24	9,325	412	42–52	8,598	781.6
June 4	10,678	467	53–63	9,806	809.63
16	9,911	415	64–75	9,911	825.9
25	9,325	447	76–84	6,847	760.77

COLONY NO. 451

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 3[4]	1,700	--------	24–26	1,700	566.7
13	9,173	7	27–36	8,040	804.0
25	10,504	81	37–48	10,504	875.3
June 6	15,256	125	49–60	15,256	1,271.3
17	14,247	458	61–71	12,976	1,179.6
			72	[3] 1,225	[3] 1,225.0
30	15,236	243	73–84	15,236	1,269.7

COLONY NO. 452

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 3[4]	2,343	--------	22–26	2,343	468.6
13	8,069	56	27–36	7,132	713.2
25	9,620	66	37–48	9,620	801.7
June 6	12,151	549	49–60	12,151	1,012.6
17	14,381	231	61–71	13,368	1,215.3
			72	[3] 1,208	[3] 1,208.0
30	14,400	555	73–84	14,400	1,200.0

COLONY NO. 453

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 3[4]	3,557	13	22–26	3,557	711.4
13	13,467	97	27–36	12,044	1,204.4
25	15,339	435	37–48	15,339	1,278.3
June 6	18,219	625	49–60	18,219	1,518.3
17	19,414	656	61–71	17,926	1,629.6
29	16,942	678	72–83	16,942	1,411.8
			84	[3] 1,412	[3] 1,412.0

COLONY NO. 454

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 3[1]	1,788	--------	25–26	1,788	894.0
13	10,531	63	27–36	8,743	874.3
25	11,270	515	37–48	11,270	939.2
June 6	16,209	486	49–60	16,209	1,350.75
17	16,435	442	61–71	15,084	1,37[illegible].3
			72	[3] 1,408	[3] 1,407.5
30	17,324	654	73–84	17,324	1,443.7

COLONY NO. 455

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
Apr. 28[7]	4	--------	21	4	4.0
May 3	3,988	--------	22–26	3,984	796.8
13	14,597	59	27–36	13,003	1,300.3
25	14,482	64	37–48	14,482	1,206.8
June 6	15,540	87	49–60	15,540	1,295.0
17	12,094	2	61–71	10,799	981.7
29	10,027	3	72–83	10,927	910.6
			84	[3] 911	[3] 910.6

COLONY NO. 463

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 11[4]	2,408	--------	22–26	2,408	481.6
			27–28	1,493	746.5
25	12,138	36	29–40	12,138	1,011.5
June 6	13,199	125	41–52	13,199	1,099.9
17	16,198	485	53–63	15,098	1,372.6
29	17,936	372	64–75	17,936	1,494.7
July 8	16,140	349	76–84	11,656	1,295.1

COLONY NO. 471

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 21[6]	1,524	--------	24–29	1,524	254.0
June 1	2,610	--------	30–40	2,358	214.2
13	5,404	--------	41–52	5,404	450.3
23	8,620	--------	53–62	7,719	771.9
July 5	10,911	4	63–74	10,911	909.2
15	10,665	123	75–84	8,847	884.7

COLONY NO. 472

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 13[7]	1	--------	21	1	1.0
21	6,538	14	22–29	6,537	817.1
June 1	11,829	125	30–40	11,012	1,001.1
13	13,447	165	41–52	13,447	1,120.6
23	17,033	252	53–62	14,792	1,479.2
July 5	19,315	233	63–74	19,315	1,609.6
15	17,070	259	75–84	13,851	1,385.1

COLONY NO. 473

Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 21[8]	6,450	2	24–29	6,450	1,075.0
June 1	12,826	40	30–40	11,751	1,068.3
13	11,936	31	41–52	11,936	994.7
23	17,309	195	53–62	15,380	1,538.0
July 5	19,756	105	63–74	19,756	1,646.3
15	16,091	254	75–84	12,708	1,270.8

[1] Sealing began on the preceding day.
[3] Estimated.
[4] First sealing occurred 2 days earlier.
[6] First sealing occurred four days earlier.
[7] Obviously not a full day.
[8] First sealing occurred five days earlier.

TABLE 5.—*Record of sealed brood and computed emergence of workers in package colonies at Somerset, Md., 1927*—Continued

COLONY NO. 475

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 21[8]	7,133	6	22–29	7,133	891.6
June 1	13,476	14	30–40	12,584	1,144.0
13	14,265	379	41–52	14,265	1,188.7
23	17,574	401	53–62	15,197	1,519.7
July 5	15,065	853	63–74	15,065	1,255.4
15	10,506	478	75–84	8,055	805.5

COLONY NO. 491

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
June 2[6]	2,701	0	24–26	2,791	930.3
			27	[3] 708	[3] 707.5
15	5,817	7	28–39	5,817	484.75
27	8,772	4	40–51	8,772	731.0
July 8	12,107	0	52–62	11,376	1,034.2
19	11,151	0	63–73	10,117	919.7
30	12,489	0	74–84	11,569	1,051.7

COLONY NO. 492

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 28[7]	1	0	21	1	1.0
June 2	1,645	0	22–26	1,644	328.8
			27	[3] 490	[3] 490.0
15	7,821	0	28–39	7,821	651.75
27	8,264	0	40–51	8,264	688.7
July 8	10,408	1	52–62	9,710	883.6
19	8,698	0	63–73	7,815	710.4
30	7,743	0	74–84	7,033	639.4

COLONY NO. 493

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
June 2[1]	1,619	....	25–26	1,619	809.5
			27	[3] 803	[3] 803.0
15	9,557	298	28–39	9,557	796.4
27	10,201	377	40–51	10,201	850.1
July 8	12,466	277	52–62	11,616	1,056.0
19	7,789	....	63–73	6,733	612.1
30	8,490	1	74–84	7,878	716.2

COLONY NO. 494

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
May 28[7]	4	....	21	4	4.0
June 2	3,978	....	22–26	3,974	794.8
			27	[3] 902	[3] 902.0
15	12,100	19	28–39	12,100	1,008.3
27	12,347	9	40–51	12,347	1,028.9
July 8	14,542	....	52–62	13,513	1,228.4
20	12,248	....	63–74	12,248	1,020.66
Aug. 1	11,147	....	75–86	11,147	928.9

COLONY NO. 495

Sealed-brood counts			Computed emergence of workers		
Date	Worker	Drone	Days after installing package	Emergence	Average daily emergence
June 2[6]	1,080	....	24–26	1,080	360.0
			27	[3] 433	[3] 443.0
15	6,277	131	28–39	6,277	523.0
27	13,858	129	40–51	13,858	1,154.8
July 8	15,015	117	52–62	13,860	1,260.0
20	11,870	3	63–74	11,870	989.15
Aug. 1	12,007	....	75–86	12,007	1,000.5

[1] Sealing began on the preceding day.
[3] Estimated.
[6] First sealing occurred 2 days earlier.
[7] Obviously not a full day.
[8] A few sealed cells were found on May 13 but these have been disregarded in the computation.

DISCUSSION OF FACTS BROUGHT OUT IN 1927 BY PACKAGE COLONIES AS A WHOLE

WEIGHT OF LIVE BEES IN PACKAGE ON ARRIVAL IN COMPARISON WITH WEIGHT BILLED BY SHIPPER

Since each of the weekly lots consisted of one 1-pound, one 2-pound, one 3-pound, one 4-pound, and one 5-pound package, the total weight of bees in each shipment should have been 15 pounds. Furthermore, since 10 shipments in all were received, the total weight of bees in these 10 shipments should have been 150 pounds. As a matter of fact, when the individual weights of live bees in all the packages are added the total (Table 6) is found to be 152⅔ pounds. The total weight of bees in the 40 colonies actually used in the experiment in 1927 should have been 119 pounds, but the actual live weight received was 120 pounds.

TABLE 6.—*Weight of live bees in packages when received at Somerset, Md., 1927*

Weight of bees called for in the order	Weight of live bees in packages in— Lot 1		Lot 2		Lot 3		Lot 4		Lot 5		Lot 6	
Pounds	*Pounds*	*Kilos*	*Pounds*	*Kilos*	*Pounds*	*Kilos*	*Pounds*	*Kilos*	*Pounds*	*Kilos*	*Pounds*	*Kilos*
1	1.56	0.71	1.47	0.67	1.21	0.55	0.79	0.36	1.91	0.87	1.63	0.74
2	1.94	.88	2.13	.97	2.51	1.14	2.13	.97	1.83	.83	1.98	.90
3	2.05	1.34	3.59	1.63	2.99	1.36	3.17	1.44	2.71	1.23	3.45	1.57
4	3.92	1.78	4.20	1.91	4.27	1.94	2.84	1.29	3.85	1.75	4.05	1.84
5	5.32	2.42	5.19	2.36	4.20	1.91	2.49	1.13	4.20	1.91	6.45	2.93
Total	15.69	7.13	16.58	7.54	15.18	6.90	11.42	5.19	14.50	6.59	17.56	7.98

Weight of bees called for in the order	Lot 7		Lot 8		Lot 9		Lot 10		Total		Average	
1	1.32	0.60	0.64	0.29	2.51	1.14	1.47	0.67	14.51	6.60	1.451	0.66
2	2.22	1.01	2.11	.96	2.86	1.30	2.33	1.06	22.04	10.02	2.204	1.002
3	3.08	1.40	3.12	1.42	2.93	1.33	3.37	1.53	31.36	14.25	3.136	1.425
4	4.14	1.88	2.90	1.32	5.08	2.31	4.47	2.03	39.72	18.05	3.972	1.805
5	4.86	2.21	4.00	1.82	3.89	1.77	4.47	2.03	45.07	20.49	4.507	2.049
Total	15.62	7.10	12.77	5.81	17.27	7.85	16.11	7.32	152.70	69.41	15.27	6.941

In the foregoing totals the weight of dead bees is not included; this weight (Table 7) was almost 3¼ pounds on the basis of 5,000 bees to the pound. This is slightly more than 2 per cent of the weight called for in the total order, or of the total poundage shipped. Although the weight of live bees when received favored the purchaser, yet an actual loss in dead bees of even 2 per cent seems higher than necessary, especially when it is noted that six packages (Nos. 402, 431, 435, 442, 443, and 474) furnished about half of the total number of dead bees. The number in each of the packages ranged from 1,105 to 1,870. No particular reason was found for this heavy mortality save in the case of No. 431, in which the 1,374 dead bees may be accounted for in part by the fact that the sirup container had no hole and so the bees had no access to the feeder. All of the other five packages had taken sirup, some of them quite abundantly, but none were out of sirup.

TABLE 7.—*Number of dead bees in packages on arrival*

Package No.	Dead bees	Package No.	Dead bees	Package No.	Dead bees	Package No.	Dead bees
401	660	424	100	452	71	475	695
402	1,870	425	100	453	16	481	50
403	330	431	1,374	454	200	482	150
404	220	432	100	455	80	483	120
405	15	433	200	461	35	484	250
411	90	434	150	462	220	485	75
412	52	435	1,127	463	100	491	110
413	50	441	636	464	230	492	100
414	45	442	1,450	465	100	493	76
415	125	443	1,642	471	25	494	250
421	45	444	372	472	10	495	175
422	50	445	944	473	75		
423	100	451	50	474	1,105	Total	10,214

Of the other 44 packages, 25 had 100 or less dead bees; 8 had between 101 and 200 dead bees; 5 had between 201 and 300; while the other 6 had between 301 and 1,000. There were no signs that starvation played much part in the loss occurring in these 44. The bees in each package had taken sirup on the railroad trip, but on arrival, with only 7 exceptions, each package still had over 100 grams of sirup in the can. Packages Nos. 412 and 444 had 10 and 20 grams, respectively, while packages Nos. 475, 481, 493, 494, and 495 arrived with their sirup cans empty. Package No. 475, with 695 dead bees, had the largest number of dead bees of any of these 7 packages, while package No. 481, with 50 dead bees, had the smallest number. None of the seven packages arriving with the smallest quantities of sirup in their feeder cans were among the six showing the highest mortality.

The average weights of the individuals (Table 9) in the seven foregoing packages give no indication of starvation since only one (No. 494) shows a low figure (107.25 mgm) in this respect. As a matter of fact, No. 472, which had the lowest average weight for individuals of any of the 45 packages for which these data were determined, arrived with sirup left in its feeder can and had only 10 dead bees.

The mere presence of sirup in the can does not necessarily mean in itself an abundance of sirup available to the bees, because the sirup may not have passed readily from the can. Possibly this was a contributing cause of the high mortality rate in No. 474, even though the fact that this package had a low average weight for individuals and when received had over 100 grams of sirup left in the feeder can does not differentiate it from No. 472.

The individual lots and the packages within each lot display a wide variation. The total live weights for the separate lots varied from 11.42 pounds to 17.56 pounds. (Table 6.) As for the individual packages, in no instance did the 1-pound package contain exactly 1 pound of live bees. Often it weighed more, but sometimes it weighed less. The one in lot No. 8, for instance, contained only 0.64 pound, while the one in lot No. 9 contained 2.51 pounds. Varying values for the other lots could be cited. The range for the 2-pound package was somewhat less, the minimum being 1.83 pounds (that in lot No. 5) and the maximum 2.86 pounds (that in lot No. 9). The 3-pound package ranged from 2.71 up to 3.59 pounds. The 4-pound package fluctuated about as widely as did the 1-pound package, ranging from 2.84 to 5.08 pounds. The 5-pound package fluctuated even more widely, ranging from 2.49 to 6.45 pounds, and in only three lots did it contain 5 pounds of bees or more. If these packages are typical of the ordinary run of commercial packages, such wide variations in the actual weights may account in part for the widely different results sometimes reported from packages of different sizes. It could not be expected that a supposedly 1-pound package which really contained 2½ pounds would compare other than favorably with a 3-pound package, especially if the latter happened to be a little underweight, or even with a supposed 5-pound package which really contained only 2½ pounds, as did one package in this experiment.

Under a system whereby the bees are weighed as shaken, errors on the part of the helpers are to be expected, when all the conditions under which bees are shaken are taken into consideration. Errors would naturally be greatest in packages of about the 1-pound size because 1 pound may be so quickly shaken in directly from the frame or let in from a container that it is easy to get over the mark. Once the bees are in, it is less bother as well as less painful to nail the package up rather than to let out or remove the excess bees, expecially when they have become angry. On the other hand, before a 5-pound package is completely filled the bees already in the package have had sufficient time to become quite stirred up and to make vigorous attempts to get out of the funnel. If, in addition, the last colony from which bees are being shaken does not furnish quite enough bees to reach the 5-pound mark, a tendency to stop short of the mark, with the thought that a few more or less matters little, might well be expected. That such actually is the case seems evident from the averages for the various packages. Thus (Table 6) the 1-pound packages averaged nearly one-half pound overweight, the actual average being 1.451 pounds. The 5-pound packages averaged nearly one-half pound underweight, their actual average being only 4.507 pounds. The 2-pound packages were one-fifth of a pound overweight. The 3-pound packages averaged about 0.14 pound overweight; while the average of the 4-pound package was a mere trifle underweight, the exact amount of shortage being 0.028 pound.

If the foregoing conditions are general, even though the package shipper loses nothing, owing to the fact that the average of the weights of all his packages irons out to the proper figure in the long run, yet individual purchasers of the bees here and there lose money on their orders, while others obtain an undeserved gain. Since it seems hard to get accurate weighings at the time of shaking, and since it is a simple matter to have shipping containers of a standard weight as well as feed cans which contain a standard weight of a given sirup, it would seem a simple and businesslike procedure to weigh each package again at the station or elsewhere just before shipping, to deduct the proper tare to cover shipping cage and food, and to charge the purchaser only for the weight of bees actually in the package.

Under the foregoing plan, the shipper could collect for only 2½ pounds of bees in the case of package 435, received on April 6, instead of receiving pay for a 5-pound package. On the other hand, he would receive pay for 2½ pounds of bees instead of for only 1 pound in cases like package No. 481, received on May 11. Such a scheme would entail little additional burden on the shipper. The result would be full value to the buyer at least in respect to weight, and, on the other hand, full value to the shipper for every pound sold, regardless of accuracy or its lack on the part of those doing the shaking.

Of course it would be far better for the purchaser to get the exact weight he orders in each package, because if he decides he needs a certain number of 3-pound packages for a certain purpose he does not order on the basis of total poundage but of individual units. Otherwise he would order only in terms of total poundage. Consequently, in the example given, although the total poundage would be the same, he would not want half of his packages to contain only 1½ pounds and the other half to contain 4½ pounds, because the strength of the packages would be too unequal for his purpose, and he ought not to be given the task of taking from one and adding to the other in order to equalize them.

RELATION BETWEEN NUMBER OF BEES IN PACKAGE AS COMPUTED ON BASIS OF INDIVIDUAL SAMPLE AND BASIS OF 5,000 BEES TO THE POUND

The numbers of bees in each package, computed on the basis of the individual weights derived from the representative sample (Table 8), also show wide variation. Thus the 4-pound package of lot 2, on March 23, contained 4.2 pounds of live bees, as did the 5-pound packages of lot 3 on March 31 and of lot 5 on April 14. Yet for the 4-pound package of lot 2 the computation gives 14,585 bees; for the 5-pound package of lot 3, 13,066 bees; and for the 5-pound package of lot 5, only 11,365 bees, a number about 20 per cent lower than that computed for the 4-pound package of lot 2. As another example, the 4-pound package in lot 10 on arrival contained 4.47 pounds of live bees while the 5-pound package in lot 6 contained 6.45 pounds, being about 40 per cent heavier, yet the computed total for the latter in bees, 19,376, was only 448 more than that computed for the former. As an extreme case, package No. 445 contained over 1¼ pounds more live bees than did package 474, but its computed total of individual bees was less. These variations are due obviously to variations in the average weights of individual bees in each package. Such variations in turn may probably be explained, in part at least, by the size of the load of food carried. In this connection, since the bees in the samples had been confined not more than three days, the rectal content is disregarded.

TABLE 8.—*Number of live bees in packages on arrival* [1]

Package No.	Worker bees	Package No.	Worker bees	Package No.	Worker bees	Package No.	Worker bees
411	5,044	433	10,715	455	19,376	482	9,049
412	7,754	434	8,638	461	4,306	483	9,029
413	11,985	435	7,294	462	7,429	484	16,145
414	14,585	441	6,680	463	10,755	485	12,334
415	17,229	442	6,573	464	14,329	491	6,413
421	3,952	443	10,120	465	14,288	492	8,937
422	8,129	444	13,629	471	2,199	493	10,918
423	10,021	445	11,365	472	9,346	494	18,928
424	14,836	451	5,831	473	10,147	495	16,603
425	13,066	452	5,622	474	12,241		
431	3,175	453	10,300	475	14,527		
432	6,519	454	14,371	481	8,678		

[1] Computed from data in Tables 6 and 9.

In Table 9, showing average individual weights in samples of bees, the minimum average is 102.71 mgm, and the maximum 168.06 mgm. On the other hand, if a pound of bees contains 5,000 bees on an average (*34, p. 760*), the average weight of an individual bee is 90.91 mgm. In no case, as just pointed out, was such a low figure found. Obviously, therefore, under these conditions, computing the number of bees in the packages on a basis of 5,000 bees to the pound would give totals different from those obtained by using the average individual weight of bees in a representative sample. For instance, package 421 arrived with 1.2 pounds of living bees, which, at 5,000 bees per pound, would mean 6,000 bees. On the basis of individual weights (Table 10) the number was 3,952, or less than two-thirds as many.

TABLE 9.—*Average weight of bees in samples from 45 packages, 1927*

Lot No.[1]	Size of package as billed	Bees in sample	Weight of sample	Average weight of individual bees
	Pounds	*Number*	*Mgm*	*Mgm*
	1	51	6,774	132.82
	2	52	6,505	125.10
2	3	50	6,800	136.00
	4	45	5,893	130.96
	5	48	6,575	136.98
	1	51	7,097	136.16
	2	49	6,870	140.24
3	3	79	10,722	135.72
	4	63	8,238	130.76
	5	68	9,940	146.18
	1	105	11,905	113.38
	2	61	9,077	148.80
4	3	83	11,154	134.39
	4	65	9,707	149.34
	5	90	13,944	154.93
	1	83	10,810	130.24
	2	64	8,081	126.27
5	3	78	9,480	121.54
	4	95	12,198	128.40
	5	84	14,117	168.06
	1	79	10,026	126.91
	2	71	11,366	160.08
6	3	126	19,206	152.43
	4	111	13,922	125.42
	5	117	17,693	151.22
	1	85	11,844	139.34
	2	57	7,749	135.95
7	3	93	12,106	130.17
	4	65	8,528	131.20
	5	83	12,838	154.67
	1	80	10,552	131.90
	2	80	8,217	102.71
8	3	78	10,915	139.94
	4	94	10,136	107.83
	5	71	8,895	125.28
	1	69	9,064	131.36
	2	62	8,907	143.66
9	3	70	10,311	147.30
	4	91	13,020	143.08
	5	74	10,620	143.51
	1	58	6,060	104.48
	2	122	14,471	118.61
10	3	111	15,556	140.14
	4	125	13,406	107.25
	5	86	10,515	122.27
Total		3,522	471,910	
Average weight of bees in samples				133.99
Weighted average[2] individual weight of bees in the packages				135.85

[1] Samples were not taken from lot No. 1.
[2] Method of obtaining this weighted average is given on p. 24.

Since in every case the average individual weight of the workers in the packages is appreciably greater than 90.91 mgm it may be assumed that the difference is made up by the weight of honey or sugar sirup taken by the bee when smoked just prior to shaking, or else taken from the feeder during shipment. It has been reported that bees at times may carry their own weight in honey in their honey sacs. This condition was not quite reached in any of the packages, if we accept the average weight of the worker bee as 90.91 mgm, because the highest average individual weight is only 168.06 mgm.

The total number of bees in the samples taken from the 45 packages in lots 2 to 10, inclusive, was 3,522. Since their total weight was 471,910 mgm, the unweighted average individual weight is 133.99 mgm. The weighted average, obtained by first multiplying the average individual weight calculated for each package (Table 9) by the weight of living bees determined for that package (Table 6) and then dividing the sum of these products by the sum of the live weights of all of these packages, is a trifle larger than the unweighted average, being 135.85 mgm. This figure is very nearly one and one-half times as large as 90.91 mgm, the figure commonly accepted in this country as the average weight of empty bees, and may mean that the bees in the packages were carrying nearly half their weight in honey or sugar.

In other words, one-third of the weight of the bees at the time they arrived was really sugar sirup or honey in their honey sacs. Whether they carried this much when they were placed in the packages is another matter, but if they had no honey in their honey sacs when they were shaken into the containers, and if they made up the difference in average weight by sirup taken on the trip, then the total poundage of bees was one-third underweight when shipped. This does not seem likely.

Although it is only to be expected that bees when shaken into packages will be carrying some honey in their honey sacs, the amount will vary under different conditions and manipulations. Certain producers may use every care to avoid disturbances which cause the bees to fill their honey sacs at the time of shaking; others, intentionally or not, may so manipulate the bees prior to the shaking process that the bees will have a maximum load in their honey sacs when they are put into the shipping cages. Under these two extremes a pound of bees of uniform size would vary in the number of bees it contained; a pound put up under the last mentioned conditions would contain fewer bees but more honey or sirup. Until some method is arrived at of selling bees more nearly on the basis of numbers instead of weight, the purchaser may at times be buying more honey and fewer bees than he is aware of.

IMPORTANCE OF QUANTITY OF BEES IN PACKAGE

The relative importance of different-sized packages of bees depends on the use to which they are to be put and the time when they are received. If they are bought primarily to build up into colonies to gather the honey flow or to act as pollenizers, their proper size will be governed somewhat by the time available for them to build up. Obviously, the shorter the time, the larger should be the package. If they are bought solely to act as pollenizers, the package should certainly be as large as practicable. If they are bought to reinforce an established colony, the foregoing considerations would also seem to govern.

RELATION BETWEEN SIZE OF PACKAGE AND RAPIDITY OF BUILDING UP

The rapidity with which a colony builds up is of course dependent on a number of factors, which include the number of bees on hand, the prolificness of the queen, weather conditions, and the quantity of nectar and pollen available. In this experiment, as already mentioned, an endeavor was made to provide uniform queens and food in abundance for the colonies. The weather early in the experiment was somewhat unseasonable at times, but on the whole proved favorable in the case of most of the colonies. Hence, at this point only the question of size of package as related to rapidity of building up will be discussed.

In a tabulation (Table 10) by colonies, showing the weekly population in bees reared after the packages were installed, arranged in the order of the number of bees in the packages when they were received, with few exceptions a general tendency for the larger packages to build up more quickly into a higher total population is apparent. This is also shown graphically in Figure 3. If the packages are divided into two groups, the first comprising those packages with 10,021 bees or fewer when received, and the other those packages with more than this number, 17 colonies fall within the first group and 18 within the second. Eight weeks after being received, only 2 of the first 17 colonies, or roughly 12 per cent, had over 30,000 bees, while 7 of the last 18, or roughly 40 per cent, had this number or more. In the next week these figures had moved up to four-sixteenths (25 per cent) and thirteen-seventeenths (over 75 per cent) respectively, 1 colony having dropped out of each group (Nos. 411 and 425) for reasons mentioned earlier.

The highest population computed for any colony in the course of the first eight weeks was 43,000 in No. 453, while No. 455 was second with 41,800. The computed number of bees in No. 453 on arrival was 10,300 while No. 455 had the most of any of the 35 packages, 19,376. Of the second group, 3 had already reached 40,000 or more by the end of the eighth week, but none of the first group had done so. Five of the second group had 35,000 or more, but the same can be said of only 1 of the first group, and this was the second strongest package in this group originally. Fourteen packages in the second group had 25,000 or more, but only 5 of the first group exceeded the 25,000 point.

TABLE 10.—*Computed worker populations for successive weeks after installing package colonies used in 1927, arranged in order of package strength computed on basis of representative sample*

Colony No.	Computed number of bees in package when received	Computed number of bees in colony at end of number of weeks specified [1]								
		4	5	6	7	8	9	10	11	12
471	2,199	1,270	2,800	4,781	7,933	12,372	16,643	21,468	25,787	28,828
431	3,175	2,187	3,944	5,533	8,997	14,538	19,390	26,671		
421	3,952	975	4,459	6,983	9,899	15,807	22,214	26,726	32,433	
411	5,044	79	313	808	1,252	1,372				
452	5,622	3,769	8,701	14,284	20,107	27,195	31,122	34,637	37,537	40,114
451	5,831	3,308	8,936	14,992	21,515	30,414	35,730	38,359	41,056	43,421
491	6,413	3,984	7,377	11,509	16,626	23,259	26,400	29,445	32,279	34,524
432	6,519	4,301	7,568	9,857	14,805	24,065	29,755	37,453		
442	6,573	2,600	5,024	7,118	11,776	18,084	22,941	28,539	35,074	40,788
441	6,680	2,958	5,829	8,834	13,507	19,464	24,133	28,918	33,962	38,350
435	7,294	4,899	9,013	12,596	18,853	25,221	27,310	31,012		
412	7,754	133	438	1,276	1,808	2,101	2,306	2,178	2,461	3,207
422	8,129	1,274	6,008	11,309	16,591	21,638	27,279	29,115	30,462	
434	8,638	5,218	9,653	13,434	19,256	25,343	32,610	38,189		
492	8,937	2,787	7,349	12,022	16,843	22,637	25,863	26,274	26,290	25,945
472	9,347	5,720	12,554	19,791	27,635	36,014	41,679	46,122	49,469	51,321
423	10,021	223	4,340	9,270	14,056	18,538	24,730	27,975	31,117	
443	10,120	4,143	8,432	12,718	19,538	27,682	32,676	37,425	42,206	44,800
473	10,147	5,375	12,800	20,191	27,154	36,290	41,789	45,828	48,922	50,918
453	10,300	5,966	14,398	23,271	32,459	43,087	48,083	51,059	52,285	52,960
433	10,715	4,952	9,224	12,849	18,474	27,958	32,919	39,134		
463	10,755	3,901	10,081	18,238	25,937	34,727	40,434	43,817	40,624	47,991
493	10,918	3,218	8,793	14,529	20,480	27,460	31,190	29,900	28,865	27,927
445	11,365	4,235	9,303	14,449	19,020	25,864	27,926	28,639	29,144	28,998
413	11,985	1,501	4,551	9,239	13,072	17,246	22,934	27,704	32,328	38,057
425	13,066	2,214	7,907	14,925	22,724	29,991				
444	13,629		3,764	9,204	14,920	22,059	30,266	33,668	35,356	36,675
475	14,527	6,241	13,997	22,094	30,415	40,060	44,192	45,224	44,565	41,882
414	14,685	1,003	4,230	9,363	13,540	18,068	25,368	32,108	37,201	43,294
454	14,671	3,537	9,657	16,167	23,153	32,609	38,589	42,068	46,556	48,676
424	14,836	576	4,690	9,418	14,615	10,835	24,491	26,606	28,506	
495	16,603	2,049	5,731	11,299	19,383	27,993	34,493	37,735	39,125	38,045
415	17,229	2,103	6,451	13,007	19,902	27,507	34,229	38,072	40,325	42,342
494	18,928	5,882	12,946	20,066	27,208	35,404	37,071	38,058	37,807	37,107
455	19,376	6,589	15,691	24,232	32,768	41,829	43,369	41,139	39,044	36,882
401	(2)	286	1,434	3,473	7,106	10,529	12,397	12,287	10,697	7,297
402	(2)	1,301	2,203	4,001	7,854	11,751	14,356	18,224	22,899	25,637
403	(2)	2,516	5,208	9,131	10,043	25,133	30,383	34,842	37,857	38,671
404	(2)	868	5,553	10,036	17,908	27,075	36,031	40,881	45,313	44,830
405	(2)	3,155	7,362	11,894	20,157	29,280	35,859	41,517	46,273	49,110

[1] Only bees reared after installing the packages are considered in the computations. From the computations given in Table 5 a few bees emerged in colonies Nos. 441, 455, 472, 475, 492, and 494, even on the twenty-first day after installation, the last day of the third week.
[2] Number of bees in package when received was not computed.

In relative rate of increase, the smaller packages appear at an advantage. If the package containing the largest number of bees when received, No. 455, is used as a base, it is easy to determine the ratio between the population of this package and that of any of the other packages when received by dividing the number of bees in the

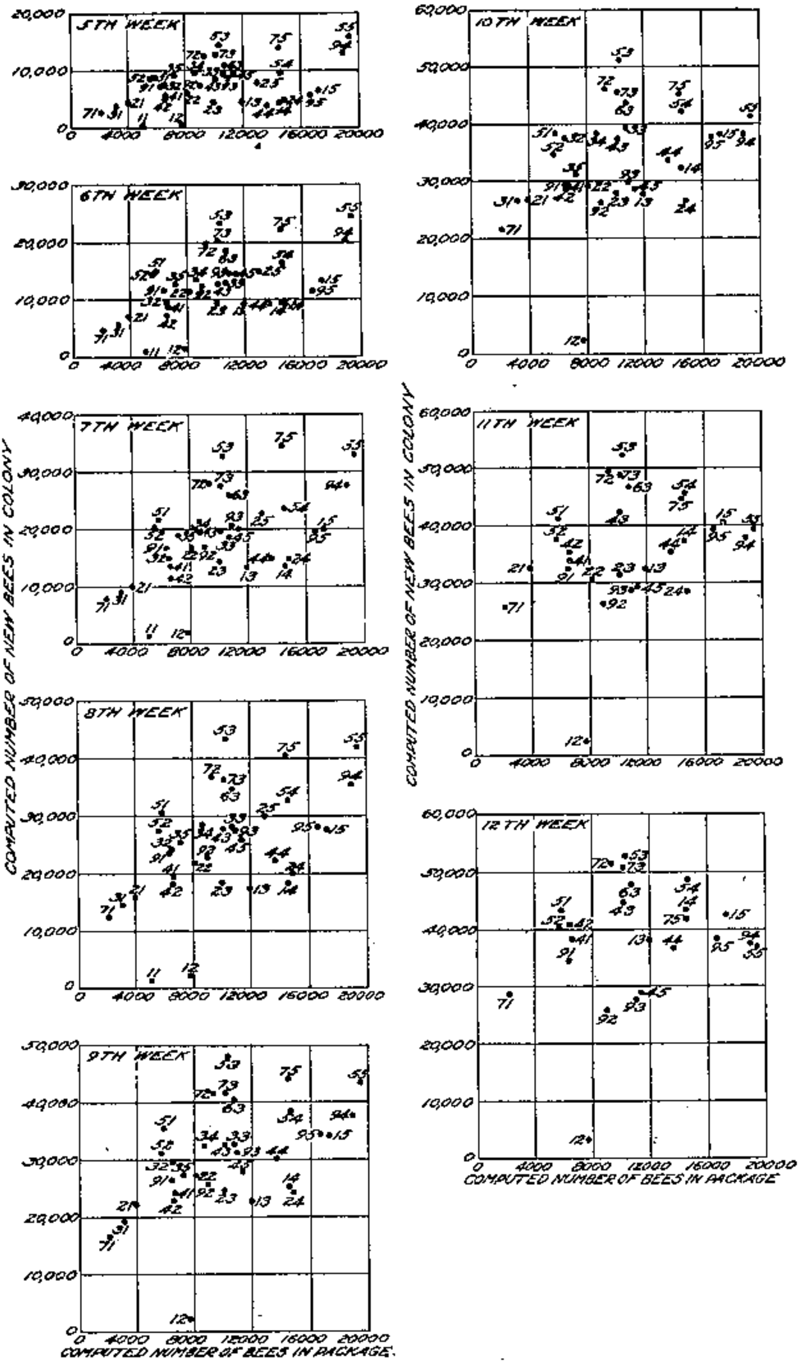

FIGURE 3.—Computed number of new bees in package colonies in specified weeks after installation in 1927. Each colony is represented by a dot and is identified by the last two figures of the number assigned to it. The horizontal position of each dot indicates the computed number of bees in the package when it was received. The vertical position of each dot indicates the computed number of bees present that were reared after the package was installed

latter into that in No. 455. Thus it is seen (Table 11) that No. 455 had 8.81 times as many bees when received as did No. 471; in other words, No. 455 would have made 8.81 packages the size of No. 471. If the computed population in No. 471 at the end of 12 weeks is multiplied by 8.81, it is evident that 8.81 packages the size of No. 471 at this time would have had 253,975 worker bees on hand, theoretically. This number is nearly seven times the number computed as being in No. 455 at the end of the same period. All the other packages show roughly the same tendency in a degree varying directly with their original population. It should be pointed out, however, that No. 471 at its height of population (28,828) at the end of the twelfth week actually had less than 70 per cent as many bees as No. 455 at the height of its population (43,369) at the end of the ninth week. At the latter date the equivalent of 8.81 packages, each the size of No. 471 originally, would have had a collective population (8.81× 16,643) only about 3⅜ times as great as that of No. 455. The comparative cost in honey, and otherwise, of producing all these bees in both cases is not under consideration at this time. No. 455 apparently was not laboring under ideal conditions for brood rearing, since No. 453, which began its career with only a little over half the number of bees in No. 455, at the end of the ninth week had nearly 5,000 more bees. This colony led all others in maximum population attained during the experiment, having 52,980 bees at the end of the twelfth week.

TABLE 11.—*Converted populations of colonies obtained by multiplying the computed population of each colony by a factor equal to the ratio of the original population of package No. 455 to that of each package in question*

Colony No.	Ratio between No. 455 and each package when received	Converted population at end of number of weeks specified								
		4	5	6	7	8	9	10	11	12
471	8.81	11,180	24,747	42,120	69,890	108,907	146,625	189,133	227,183	253,975
431	6.10	13,341	24,058	33,751	54,882	88,682	118,279	162,693		
421	4.00	4,778	21,840	34,217	48,565	77,454	108,849	130,957	158,922	
411	3.84	303	1,202	3,448	4,808	5,268				
452	3.45	13,003	30,225	49,260	69,369	93,823	107,371	119,498	129,503	138,393
451	3.32	10,993	29,668	49,773	71,430	100,974	118,624	127,352	136,306	144,158
401	3.02	12,032	22,279	34,757	50,211	70,242	79,728	88,924	97,483	104,262
432	2.97	12,774	22,477	29,275	43,921	71,473	88,372	111,235		
442	2.05	7,936	14,821	20,998	34,739	53,348	67,676	84,190	103,468	120,325
441	2.00	8,578	16,904	25,619	39,170	56,446	69,986	83,848	98,490	111,215
435	2.66	13,031	23,975	33,505	50,149	67,088	72,645	82,492		
412	2.50	332	1,095	3,190	4,620	5,252	5,765	5,445	6,152	8,018
422	2.38	3,032	14,513	26,915	39,467	51,408	64,924	69,203	72,500	
434	2.24	11,688	21,623	30,092	43,133	63,488	73,046	85,543		
402	2.17	6,048	15,947	26,388	36,549	40,122	56,123	57,015	57,049	56,301
472	2.07	11,840	25,987	40,967	57,204	76,412	86,276	95,473	102,401	106,234
423	1.93	430	8,376	17,891	27,128	35,778	47,729	53,992	60,056	
443	1.91	7,913	16,105	24,201	37,318	52,873	62,411	71,482	80,728	85,568
473	1.91	10,266	24,503	38,505	51,864	69,314	79,817	87,531	93,441	97,253
453	1.88	11,216	27,066	43,749	61,023	81,004	90,396	95,991	98,296	99,002
433	1.81	8,963	16,695	23,257	33,438	50,604	59,583	70,833		
463	1.80	7,022	19,766	32,528	46,687	62,509	72,781	78,871	83,923	86,384
493	1.77	5,696	15,564	25,716	36,250	48,604	55,206	62,923	51,091	49,431
445	1.70	7,200	15,815	24,563	33,864	43,960	47,474	48,686	49,545	49,297
413	1.62	2,432	7,373	14,967	21,177	27,939	37,158	44,860	52,371	61,652
425	1.48	3,277	11,702	22,089	33,632	44,387				
444	1.42		5,345	13,070	21,185	31,324	42,078	47,800	50,206	52,078
475	1.33	8,301	18,616	29,385	40,452	53,280	68,775	60,148	59,271	55,703
414	1.33	1,360	5,625	12,452	18,008	24,030	33,730	42,703	49,477	57,581
454	1.32	4,660	12,747	21,340	30,562	43,044	50,937	55,530	60,134	64,252
424	1.31	755	6,144	12,338	19,146	25,984	32,093	34,854	37,343	
405	1.17	2,397	6,705	13,220	22,678	32,752	40,357	44,150	45,776	44,513
415	1.12	2,355	7,225	14,508	22,290	30,808	38,336	42,641	45,164	47,423
494	1.02	6,606	13,205	20,467	27,813	36,173	38,730	38,819	38,563	37,849
455	1.00	6,589	16,691	24,232	32,768	41,829	43,369	41,139	39,044	36,882

For relative increase in population, therefore, there seems in this experiment some advantage in using an equivalent number of smaller packages in place of one large package, provided there is sufficient time to build up. On the other hand, in this experiment, it was the larger packages which gave quick results, such as are so highly desirable in cold weather, or if the package bees are to be used directly as pollinating agents or honey gatherers. Nos. 411 and 412 are good examples of the fact that small packages can not be used at all seasons and under all conditions. The one had 5,044 bees and the other 7,754 on arrival, yet No. 411 succumbed to rigors of weather and the development of No. 412 was much reduced under the same conditions. The splendid record of No. 471, which began with 2,199 bees and increased its population slightly more than thirteenfold in 12 weeks, may be attributed in part to the good weather under which it developed.

Any apparent advantage of a small package over a large one, if received in favorable weather and with sufficient time to build up, seems due to the fact that under normal conditions the larger package reaches the normal seasonal level of colony population quicker. Consequently, if received too early, it can only drift with seasonal factors after building up, and so, among other things, it may even get the swarming impulse. The smaller package, however, has a longer road to travel in building up, and hence, if it succeeds in doing this, its record may look more impressive than that of the larger package installed at the same time.

ACTUAL LENGTH OF TIME NECESSARY FOR BUILDING UP

Regardless of the size of the original package, it is of the utmost importance that a package colony should build up quickly enough to avoid the danger of all the original bees disappearing before the colony is able to shift for itself. If the average period of life for the worker bee during the active season is 5 or 6 weeks, and if the bees in the package are young enough to average about 1 week in age, it is to be expected that some period after receipt of the package bees, but before about 5 weeks later, will be marked by the heaviest mortality among them. If this is the case it should be attended by a reduction in brood-rearing activity from the rate in the period immediately preceding and following. This would result in reduced emergence during a corresponding length of time three weeks later.

The emergence rates (Table 5) of the package colonies between the date of receipt and eight weeks later show such a break in 23 of 40 cases, beginning as early as the end of the fourth week in some colonies and not ending until during the eighth week in the case of others. These colonies were Nos. 402, 403, 404, 405, 411, 412, 413, 414, 421, 422, 423, 431, 432, 433, 434, 435, 441, 442, 443, 455, 473, 491, and 493. Fourteen of the remaining seventeen colonies (Nos. 415, 424, 444, 445, 451, 452, 453, 454, 463, 472, 475, 492, 494, and 495) showed within eight weeks from installation a period marked by slight or comparatively slight increase in the rate of emergence. After the break the rate of emergence rose to a level much higher in most cases than it had attained before. Even in Merrill's colonies an apparently similar condition is found.

By the end of five or six weeks after being installed, 26 of the 35 colonies used in 1927, whose original package population was determined, had reared enough new bees to equal this population.

(Table 12.) Deducting three weeks, the time during which no bees emerged after the package was installed, gives a period of from two to three weeks during which the emergence was sufficient to equal the original package population. During the next two weeks, in all cases except one, the increase in population likewise at least equalled the population in the packages originally. In several instances this occurred within one week. As a matter of fact, the computations show that at the end of the eighth week 13 of the 26 colonies had populations in new bees which were more than 3 times as large as those in their corresponding packages, while 6 of the 13 had reared enough new bees to make populations 4 to 5 times as large. After tracing the development of the packages this far, it becomes difficult to make generalizations as to the subsequent rate of increase which will fit the majority of the package colonies.

TABLE 12.—*Ratio between population* [1] *of package colonies for successive weeks and the population of the respective packages on arrival, 1927*

Colony No.	Computed number of bees in package	Ratio of population of colony (at end of number of weeks specified) to original population of package								
		4	5	6	7	8	9	10	11	12
471	2,190	0.58	1.27	2.17	3.61	5.03	7.57	9.76	11.73	13.11
431	3,175	.69	1.24	1.74	2.83	4.58	6.11	8.4		
421	3,952	.25	1.13	1.77	2.5	4.0	5.62	6.76	8.21	
411	5,044	.016	.062	.18	.25	.27				
452	5,622	.97	1.56	2.54	3.58	4.84	5.54	6.16	6.68	7.14
451	5,831	.57	1.53	2.57	3.69	5.22	6.13	6.58	7.04	7.45
491	6,413	.62	1.15	1.79	2.59	3.63	4.12	4.50	5.03	5.38
432	6,519	.66	1.16	1.51	2.27	3.69	4.56	5.75		
442	6,573	.41	.76	1.08	1.79	2.75	3.49	4.34	5.34	6.21
441	6,680	.44	.87	1.32	2.02	2.91	3.61	4.33	5.08	5.74
435	7,294	.67	1.24	1.73	2.58	3.46	3.74	4.25		
412	7,754	.017	.056	.16	.23	.27	.3	.28	.32	.41
422	8,129	.16	.75	1.39	2.04	2.66	3.36	3.58	3.75	
434	8,638	.6	1.12	1.56	2.23	3.28	3.78	4.42		
492	8,937	.31	.82	1.35	1.88	2.53	2.89	2.94	2.94	2.9
472	9,338	.61	1.34	2.12	2.96	3.95	4.46	4.94	5.3	5.5
423	10,021	.02	.43	.93	1.4	1.85	2.47	2.79	3.11	
443	10,120	.41	.83	1.26	1.93	2.74	3.23	3.7	4.18	4.43
473	10,147	.53	1.27	1.99	2.68	3.58	4.12	4.52	4.82	5.02
453	10,300	.58	1.4	2.26	3.15	4.18	4.67	4.96	5.08	5.14
433	10,715	.46	.86	1.2	1.72	2.61	3.07	3.65		
463	10,755	.36	1.021	1.7	2.41	3.23	3.76	4.07	4.34	4.46
493	10,918	.29	.81	1.33	1.88	2.52	2.86	2.74	2.64	2.66
445	11,365	.37	.82	1.27	1.75	2.28	2.46	2.52	2.56	2.55
413	11,985	.13	.38	.77	1.09	1.44	1.91	2.31	2.7	3.18
425	13,006	.17	.61	1.14	1.74	2.3				
444	13,629		.28	.68	1.09	1.62	2.22	2.47	2.59	2.69
475	14,527	.43	.96	1.52	2.09	2.76	3.04	3.11	3.07	2.88
414	14,585	.07	.29	.64	.93	1.24	1.74	2.2	2.55	2.97
454	14,671	.24	.66	1.10	1.58	2.22	2.63	2.87	3.11	3.32
424	14,836	.04	.32	.63	.99	1.34	1.65	1.79	1.92	
495	16,603	.12	.35	.68	1.17	1.09	2.08	2.27	2.36	2.29
415	17,229	.12	.37	.78	1.16	1.6	1.99	2.21	2.34	2.46
494	18,928	.31	.68	1.06	1.44	1.87	2.01	2.01	2	1.96
455	19,376	.34	.81	1.25	1.69	2.16	2.24	2.12	2.02	1.9

[1] Only bees reared after installing the packages are considered in the computations.

In the two cases in 1926 in which the population in the eleventh week was computed, a slight increase was evidently still in progress even then. Of 29 package colonies investigated in their twelfth week in 1927, 24 attained their maximum population in this week. Three of this number belonged to lot 1, and so their original package populations were undetermined, but 9 of the remaining 17 belonged to the group having populations of more than 10,021 on arrival.

The points just discussed are of special interest and importance since, coupled with the fact that none of the packages studied for 10 or more weeks reached its maximum population (Table 10, figs. 4–6) before the ninth week, they would seem to indicate that packages should be installed at least eight to nine weeks in advance of the main honey flow if they are expected not only to replace themselves but also to reach approximately their maximum strength before the nectar flow is on.

In general, the smaller the package, the longer the time it requires to build up; but no package should be bought earlier than the time required to fulfill the purpose for which it is bought, whether this be for it to build up in time for a honey flow or for its bees to serve directly as pollinating agents. If packages are obtained too early, the beekeeper may be rushed for time when they arrive, he may pay a

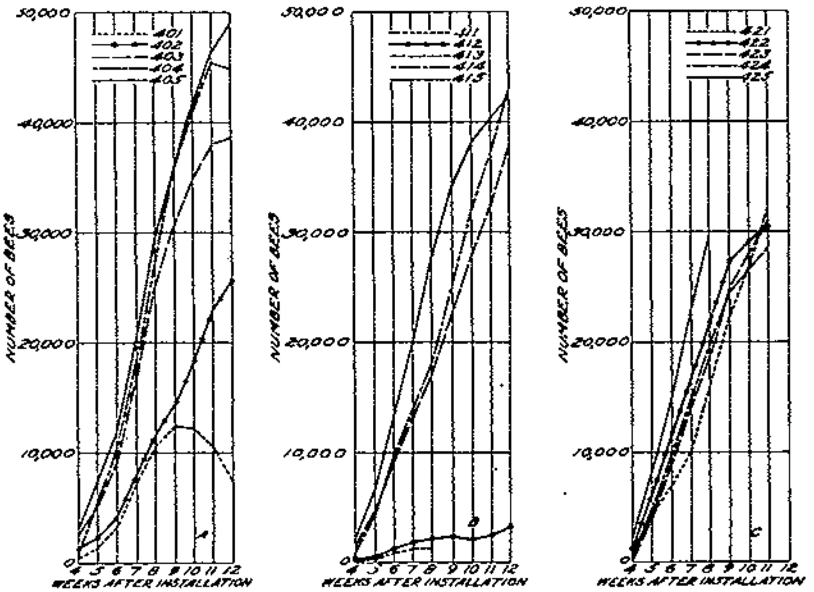

FIGURE 4.—Computed worker populations in package colonies in successive weeks after installation: A, Colonies Nos. 401, 402, 403, 404, and 405; B, colonies Nos. 411, 412, 413, 414, and 415; C, colonies Nos. 421, 422, 423, 424, and 425

price higher than he would pay later in the season, in certain regions he may run the risk of losing the bees in unseasonable weather during shipment or after arrival, or he may even run the risk of having them build up to maximum strength so soon that they will get the swarming fever before the main honey flow is on. Needless to say, obtaining packages too late may also mean wasted time and money on the part of the purchaser. The beekeeper must know his region, its weather, its honey flows, and its pollen yields. He can then pick the right size of package and install it at that time of the year which will give him the biggest return for the time and money spent.

That the foregoing conclusions on the time required for packages to build up and on the merits of different sizes of packages are borne out in apiary practice seems evident from the two following quotations. L. T. Floyd, provincial apiarist of Manitoba, speaks in favor of 2-

pound packages for Manitoba, a region providing 12 weeks in which packages can build up for the main honey flow. He says (*7*):

When a two-pound package of bees delivered on May 1 will, in a good season, build up and gather a 200-pound crop of honey it should satisfy any one. Bees are able to do this in Manitoba because the crop comes in August and September. If larger packages are used, swarming becomes a problem.

Demuth (*6*), on the other hand, in summing up for the United States, in which are many localities where main honey flows come at times which afford much less than 12 weeks for colonies to build up, says:

Experience of those who have purchased many packages of bees would indicate that the three-pound package is large enough for the capacity of the ordinary

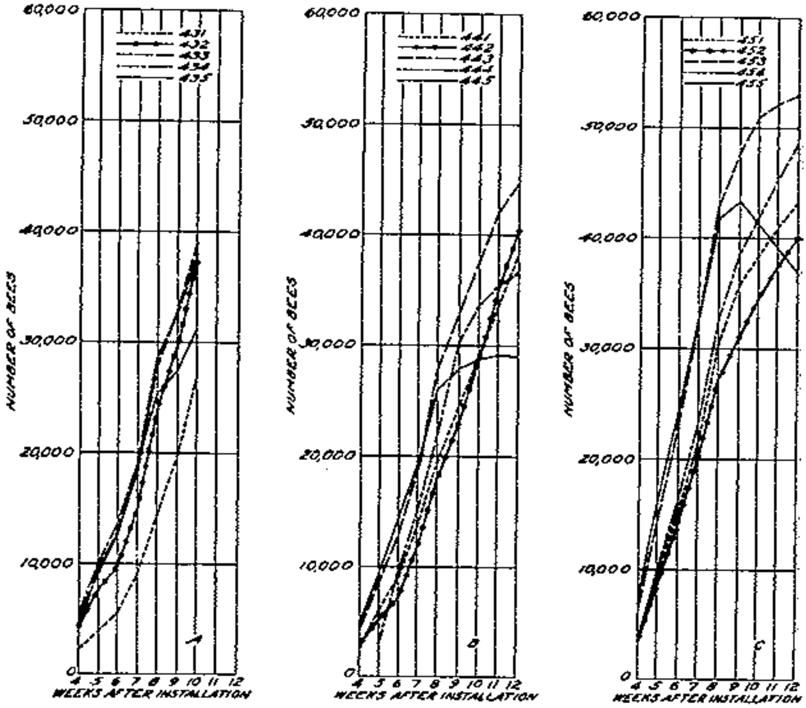

FIGURE 5.—Computed worker populations in package colonies in successive weeks after installation: A, Colonies Nos. 431, 432, 433, 434, and 435; B, colonies Nos. 441, 442, 443, 444, and 445; C, colonies Nos. 451, 452, 453, 454, and 455

queen, provided there are about eight weeks for building up for the honey flow. Many have found the two-pound package to be more profitable than the three-pound package.

IMPORTANCE OF BEES OF PROPER AGE

In this experiment no attempt was made to get bees of any particular age other than the effort to secure bees uniform in condition. In view of the division of labor among bees it is apparent that if the packages are to be used for developing into new colonies the bees should be young enough to engage actively in brood-rearing activities. The same thing is true if they are to aid weakened colonies. If the bees in the package are to be used directly as honey gatherers or pollen gatherers, then on arrival they should be of the proper age physiologically for these tasks. Practical methods for filling the packages with bees of the desired age remain to be worked out.

LENGTH OF TIME ON ROAD

Since the length of a bee's life depends upon how much work it accomplishes, the less time spent in shipment, the better for the package colony, whether the bees are young or old. According to the investigations of Rösch (*37*) and Soudek (*39*), a deterioration of the pharyngeal glands probably is taking place at all times, and a few extra days on the road under conditions tending to age the bees physiologically would mean that the workers would be proportionately less able to feed young larvae. On the other hand, since at least three

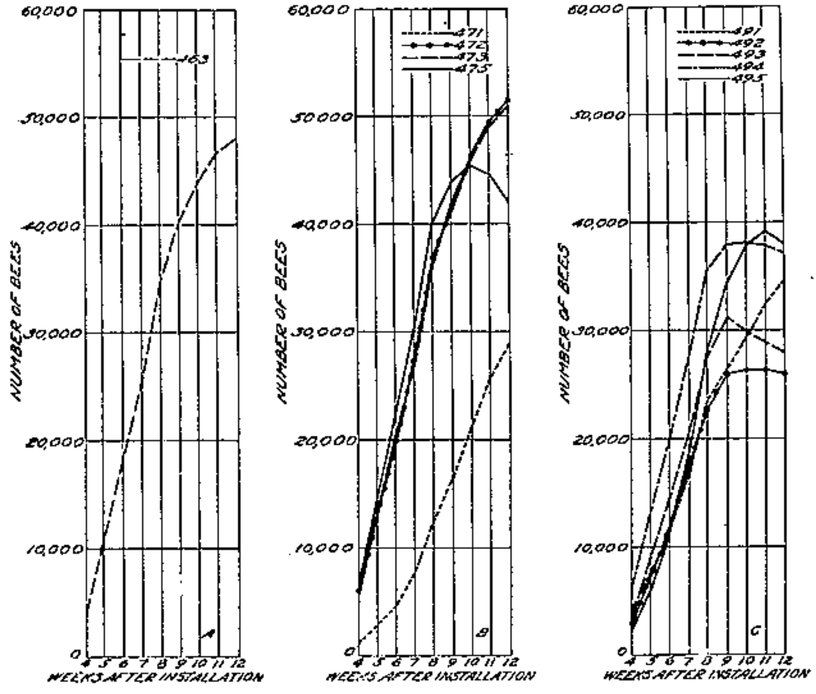

FIGURE 6.—Computed worker populations in package colonies in successive weeks after installation: A, Colony No. 463; B, colonies Nos. 471, 472, 473, and 475; C, colonies Nos. 491, 492, 493, 494, and 495

weeks must elapse after the package is installed before new recruits will be added to the colony by brood rearing, it is highly essential to have the package bees at work as soon as possible in order to rear the largest possible number of new bees before the original package bees die off.

There is practically no region in the continental United States in which an express package can not be received within two or three days from a region producing package bees. Consequently, since the bees in this experiment were on the road at least two days, it is felt that fairly normal conditions were obtained so far as the length of time in transit is concerned. These bees, furthermore, were shipped in weather varying from freezing to midsummer temperatures. Although, other things being equal, it is quite obvious that bees should be bought from the point which involves the shortest time on the road, this is not always done. For instance, it is said that shipments to some points in Canada are on the road for a week (*8*). Under normal conditions such a length of time scarcely seems necessary in the United States if the packages are bought from the nearest producing center. If it is necessary, special attention should be paid to the conditions under which the packages are shipped. The use of refrigerator cars for this purpose would seem to offer a fruitful field of investigation.

EFFECT OF WEATHER CONDITIONS AT TIME OF INSTALLATION

The most noticeable consequence of unseasonable weather during the experiment in 1927 was the loss of package colony No. 411, which, when received, was not large enough to resist the cold. The development of No. 412 was likewise interfered with. On other occasions, because of cold weather, the bees did not leave their shipping cages readily during the night following installation and had to be shaken out when the cages were removed the following morning. This happened principally in lot 2, package 422 of lot 3, and in lot 7. A handful of bees were still lingering the next morning in the cages of lots 1 and 4, and in the remaining packages of lot 3.

Cold weather at the time of installation also retarded the taking of sirup freely by lots 2 and 3. The two larger colonies in each lot lowered the sirup only one-half inch in the jar on the day after installation; the other colonies took scarcely any sirup. Lot 1 took sirup freely on the first day because the weather was somewhat warmer.

Cold weather or cool and rainy weather checked flights for the first day or two after arrival in the case of lots 2, 3, 4, and 7. Weather conditions were so favorable on the days of installing lots 5, 8, 9, and 10, however, that those lots had good flights before night.

USE OF SIRUP WHEN INSTALLING PACKAGES

All the package colonies used in 1927 began to take sirup from the feeders to a greater or less extent within 24 hours after being installed, depending somewhat upon the temperature but to a certain extent apparently regardless of current nectar flows. It is to be remembered that the bees were hived upon combs which were empty except for the cupful of sirup in one of them. The bees in the first lot took more sirup within 24 hours after installation than did those of any other lot. This was to be expected in view of the fact that little, if any, nectar was available from the field so early in the year. The bees in some of the succeeding packages were evidently deterred by prevailing low temperatures from taking sirup during the first 24 hours. Lot No. 10, however, which arrived during the tuliptree nectar flow and under favorable temperature conditions, took sirup readily even within a few hours after installation.

As a matter of fact, the bees in the three largest packages of lots 1 and 10, the first and the last lot, began to take sirup more readily than those in the packages of any of the other lots. Those in Nos. 403 and 405 emptied the 2-quart jar of sirup within 24 hours of installation, being the only packages to do so, while colonies 402, 404, 493, 494, and 495 required 24 hours longer for the purpose. The only other packages which emptied the 2-quart feeder within 48 hours of installation were Nos. 454, 472, 475, and 483. Eleven package colonies (Nos. 401, 414, 415, 442, 444, 445, 453, 465, 473, 474, and 485) required three days. The bees in the remaining packages required from four to nine days to empty the jar.

It is evident from the data given on the brood-rearing activity of the package colonies that the leaders in this respect took sugar sirup actively on installation regardless, at least at first, of whether or not nectar was available in the field. It would seem that the work of the bee in using sirup from the feeder would cause it far less wear and tear than gathering nectar from the field. If this holds true, and if the bee could be kept from deserting the feeder for the field, the bee's energy would be conserved by giving sirup during this period, and a correspondingly greater number of new bees would be reared before the original package bees died off. Perhaps giving sirup to the package bees when installed is better than giving combs of honey. This would seem to be the case if the bees, which ordinarily would carry the sirup from the feeder, should engage in gathering nectar from the field in case combs of honey were substituted for the sirup. In the latter event it would seem that they would wear out sooner than if they had been carrying sirup from the feeder, although their activities under such conditions are not well known.

EFFECT OF PRESENCE OR ABSENCE OF A QUEEN BEE IN THE PACKAGE DURING SHIPMENT

It has been frequently stated in beekeeping circles that combless package bees ship better with queen bees than without queen bees. In this experiment the packages in lots 1, 2, 3, 9, and 10 were shipped without queen bees. Except for No. 402, none of these packages showed any greater rate of mortality than did those packages shipped with queen bees. In fact, the highest loss in any lot occurred in lot 5, of which all the packages contained caged queen bees. There appeared to be no particular difference in the promptness with which queen bees arriving caged in the packages and those shipped separately began to lay. In each case the bees immediately began to release the queen from the Miller cage, and acceptances were as many in one case as in the other. Of the two original queen bees not accepted when released, one (that in No. 404) had been given to a package which had been shipped queenless, while the other (that in No. 444) had accompanied the package in shipment from the producer. Of the other 24 queen bees in the group not shipped with the packages, all survived, and none was even balled, with the exception of the queen in No. 483, which was released in good shape but was balled on the third day when the hive was opened. Of the 25 queens which came with the packages, in addition to the 1 lost as already mentioned, 3 more were lost within nine days of the time of arrival, while 2 others were balled, but not fatally, soon after being released from their cages. Another proved incapacitated in some way. So far as this experiment is concerned, therefore, practically as good results were obtained by shipping the packages queenless as by shipping them with queens.

It may be added that all the queens shipped in the packages were in mailing cages which contained both candy and attendants. Only one of these queens (that in No. 475) was lost in shipment.

BALLING THE QUEEN BEE

It is only repeating an old axiom to mention that a colony in which a queen has been newly introduced should not be disturbed for several days. In this experiment, however, it was desired to get exact data on how soon the queen was released from the Miller cage and when she commenced egg laying. For this reason the colonies were examined each day after being installed until these facts were ascertained. In spite of every precaution four queens (those in 424, 454, 473, and 483) were found balled within two days after the packages were installed. They were thereupon rolled in honey, returned to their colonies, and three (those in 424, 454, and 473) were reaccepted. This treatment apparently did not save the fourth, since No. 483 was found queenless four days later. Two queen bees (those in 404 and 444) were lost within two days after being introduced, whether because of the premature opening of the hive or not. Three others (those in 461, 465, and 474) were lost within six to nine days after being introduced, although balling, if it occurred, was not observed.

IMPORTANCE OF TIME WHEN THE QUEEN BEE IS RELEASED

Needless to say, the quicker the queen begins to lay in the package colony the better. For purposes of building up, this becomes doubly important when the time between receipt of the package and the opening of the honey flow is limited, and also in case the bees in the package are just passing out of the nurse-bee stage. Since none of the queens used in this experiment came free in the package, each was introduced as described earlier. In 6 of the 35 colonies, into which the queen bees were introduced without use of the tin over the Miller cage, a few cells of sealed brood were found (Table 13) on the ninth day after the package was installed. The queens in one-half of these (Nos. 475, 492, and 494) had not been shipped in the packages. In 13 cases 10 days elapsed between installation and the occurrence of the first sealed brood; in 6 cases, 11 days; in 6 cases, 12 days; and in 2 cases, 13 days. In 5 of the remaining 6 colonies of this group, the original queen bees were lost during the first few days, while eggs were found in the sixth on the fifteenth day after the package was installed.

In 8 of the 15 package colonies whose queen bees were caged safely for one day while being introduced, sealed brood was found on the eleventh day after the queen was installed. In 2 instances this period was 12 days, while 16 days was the longest period for any of the remaining 5 queens.

TABLE 13.—*Number of days from time of installation of package to appearance of sealed brood*

Package No.	Days	Remarks
401	11	Queen caged safely one day.
402	11	Do.
403	11	Do.
404	15	This refers to the second queen. She was caged safely one day.
405	11	Queen caged safely one day.
411	15	Queen given one day after installing package. She was caged safely five hours.
412	12	Do.
413	12	Do.
414	13	Do.
415	11	Do.

TABLE 13.—*Number of days from time of installation of package to appearance of sealed brood*—Continued

Package No.	Days	Remarks
421	11	Queen caged safely one day.
422	11	Do.
423	16	Do.
424	14	Queen caged safely one day. She was balled once during the 14-day period.
425	11	Queen caged safely one day.
431	10	
432	10	
433	10	
434	10	
435	10	
441	9	
442	10	
443	10	
444	19	This refers to second queen.
445	10	
451	12	
452	10	
453	10	
454	13	Queen was balled once during this period.
455	9	
461		Queenless on ninth day.
462		Unsealed brood on fifteenth day.
463	10	
464	12	
465		Queenless on ninth day.
471	12	
472	9	
473	12	Queen was balled once during this period.
474		Queenless on sixth day.
475	9	
481	10	Queen given one day after installing package.
482	11	Do.
483		Queen given one day after installing package. Queenless on sixth day. The queen was balled once during this period.
484	11	Queen given one day after installing package.
485	10	Do.
491	12	
492	9	
493	13	
494	9	
495	12	

It is an open question whether the proportion of colonies in which sealed brood was found nine days after installing the package would have been materially increased if the queens had been shipped free in the packages. Even if this had been the case, it must be remembered that the sealed cells found on the ninth day after the packages were installed had been sealed only a few hours at most, while the majority of the sealed cells found on the tenth day, which marks the end of the first 24 hours of sealing, arose from eggs laid within 24 hours after the packages were installed. It is readily apparent that in all such instances the workers in less than 24 hours ate through the candy imprisoning the queen in the Miller cage and that the queen began laying within a few hours at the most.

IMPORTANCE OF A PROLIFIC QUEEN BEE

Thirteen of the 40 queens in the colonies whose sealed brood was counted in 1927 had daily effective egg-laying averages of over 1,400. Three of these were in excess of 1,600, the highest being 1,646. All 3 of the queens used in the experiments in 1926 attained daily effective egg-laying averages in excess of 1,400 but below 1,599. Of the remaining 27 queens used in 1927, 11 attained over 1,200 for this rate but below 1,399, while 7 had rates between 1,000 and 1,199. Six were between 883 and 987.

Three queens, those in colonies 401, 411, and 412, had daily average rates below 600. Their low rates are to be explained by the fact that the queen in No. 401 soon proved to be a drone layer, while the queens in Nos. 411 and 412 arrived during such inclement weather and with so few bees in comparison with the other colonies of this lot that they were handicapped by the unfavorable conditions.

The data on the effective egg-laying rates, taken in connection with the computed number of bees originally in the packages, give some interesting facts. Apparently there was considerable variation in the prolificness of the queens, since the highest egg-laying rate was not found in the colony which developed from the package with the largest number of bees. For instance, No. 473, the colony whose queen had the maximum daily effective egg-laying average, 1,646, had only 10,147 bees on arrival, whereas the queen of the largest package, No. 455, which contained 19,376 bees, had a maximum daily effective rate of only 1,300. This rate was attained early, however. No. 432 had only 6,519 bees in its original package, but its queen attained a rate of 1,566 before the end of the experiment, whereas No. 424 had 14,836 bees, but its queen subsequently attained a daily effective rate of only 947.

It must be remembered that the data just given on effective egg-laying rates represent only the maxima and cover only a few days. Nevertheless, they indicate differences in the individual queen bees.

It is quite evident that the package whose queen soonest attains a satisfactory effective average will be apt to maintain an advantage in population over other colonies during the first few weeks. Thus, 7 of the 40 queens used throughout the experiment attained an effective daily egg-laying average of over 1,000 within 30 days after the packages were installed. These were: The queen in No. 473, which attained an average of 1,075 by the twenty-fourth day; the queens in Nos. 453 and 455, which attained 1,204 and 1,300, respectively, on the twenty-seventh day; the queen in No. 494, which reached 1,008 on the twenty-eighth day; the queen in No. 463, which reached 1,011 on the twenty-ninth day; and those in Nos. 472 and 475, which showed averages of 1,001 and 1,144, respectively, on the thirtieth day. It is to be noted (Table 10) that none of the other package colonies surpassed any of these seven in the computed total number of new bees on hand in each until the ninth week after installation. That a prolific queen can, to a certain extent, overcome a handicap in regard to number of workers in her colony is shown in these seven packages also, since Nos. 453 and 455 arrived with 10,300 and 19,376 bees, respectively, but on the twenty-seventh day the effective egg-laying averages of the queen in each showed a difference of only about 7 per cent.

PACKAGE BEES AS POLLENIZERS

The observations made as to the time when pollen gatherers were first seen in the different package colonies is of interest in connection with the use of package bees as pollenizers and in determining how long in advance of blossoming they should be obtained. As stated before, most of the packages were received after 4 p. m. and were installed before dark. In the case of 21 packages (Nos. 401, 402, 403, 404, 405, 451, 452, 453, 454, 455, 475, 481, 482, 483, 484, 485, 491, 492, 493, 494, and 495), bees were observed coming in with pollen within one day after they had been received. In most of these cases the pollen gatherers were observed between 8.30 and 9 a. m. Both the smaller and larger packages were represented. Weather conditions undoubtedly prevented the gathering of pollen so soon by the colonies in some of the other lots. It is of special interest that in colony 494, belonging to a lot hived at noon, pollen gatherers were observed returning at 4 p. m. This experiment shows that bees from packages may begin to gather pollen within a few hours after being installed. Since the period for pollinating any plant is relatively short, such behavior on the part of the bees is of particular value because it makes feasible the procuring of packages just at pollinating time merely for pollinating purposes without any idea of having the bees build up into colonies.[5]

PACKAGE BEES AS HONEY GATHERERS

Although most of the 3-pound packages were placed on scales, unfortunately none received at the time of the main honey flow was thus treated, package No. 473, received on May 4, being the last to be put on scales. The main honey flow was on by May 20, by which time the bees in No. 473 had already been at work over two weeks. The first brood in this colony was sealed on May 17, which means that no young bees emerged before May 26. Nevertheless, this colony gained 0.66 pound during the daytime on May 21, 0.79 pound on May 22, 0.86 pound on May 23, and 0.7 pound on May 24. It would have been of particular interest to test the performance of the lot received on May 11 and more particularly the performance of the lot installed on May 19. Even colony No. 463, however, furnishes a little evidence on this question, since it was received on April 27 and its first new bees were not out before May 16. It is rather doubtful that many, if any, of these were flying five days later, May 21, on which date the colony gained 0.55 pound during the daytime. On May 22 the daytime gain was 0.86 pound, on May 23 it was 1.32 pounds, and on May 24 1.54 pounds. Possibly at this time young bees were also flying.

Although these gains are slight even in comparison with those of colony No. 403, which on several days in May brought in over 7 pounds of nectar, the highest amount, 9.5 pounds, being on May 23, it must be recalled that these package colonies were rearing brood as well as gathering nectar and pollen. They had been working for over two weeks after being installed, with no help from newly emerged bees in No. 463, and with scant, if any, help from the few bees newly emerged by this time in No. 473. Consequently it is reasonable to suppose that package bees, especially those of field age, if added to a weak colony at the time of the honey flow, would prove of immediate value in gathering honey.

It is interesting to compare the amount of nectar which the computed field force of some of the colonies described here might have gathered with what other typical package colonies are reported actually to have gathered in the sweetclover region. Colony No. 301 will show this as well as any. Munro[6] has stated that a package received on June 3, 1926, at the apiary of the North Dakota Agricultural Experiment Station showed a gain of 268 pounds from July 21 to September 17. In a private communication he furnished the

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[5] See footnote 4.
[6] MUNRO, J. A. N. Dak. Beekeepers' Assoc. News Letter, v. 4, no. 1, October, 1926. [Mimeographed.]

additional information that the package had contained 3 pounds of bees and that sweetclover in his region in 1926 was in blossom from about the middle of June until the middle of September. This means that the package was received approximately two weeks before the beginning of the main honey flow. By July 21 the colony had gathered about 50 pounds. Its highest 24-hour gain, 18¼ pounds, came on July 31, a little more than eight weeks after the package was installed. Its highest 24-hour gain during the next month was 15 pounds, on August 12, ten weeks after being received, while on September 6 it made a gain of 10¾ pounds.

From computations based on counts of its sealed brood, colony No. 301 (Table 14) should have had approximately 21,000 field bees on hand at the end of eight weeks after being received, if we follow Rösch's results previously cited. This figure was barely exceeded during the remaining weeks of the observations. If worker bees on an average go to the field younger than at the age given by Rösch, or if their average length of life is longer, the number of bees given here would be too small, at least during some of the succeeding weeks. Thus, assuming a duration of life of six weeks, of which the last three weeks are devoted to field duties, about 28,000 field bees were on hand by the end of the ninth week of the observations.

Assuming that each bee makes 10 trips per day to the field for nectar, as is well warranted both by Park's work (*29, p. 132; 30, p. 213*) and by that of Himmer (*13, p. 146*), and assuming further that each bee carries in one-fourth of its own weight in nectar on each trip, but that, according to Hambleton (*12*), one-fourth of this nectar is evaporated off as water overnight, a field force of 21,000 could be expected to make a daily gain of 7⅞ pounds during the honey flow. A field force of 28,000 could give a result of nearly 10 pounds daily. Both of these calculations are based on the assumption of 5,000 worker bees to the pound.

TABLE 14.—*Population of worker bees in colony No. 301 reared after hiving package on April 23, 1926, as calculated from computed emergence rates*

Date	Number of weeks after hiving package	Computed number of worker bees in the colony, assuming a 5-week average period of life and a division of duties according to Rösch				
		Cell cleaners, 0–2 days	Nurse bees, 3–10 days	Intermediate bees, 11–19 days	Field bees, 20–35 days	Total
Apr. 30	1	0	0	0	0	0
May 7	2	0	0	0	0	0
May 14	3	0	0	0	0	0
May 21	4	2,888	6,859	0	0	9,747
May 28	5	2,272	11,207	5,144	0	18,623
June 4	6	2,739	9,780	13,500	1,715	27,743
June 11	7	2,706	10,778	10,999	12,635	37,118
June 18	8	2,794	11,000	12,208	20,895	46,897
June 25	9	2,713	11,054	12,223	20,736	46,726
July 2	10	2,899	11,040	12,491	21,289	47,719

It should be borne in mind, however, that the days in the sweetclover region of the North are long and that the season of the sweetclover honey flow itself in that region is relatively long, being between two and three months.

In certain western arid regions the nocturnal loss in weight of nectar by evaporation is even less than that used in the foregoing calculations. Furthermore, according to Gillette *(11)* and Park *(29, p. 133)*, bees usually carry loads equal to about one-half or even more of their own body weight, while Park *(29, p. 132)* found bees under optimum conditions making 20 trips or more daily. If optimum conditions recorded by various investigators are assumed, the field force of 21,000, computed for colony 301, could account for much more than a daily gain of 20 pounds, and under sweetclover conditions would, theoretically, at least, be capable of equalling the large honey crops mentioned earlier in this bulletin. It is felt, for this reason, that this colony and the others were fairly typical package colonies in their development, especially since larger field forces were attained in others of the package colonies before the end of the experiment.

SUMMARY

Some of the results of the experiment may be briefly summarized as follows:

The actual live weight of bees in individual packages when received bore little relation to the weight billed by the shipper. As a rule the smaller packages weighed more and the larger packages less than the billed weight.

In no case did the bees average 5,000 bees to the pound. If the latter figure holds for empty bees, the individual weights of the bees in these packages as determined on their arrival may be taken to indicate that, on an average, they were holding approximately half their weight in sirup.

In the colder weather the larger packages showed to advantage. The larger packages also built up to normal colony strength quicker. Over a sufficiently long period, on the other hand, the smaller packages showed a higher relative increase.

Packages should be allowed eight to nine weeks in which to build up, and, if small, even more.

Under good conditions package bees can easily stand at least two or three days' shipment.

Package bees in this experiment made use of a feeder in the hive even when a nectar flow was on in the field.

In this experiment no particular difference could be detected in the condition on arrival of those packages shipped with queen bees and those shipped without them. Nor was there any difference in the time elapsing before the queen bees in the two cases began to lay.

In the experiment, regardless of the known risk of having the queen bees balled, it was necessary to examine the colonies daily after they had been installed. Of the 50 queen bees, 4 were found balled within two days after the bees had been installed. Three of these queens were reaccepted after being rolled in honey. Two other queen bees were lost within two days, and three within six to nine days after the packages had been installed, but it was not ascertained in these cases whether the queen had been balled.

Over half the queen bees commenced laying within 24 to 48 hours after the bees had been given access to the candy in the queen cage. Such access in the majority of these cases was given immediately at the time of installing the packages.

A prolific queen is highly essential for the optimum development of the package.

The proper age for bees in the package depends on the use to which they are to be put. If the packages are to develop into colonies or are to help weaker colonies develop, the bees should be young enough physiologically to engage actively in brood-rearing activities. If the bees are to be used directly as pollenizers or nectar gatherers, they should be just entering field age. In any case they should be young enough physiologically to insure their proper functioning in the desired activity.

Under proper conditions bees from packages will gather pollen within a few hours after being installed. This fact makes possible the use of the original bees in the package as pollenizers without the necessity of having them build up into colonies.

The original bees in certain of the packages gathered nectar. This at least indicates the feasibility of securing a larger honey crop by reinforcing weakened colonies just before the honey flow with bees of the proper physiological ages both to gather and to store nectar.

A package colony with even 21,000 field bees, under the optimum conditions prevailing in certain localities and with long seasons for nectar gathering, can store a satisfactory quantity of honey.

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