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UNIVERSITY OF MINNESOTA
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HABITS AND ACTIVITIES OF BEES[1]

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BEE COLONY

Bees are social insects. From 10 to 80 thousand of them constitute a colony. A colony is composed of one queen bee, thousands of worker bees, and during the breeding season in spring, from one to 5 thousand drones.

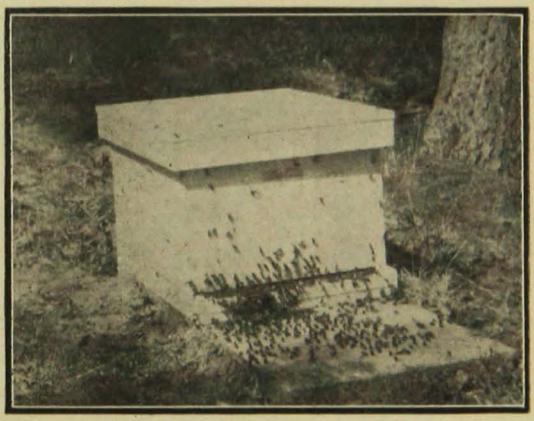

Fig. 1. Hive and Bees

The Home of the Colony

Bee colonies make their abode in dark cavities, hollow trees, and tree branches, and man-made hives. Their dwelling is filled with wax comb produced and built by themselves. The **comb** is the sphere of their home activities. It consists of thousands of six-cornered (hexagonal) wax cells adjoining each other and built in both directions from a central, vertical mid-rib. The combs are attached firmly to the ceiling and walls, but unattached at the bottom. Each comb is separated from the adjoining comb by a **bee space** of about three-eighths of an inch. The

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bee spaces are alleys of travel and communication and extend into the most remote corners. The combs are built apparently without any regulated plan and in the natural state are irregular and crooked.

The cells composing the comb are of three kinds. Worker cells are hexagonal, horizontal, and measure five to an inch. Drone cells are of the same pattern but larger, measuring four to an inch. Queen cells are round, peanut shaped, and perpendicular, located mostly alone on the edge of the combs, when built under the impulse of swarming or superseding the queen; and on the face of the brood comb in case of queenlessness. The comb is used for raising brood, for storing pollen and honey, for keeping the bees warm in winter, and for clustering of bees. (See page 11, Fig. 5.)

The Entrance

An entrance not larger than a few square inches is the avenue of communication with the outside world and also the means of ventilation. It is never closed under any conditions. When too large, the bees usually narrow it down by layers of **propolis,** a sticky substance gathered from pine trees or buds of certain plants, mixed with saliva and otherwise modified. This substance is also used for gluing together the loose parts of their home, for closing cracks, for smoothing over rough surfaces, and for covering objectionable matter when too large to be removed by the bees.

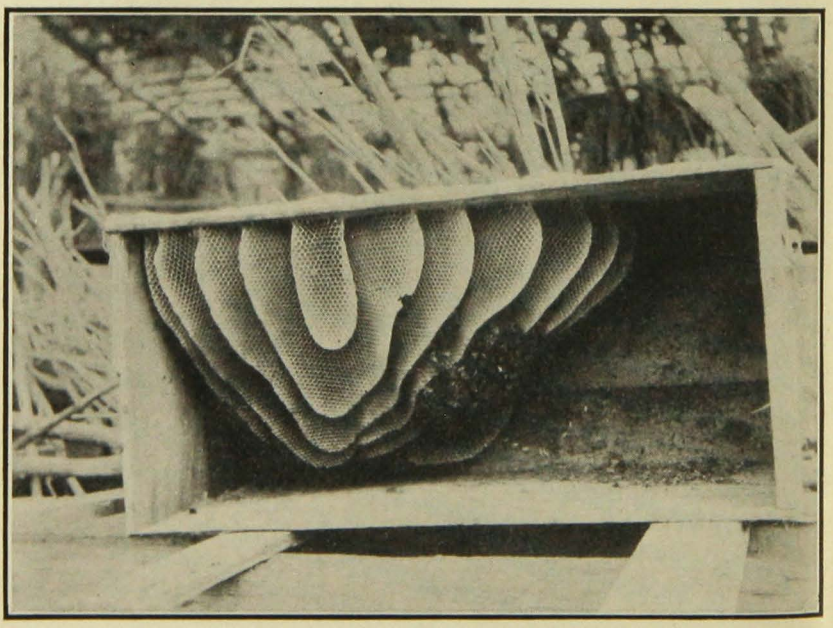

Fig. 2. Natural Combs Built Without Foundation

Members of a Colony

There are three kinds of individuals in a bee colony—the queen, the workers, and the drones.

The queen is the mother of the colony. She alone lays eggs from which all inhabitants of the hive are derived. Nearly all her working organs are stunted in favor of her egg producing organs. A mated queen lives from 3 to 5 years and may lay half a million of eggs during that time.

The workers are the most numerous. They are females that ordinarily can not lay eggs, but devote their whole life to the work of the colony. They nurse, build wax, produce heat and regulate it, cure honey, ventilate the hive, act as guards, feed the queen and drones, bring in water, pollen, and nectar. The worker bees live about 5 weeks in summer and 7 or 8 months in winter, according to the amount of work they do.

The drones are male bees and are produced only during the breeding season. The only purpose of their existence is mating with the young virgin queens. They do no work. In August they are driven out by the bees and destroyed.

Fig. 3. Queen Bee, Drone, Worker Bee

The Broodnest

The place in the wax structure where young bees are reared is called the broodnest. It is compact, approaching the shape of a ball, and darker than the rest of the wax structure. The wax combs penetrating through the broodnest and dissecting it do not materially interfere with its spherical outline. The broodnest is only a few inches in diameter in spring, but may extend over from ten to fifteen combs in early summer. The queen deposits her eggs methodically in concentric rings from the center. When bees in the center begin to hatch, in 21 days, she returns from the circumference to the center and starts with a new concentric wave of eggs.

Queen Is Mother of Colony

The queens, in Minnesota, lay eggs from spring to fall, and are capable of producing about 3000 eggs a day in early summer.

The eggs are laid on the bottom of the wax cells, previously cleaned and polished by the bees. Normally only one white, oblong egg is laid into each cell, attached by one end to the bottom. The queen may lay eggs into the small hexagonal worker cells or into the large drone cells or into the oval queen cells. From eggs laid in worker cells worker bees will hatch; from drone cells drones will come forth; and queens will develop from eggs laid in queen cells. The queen, however, does not lay eggs at random. The season of the year and internal conditions of the colony determine how many eggs she may lay, and which of the three kinds.

Two Kinds of Eggs

The eggs laid by the queen are of two kinds, fertilized and unfertilized. Fertilized eggs will hatch into female bees (workers or queens), unfertilized, into drones. Some eggs never hatch. A normal queen has the ability to determine the sex of her eggs. She deposits fertilized eggs into cells built and prepared by the bees for workers or queens, and unfertilized eggs into cells built for drones.

The queen is capable of this distinctive discrimination in the choice of sex by her control over the fertilization of her eggs. The sperm cells which she received from the drone at the time of mating are **stored** within her in a receptacle called **spermatheca.** In the process of egg laying, the queen fertilizes the eggs herself, if the wax cell she happens to be laying in is a worker cell or a queen cell. But if the cell she is laying in is a drone cell, she passes the egg unfertilized, and all such eggs will hatch into male bees, or drones. Queens that never were mated (drone layers), and sometimes worker bees in abnormal condition (laying workers) will lay only eggs that will hatch into drones.

DEVELOPMENT OF BEES

Bees, in common with other insects, develop through four stages—egg, or embryo stage; larval, or eating and growing stage; pupal, or developing stage; and adult, or propagating stage.

After the bee **eggs** are laid they are incubated and kept at a temperature of about 98 degrees F. by the nurses. This temperature is necessary for the development of bees until maturity, altho in the last days, or pupal stage, they are not so easily chilled as in the egg and larval stages.

The eggs for workers, queens, and drones hatch in 3 days and pass into the second stage of their development, the **larval stage.**

Larval and Pupal Stages

The larva, on hatching from the egg, is a small, pearl colored grub, curled on the bottom of the cell in the form of a crescent, or letter C. It is helpless and voracious. Growing fast, and frequently shedding its skin, it stands upright in its cell on the fifth day. Queens, workers, and drones develop differently after hatching from the egg, and we shall describe them separately.

The **worker larva** is kept warm and is fed for two days by nurse bees with a predigested food called chyle. Chyle resembles thick cream, tastes sour, and is produced by a set of glands found active ordinarily only in the nursing bees. Chyle-producing bees feed for at least twenty-four hours on honey, pollen, and water, before the secretion begins. Chyle is a perfect food, deriving its carbohydrates from honey and its oils and nitrates from pollen. It also contains mineral salts from alkaloids, vitamins, and other minor but essential elements. Chyle is placed by the tongue of the nurses around the larva, who consumes it through her mouth and probably absorbs some through her skin.

The larva grows very rapidly and sheds her skin once a day. She is weaned from chyle at the end of the second day and is fed for 4 days on coarser food, consisting of a mixture of honey and pollen. The influence of this coarse food, and the small size of the wax cell in which she is reared determine her for a worker bee. Her sexual organs are stunted, and only her working organs develop.

Six days after hatching from the egg the worker larva has grown to full size. She stops eating and growing, and passes into the third, or **pupal stage.**

At the beginning of the pupal stage the bees place over the cell of a full-grown larva a lid, or cap, resembling in construction the cap with which ripe honey cells are covered, only brown in color, made of porous material mixed with wax, and slightly arched.

The beginning of the pupal stage is spent in spinning a very fine cocoon in the narrow space of the capped cell. After that the pupa lies dormant. Her internal and external organs develop. At last her skin begins to harden and turn brown, and on the 11th day she bites through the porous lid and comes out a perfect bee, 21 days after the egg was laid.

The **queen bee larva,** altho produced from the same kind of egg as the worker bee, owes her difference in size and activity to two factors: (1) She is raised in a cell from four to eight times the size of the worker cell, where she has room to develop. (2) She receives nothing but chyle in superabundance during her whole larval life. The queen larva grows to full size in 5½ days, when she almost fills her cell. At the end of that period the bees seal the cell with a round lid. She now

goes into the pupa stage and grows into a mature queen bee in 7 days. Then with her strong jaws she bites a circular ring through the lid of the cell, pushes the disk aside, and emerges a fully developed queen bee, called a virgin queen, 16 days after the egg was laid.

The **drone larva** is fed royal jelly as is the queen, probably for the whole period of his larval existence, but not in such large quantities. He grows to full larval size in 6½ days. Then the drone cell is capped over with a high arched cap resembling the point of a bullet, and he goes into the pupal stage. In this stage he remains for 14 days and then bites his way out as a perfect drone, 24 days after the egg was laid.

Time Required for Different Stages of Development*

Stage	Queen	Worker	Drone
	days	days	days
Egg	3	3	3
Larval	5½	6	6½
Pupal	7½	12	14½
Total	16	21	24

* These periods, owing to weather conditions, may vary 12 hours from normal.

FOOD SUPPLIES FOR BROODNEST

The broodnest is ordinarily located near the entrance. Above and on the sides of the broodnest the bees store pollen in the form of a circle. Adjoining the pollen on top and sides they store honey. The size of this dome of honey is limited only by the supply of nectar, and in some seasons a layer of two or more feet of honey is stored around the brood. Thus all colony life of bees centers in the broodnest and takes its measure from it.

LENGTH OF BEE LIFE

Mature bees live from 5 to 30 weeks. In winter, when dormant and inactive, they may live for 6 months. During the active season their life is about 5 weeks.

Queens are known to have lived 5 years. Most of them are killed at the age of a few hours or minutes, by rival queens hatched in the colony during the breeding season. The one that remains after the slaughter of her sisters, and eventually becomes the mother of the colony, will be an object of care and solicitude for the colony as long as she can lay the amount of eggs normally required for the growth of the colony. When she begins to show signs of weakness, the bees raise a new queen and supersede her, usually the third season.

Drones are raised only in the spring and early summer as long as the bees are under the spell of breeding, race propagation, or super-

sedure. When the young queens are mated and laying, the drones are driven out of the colony to perish. In abnormal colonies, without a laying queen, they are kept indefinitely, sometimes until spring, when they ultimately perish with the doomed colony.

Length of Life of Different Bees and Cause of Death

Worker.....	5 to 30 weeks	Dies from work
Queen.....	To 5 years	Is killed or superseded by another queen
Drone.....	2 to 3 months	Is driven out by bees

ACTIVITIES OF BEES

It is not our purpose to enumerate all activities of bees, only those best known are given.

The novice in beekeeping often supposes that all the bees do is to make honey. Only a comparatively small number of bees of advanced age are honey makers, a large number being employed at other work.

The work of bees is determined by their age and also by existing conditions. As a rule the younger bees are employed at inside duties while older ones do outside work.

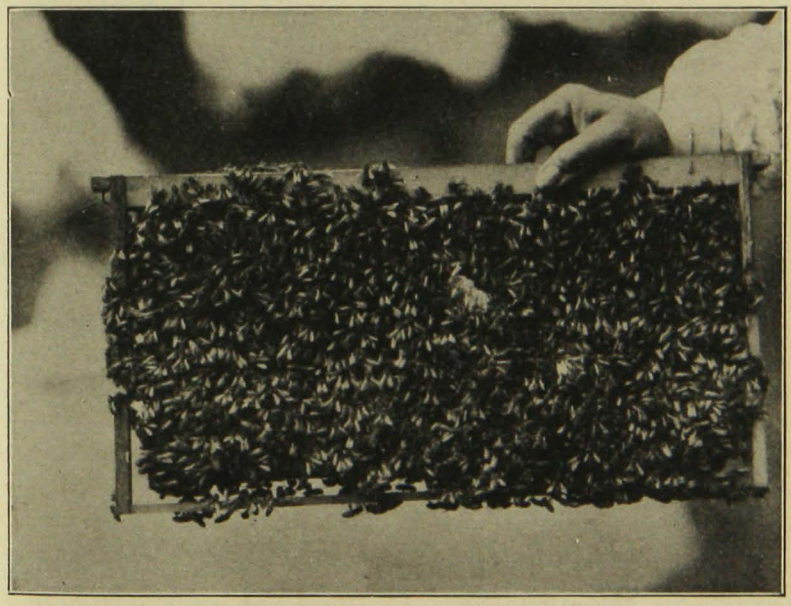

Fig. 4. Frame with Bees

The first activity of young bees is to **incubate the eggs,** to keep the larvae and pupae warm by covering their cells with their bodies, and to **produce the chyle** with which young larvae are fed. Chyle is produced by eating and digesting honey and pollen from cells sur-

rounding the broodnest, where other workers have stored them for their convenience. Water needed for digestion is brought in by the water-carrying workers, and is passed to the nurses, mouth to mouth. When the number of nurses has increased out of proportion to the brood to be taken care of, if old enough, they assume other duties, if too young they become idle.

The **wax builders** comprise that section of the colony that hangs in festoons from the edge of the combs. They are very quiet and generate a great deal of heat. They are well fed on pollen and honey, the base of which wax is made. Wax is secreted from glands located in pairs under four abdominal rings. Liquid at first, this fatty substance hardens into white scales as it oozes between the rings and is exposed to air. When about 1/16 inch long, the comb builders break off the scales, pass them to the mouth, and masticate them, adding saliva, which makes the wax pliable. Thus modified, the wax particles are pasted on the edge of the comb and molded into planes and angles for cells.

Wax is built by bees only when needed for brood or for storing honey. It is not built in cool weather unless the colony is very strong. The theory that bees secrete wax whether needed or not seems to be based on superficial observations.

Another division of young bees **regulates the temperature** and air supply of the colony. For brood raising and wax building they maintain a temperature of about 98 degrees F. Outside of the brood-raising season an average temperature of 69 degrees F. is sufficient.

The temperature is regulated upward by physical motion of the bees, who through consumption of honey and oxidation of carbon contained in it generate heat with their bodies. One bee generates very little heat, not enough to keep herself from freezing in a few minutes, but when the heat of thousands is accumulated and kept from dispersing by a dense cluster, which they form, bees have been known to withstand the most severe winters successfully, wintered in the open and very poorly protected.

When, in summer, the excessive heat of the sun tends to raise the temperature of the crowded hive to the melting point of wax, the bees reduce the temperature by evaporating water. The air feels cooler after a shower, a person feels cold when emerging from the bath, because the evaporating water consumes a great amount of heat. Nectar is about 75 per cent of water, honey only 20 per cent. The rest of the water is evaporated by fanning the nectar with the wings. If the bees carry 10 pounds of nectar in the course of one day during the honey flow, at least 5 pounds of water are evaporated from it in twenty-four hours, and the heat necessary for evaporation is taken from the inside of the hive, thus reducing its temperature.

It is well known that the hotter the weather the more the bees fan. When no nectar is coming in, the bees supposedly carry water into the hive and evaporate it. The temperature of the hive never rises above 98 degrees F. unless the entrance is closed to prevent the expulsion of vapor-saturated air, or water is not available, or the colony is small. In such cases the wax comb will melt and the bees will perish from heat.

Bees have a system of **ventilation.** The moisture-laden inside air must be expelled to make room for outside dry air, because air will not absorb water above the saturation point. Forming a line extending into all parts of the hive, they raise the abdomen and with a vigorous motion of wings drive the air from one to the other until the last fanners near the entrance drive it out of the hive. The air is usually expelled on one side of the entrance, allowing the other half to draw fresh air into the hive. The air currents thus generated are strong enough to blow out a match several inches from the entrance. The expelled air carries with it a strong aroma of nectar gathered during the day.

The **sanitation department** takes care of the cleanliness of the hive by removing all waste and foreign matter, usually far away from the hive. Objects too big to move are covered over air-tight with propolis, when they dry up and mummify, causing no harm to bees.

Another section of bees works in the **chemical department.** They make honey out of nectar. Honey is invert sugar, defined as "Nectar of flowers gathered, stored, and modified by bees." When properly cured a whole wax lid is placed over the honey cell.

Other bees **carry the nectar** to the upper stories from the cells near the entrance where the field bees have temporarily deposited it in order that they may return to the fields as quickly as possible for another load.

Still other bees **attend to the queen** and drones, who do not eat of themselves, but have the food placed in their mouths.

Still other bees **act as guards,** or police. Posted near the entrance, they admit only bees that belong to the community. An exception is made in favor of strange bees if they come loaded with pollen or honey. Drones are freely admitted in any hive.

During the time of internal work the young bees take **orientation flights** during warm afternoons. These flights are called "bee play" and somewhat resemble a swarm just emerging, and are sometimes mistaken for such by inexperienced men. The bees, during "bee play," fly around the hive in circles always **facing the hive.** Swarming and working bees face away and fly away from the hive. During orientation flight the young bees learn the landmarks of their hive, the details near the entrance, the objects surrounding, and the whole landscape for the distance of their flight. Their memory, however, is not so

perfect that their mistakes in entering wrong hives could not be noticed by a casual observer. Nor does this memory last for a long time. Confining them in the cellar for a week, stunning them with tobacco smoke, or shaking them violently makes it necessary for them to take a new orientation.

At the age of from 10 to 16 days, according to conditions, the bee assumes external activities.

Water carriers supply to nurses the water that they carry in their honey sacs, and pass to younger bees for use where needed.

Pollen gatherers collect pollen by scraping it off the flowers with the brushes on their legs. The pollen is patted and kneaded with the first two pairs of legs and laid into the pollen baskets on the last pair of legs, until it assumes the shape of round pellets, which are carried home and deposited in wax cells next to the brood.

The oldest bees in the colony are the **nectar gatherers.** Like pollen gatherers they fly from flower to flower in search of nectar. The honey and pollen bees visit only one species of flower on any one single foraging excursion, and perhaps for a much longer period of time. Bees sometimes gather pollen and honey on the same trip.

When the honey sac is filled with nectar, after visiting many flowers, the honey bee returns to her hive, deposits her load in the first convenient empty cell, even in the broodnest, and returns for another load.

Crawling among the petals of flowers and flying against the wind, the bee's wings become broken in a few weeks, and at last, unable to return home with her load, she perishes among the flowers. The mortality of bees during a good honey flow exceeds the number of hatching bees, and colonies that work hard dwindle as the result of a strong flow.

ACTIVITIES OF THE QUEEN BEE

Queen bees are normally raised only during the swarming season in June or July—in buckwheat and sweet clover regions as late as August. The bees pay little attention to virgin queens. All queens but one in the hive are killed. At the age of 5 days the queen takes her orientation flight at the time of "bee play" of the young bees. Only short flights are taken at first. Sometimes the flights are repeated on several days, but last only a few minutes each time. Then the queen takes a longer flight—her nuptial flight. The male bees, or drones, congregate in large swarms over the tops of trees or hills on sunny afternoons. Thither she takes her flight. Espied by the drones she is captured by one after a rapid circling flight and in an instant the mating takes place in the air, the drone dying in the act. The weight of the dead drone, still attached to the queen by copulation, causes the pair to fall to the

ground. Disengaging herself by a circling movement, during which the drone's organs are extracted, she returns to her home with parts of the drone's organs still protruding from the point of her abdomen like a white thread. In a few hours the bees remove these vestiges of her mating, but not until the spermatic fluid has passed entirely into the queen's receptacle—the spermatheca—where the spermatozoa arrange themselves in a systematic way. Their number is millions, and they stay alive in the spermatheca for years, the queen using only a

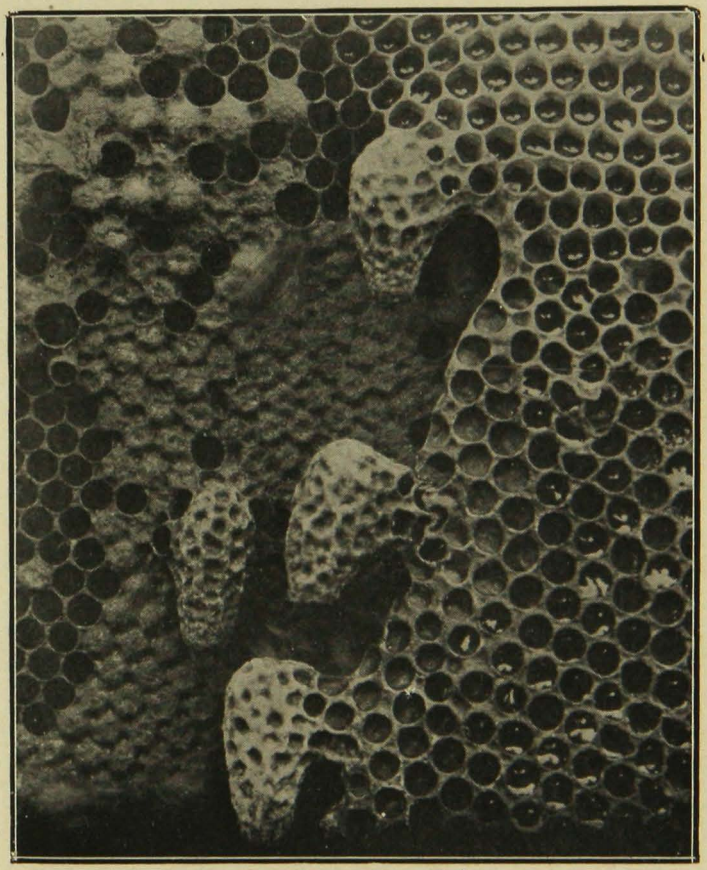

Fig. 5. Queen Cells
Upper left—Drone cells. Right—Worker cells. Center—Four queen cells.

few for each egg which she fertilizes. The queen mates only once in her lifetime. After mating, the queen's abdomen begins to enlarge, her ovaries develop, and on the third day she begins to deposit eggs.

In Minnesota the queen lays eggs from April to October—not at any other time except under abnormal conditions. No break in egg

laying occurs in the tropics. During one season a good queen may lay more than 150,000 eggs.

ACTIVITIES OF DRONES

After hatching, the drones stay in the warmest part of the hive and are fed abundantly by the bees. When nine days old they begin to take their orientation flights between eleven o'clock in the morning and five o'clock in the afternoon, and independent of "bee play." They do not all fly out at the same time or in large numbers. The mature drones congregate in nuptial swarms hunting for queens. For this reason the drone's sight and smell are highly developed. Perhaps one in ten thousand accomplishes the object of his existence.

COLONY LIFE OF BEES

All bee activities center in and radiate from the community life. Only the community can breed, keep warm, build wax, gather and store pollen and honey, and produce brood. The natural increase of bees by swarming is also an effect of community life.

The activities of the colony are determined by internal and external conditions then existing.

Internal conditions are: Strength of colony; age of bees; character, age, and prolificness of the queen; presence of drones; presence of queen cells; amount of honey and pollen; race of bees; size of their abode, etc.

External conditions are: Temperature, sunshine, wind, humidity, honey flow, season of the year, location, disturbance, etc.

A colony will react to any one of these conditions or to a combination of them, in a definite way. The saying that "bees never do anything invariably" is based on the fact that we do not properly consider, or understand, all conditions and their effect on the bees, and draw wrong conclusions. All management of bees must be based on the study of bee behavior under certain external and internal conditions. Assuming that bees will do the same thing under the same conditions, and that these conditions repeat themselves every year with slight variations, he is the best manager who is able to predict at any time, from conditions present or approaching, what the bees will do next.

It is not possible to give all reactions and activities of the bee colony in this bulletin, but the most important ones are described as briefly as possible as they succeed each other during the cycle of the year.

It is impossible to change the habits of bees, or to teach them anything new, and they do not react to training.

There are four basic instincts in a colony on which all the others are built as on a cornerstone. These are (1) the instinct of breeding; (2) the instinct of increase; (3) the instinct of hoarding; and (4) the instinct of hibernation.

Breeding Instinct

Bees in the temperate zone breed from spring till fall.

At the beginning of spring a colony has about 15,000 bees. They are the bees hatched late the preceding fall, all others having died. There is a queen, plenty of dry comb, some honey left from the summer before, and a little or no pollen. There are no young bees and no brood.

As soon as the sun awakens the decimated colony to life, self-preservation becomes dominant and manifests itself in an intense desire for brood. Cells are polished preparatory to the laying of the queen, who is fed abundantly by the bees to put her in a laying condition. Old bees, which ordinarily never nurse the young or produce chyle, eat honey and pollen, their salivary glands revive and again secrete chyle for feeding the larvae as in the time of their babyhood, until the first young bees are hatched. Water, the indispensable element in producing chyle, is eagerly sought after.

Egg laying starts in the center of the winter cluster of bees, where it is warmest. The queen lays only a few eggs at first but gradually increases the number. A round area of cells on one side of the comb is filled first, then a corresponding area on the opposite side of the comb. Then she passes to the adjoining two combs and covers a smaller area opposite the initial comb. Then she enlarges the circle of the central comb, keeping the brood in the form of a sphere.

Conditions governing brood raising.—The size of the broodnest depends:

1. On the number of bees in the colony. The queen will not produce any more eggs than the bees can incubate.

2. On temperature. The colder it is and the stronger the wind that blows around the colony the smaller is the area the bees can incubate.

3. On the amount of pollen and honey. Without honey and pollen the nurses do not secrete chyle with which to feed the young. Complete suspension of brood raising is the result.

4. On water, without which nurse bees can not digest pollen and honey.

5. On the death rate of the old bees, who at this time of the year die off rapidly both from old age and from failure to return from their flights on account of cold, storm, wind, and other causes. These conditions cause **spring dwindling** and reduce the size of the colony and

the size of the brood for three or four weeks, until the young bees begin to hatch.

6. On the condition of the queen. A virgin queen or an old failing queen is unable to produce normal brood under most favorable conditions.

Growth of broodnest.—The first hatch in spring is small and exclusively worker brood. When the bees in the center of the broodnest begin to hatch, in 21 days, the queen returns to the center and begins to refill it. This time the broodnest will be enlarged because of the increase of the colony. When after 6 weeks the queen begins to refill the broodnest with eggs for the third time, it will become so large in normally strong colonies that the queen's laying ability is taxed to the utmost to keep abreast of the growing colony. At this time a queen may lay 3000 or more eggs a day.

Swarming and Increase

With the rapid increase in young bees and the expansion of the broodnest, the existence of the colony is assured, and the queen will begin to deposit eggs in drone cells for the production of drones. The exact time when she will do this is undetermined, but normally at any time after the colony has begun to increase in strength. In warm weather and steady honey flow drone raising will occur earlier in the season. The laying of worker eggs and the expansion of the broodnest, however, continue unabated during this time.

About June 1 the queens in normal colonies reach the maximum of egg laying. The colony becomes crowded. The number of hatching bees increases enormously. There are soon more nurses than larvae to be fed. Young bees usually found in the broodnest are forced outside into the territory of wax builders, honey curers, and ventilators. A large number of bees thus become idle, and begin to loaf outside the entrance.

The swarm.—When these conditions arise, bees begin to make preparations to swarm. The first indication of swarming is the construction of from twelve to twenty or even more saucer-shaped wax cells on the under side of the wax combs. The queen in her egg-laying routine deposits fertilized worker eggs into these cups. When the queen larvae are full grown, after 8 or 9 days, and the bees begin to cap them over, it is time for the bees to swarm.

The period of swarming normally occurs in Minnesota between June 1 and July 10, when the colony has reached its maximum strength.

In a strong honey flow a large percentage of colonies will pass through the periods of worker brood and drone brood raising, but will never start queen cells. In this case the colony will not swarm that year. This will happen especially when the colony has a large

room to work in, to keep all busy. But whenever queen cells are started and filled with queen larvae, swarming will result, unless the weather is very bad or the honey flow stops, in which case the queen cells may be destroyed.

Prime swarm.—Swarming of bees occurs in the following manner. For several days before the cells for the young queen are capped over, the queen relaxes in her egg laying and the day just before swarming she lays very few, if any, eggs. She shrinks in size owing to the contraction of her ovaries. The time for the bees to swarm is the first calm, sunshiny day after the first queen cell is capped over. The swarm usually issues between ten o'clock in the morning and two o'clock in the afternoon, altho bees are known to have swarmed as early as seven o'clock and as late as five. Most swarms issue around the noon hour. (See page 19, Fig. 9.)

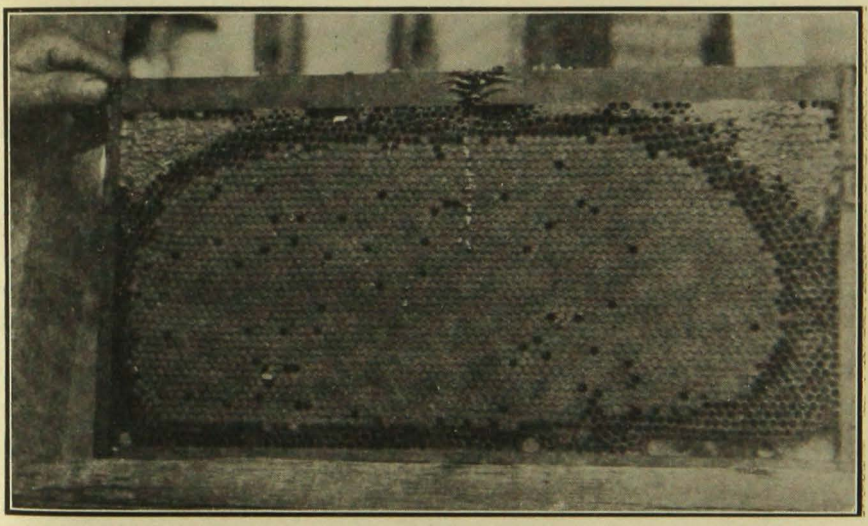

Fig. 6. Frame of Brood

The old queen goes with the swarm accompanied by about half the bees of all ages and some drones. It is supposed that all idle bees go with the swarm. The swarm leaves the old colony with great excitement and much noise. Unless the old queen accompanies it the swarm will return to the old place in a few minutes. A swarm without a queen will spread in the air over a large area. One with a queen will fly in a more compact mass. After circling in the air for about ten minutes, the swarm usually settles down on a branch of a tree or shrub, where it forms a hanging cluster. It is commonly supposed that the swarming bees send out scouts to find a home. On the return of the scouts, which may be in twenty minutes or not until

the next day, the swarm dissolves and led by the scouts it moves, slowly at first, then higher and faster, to the new home. The swarming bees enter the new abode with a sound of joy, lifting up their abdomens and fanning vigorously. Should the new home be too small or otherwise unsuited to their purposes, they may leave it in a day or two and start for a new place. They never do much work in a home that is not to their liking. But if they find the right place they begin with great energy to clean it and to build new wax comb. The queen fills the newly built cells with eggs, the foragers bring in water and pollen, and in the course of a week or 10 days, if the honey flow is on and the weather is favorable, the new home will be as well organized and supplied as the home they left.

The swarm issuing with the old queen is called the prime swarm.

After-swarms.—The colony left behind now has no queen, but a number of queen pupae and larvae. These will hatch into virgin queens 7 days after their cells are capped over. The bees guard these cells tenaciously. When the first virgin queen hatches she makes the fact known by a loud sound called "piping," which can be easily heard on a quiet evening. It seems that bees allow only this one virgin to hatch. The rest of the queens, still in their cocoons but ready to emerge, are held prisoners by the bees, but they answer the free queen's call by a muffled sound called "quacking." This piping and quacking continue until the first warm, calm, sunshiny day, when the first-hatched virgin leaves the colony leading with her another swarm called the "first after-swarm." Several days of bad weather at this time will result in the destruction of all queen cells and virgin

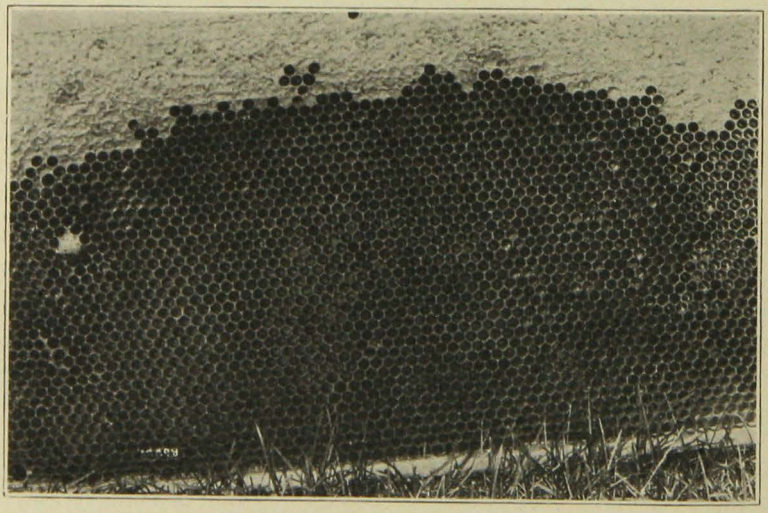

Fig. 7. Brood and Capped Honey with Started Queen Cell at Left of Comb

queens but one, and there will be no more swarming that season. "After-swarms" fly longer before settling down, and settle down farther from the home, and usually high. This first after-swarm clusters, finds a new location, starts building comb, but it will be at least 8 days before any eggs are found in it, because the virgin queen must first mate and will not lay until 3 days after she is mated.

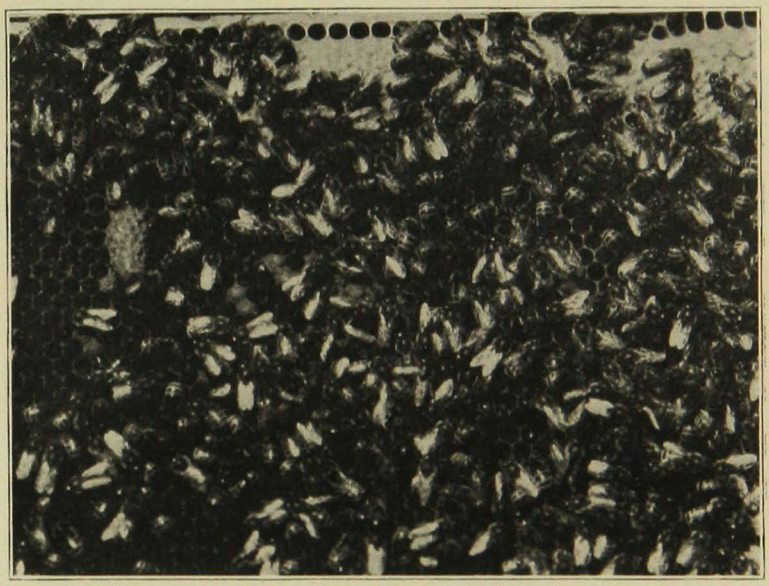

Fig. 8. Bees on Comb and Finished Queen Cell

After the first after-swarm has departed with the virgin queen, the bees release another queen, and she will swarm the following day leading the second after-swarm with her.

As many as five after-swarms have been known to issue from a colony one day apart.

If the bees decide that there has been enough swarming, those guarding the queen cells will allow the virgin queen just hatched to destroy all other queen cells and kill the young queens in their cradles; or at the time of the issuing of the first, second, or third after-swarm, they allow all queens to emerge at once, part of which will go with the after-swarm and part will remain behind. The last after-swarm is therefore usually accompanied by more than one queen, and likes to cluster in several small bunches. The bees choose the queen best to their liking and kill off the rest. Bees that have swarmed show a noted increase in industry. Beekeepers say: "It is the swarm that makes the honey."

Hoarding Instinct

Bees gather nectar at all times of the year, but are said to hoard when the instinct becomes dominant and all available workers become nectar gatherers and storage cell builders. It is a well known fact that when a colony, no matter how strong, begins hoarding it will abandon swarming.

A strong flow of nectar is always accompanied by little or no swarming. Bees that have swarmed begin hoarding at once and are our best honey makers. When the hoarding instinct has become dominant, the swarming cells are not started, the broodnest and the amount of brood begin to decrease, the bees are very gentle and not inclined to rob, they secrete and build wax rapidly, leave the colony very early in the morning, and return late in the evening. Instead of providing room for the queen to lay, they crowd the broodnest with pollen and nectar, resulting in a marked decrease of brood. No bees are seen to hang out by day, but they hang out heavy on warm nights. At noon the hives appear nearly deserted, indicating that the majority of bees are foraging.

The period of hording begins after the swarming instinct has been either satisfied or abandoned.

Honey flow.—From white clover, alsike, sweet clover, and basswood, bees gather honey in excess of all their needs.

The season of maximum honey flow in Minnesota occurs approximately between June 10 and August 1, and is longer or shorter, intense or slack, according to the season. The amount of nectar gathered by one colony during a perfect honey day runs from five to twenty-five pounds. It differs in different localities. A perfect day for honey gathering is a clear windless day, with a temperature of 80 degrees F. or more, following a cool night. The honey flow will decrease if there is no rain for about two weeks. The number of good nectar days during the honey flow will not exceed 30 per cent, windy, rainy, cloudy, or cool days make up the other 70 per cent. Minor honey flows occur only occasionally and are of short duration, as the goldenrod in August and September and the dandelion in May. Particular localities have their own local honey flows, as fireweed in the cut-over lands, Spanish needle in lowlands, and sweet clover in the Red River Valley.

The main honey flow begins with white clover, followed closely by sweet clover and alsike. When these are at their best, basswood begins to bloom about July 1, and blooms for about 17 days. Fireweed blooms about the same time. After the basswood flow is over, clovers yield nectar until they dry up, about August 1, when the honey

flow is over. Sweet clover may yield nectar abundantly till about September 1.

The **end of the honey flow** is marked by an increased inclination of bees to sting, and by their prying around hive entrances, and under cover cracks, or around the honey house, looking for an opportunity to steal honey. The drones are killed at this time.

The honey gathered by bees during the honey flow is stored above or behind the broodnest, but never below or in front of it, looking from the entrance. At the end of the honey flow most of the honey is capped over but much is left uncapped, especially on the lower parts of the combs, because it either has not been ripened sufficiently, or the cells are only partially filled. This honey is used by the bees first during the fall months, and there is no uncapped honey in the hives at the beginning of winter.

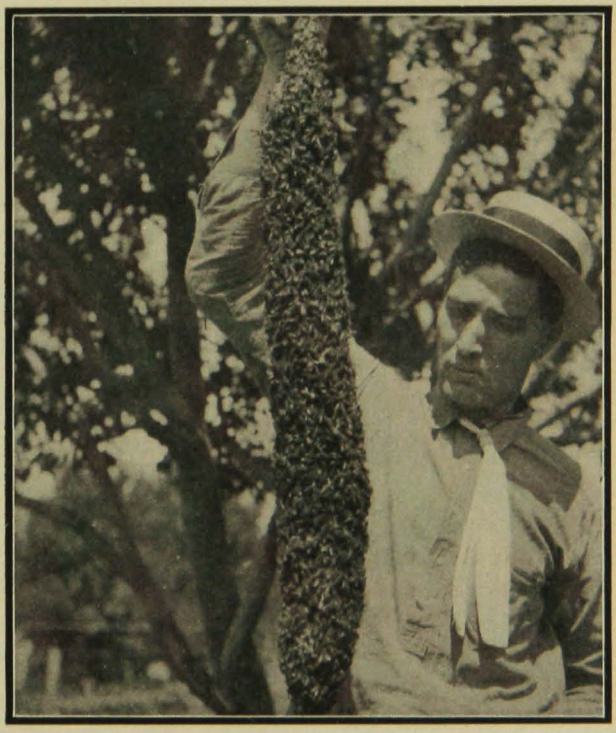

Fig. 9. Swarm Cluster

Hibernation

Wintering preparations.—All animals of the colder climates have a method of protection against the cold. Some grow a thicker fur, others burrow in the ground, others build winter houses, others migrate to warmer climates.

Most of those remaining spend the winter months in what is called hibernation, which, if hibernation is perfect, consists in complete suspension of all bodily activities, like blood circulation, nutrition, motion, nervous activities, etc.; or if hibernation is partial, the activities of the body are only partly suspended or reduced to a minimum. The bees belong to the last class.

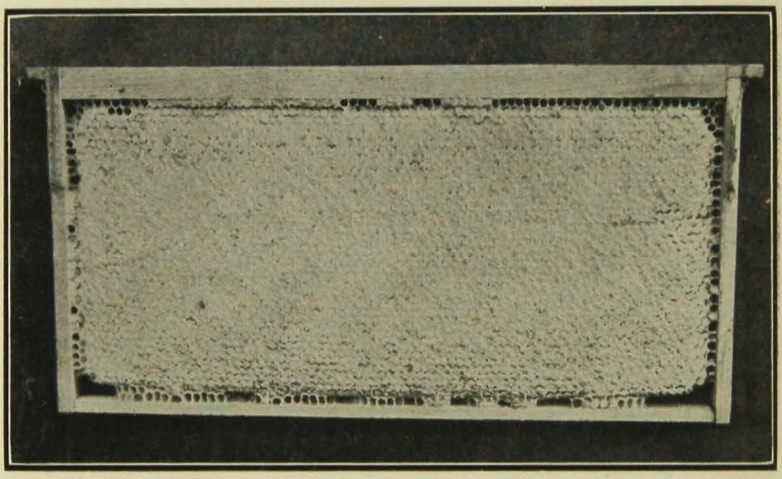

Fig. 10. Frame of Honey

In Minnesota, bees prepare for hibernation during the fall months. They suspend all brood raising about October 1. The old broodnest now becomes the winter nest. It is only on dry comb that the bees hibernate. They clean this space of all honey. The hibernation space is in the form of a sphere like the broodnest in summer and is from 6 to 10 inches in diameter. Surrounding the winter nest on top and sides are the honey stores, in physical contact with it. The winter nest is usually next to the entrance. As fall advances the bees get more and more sluggish and concentrate inside the winter nest.

Wintering.—When the temperature of the hive immediately adjoining the winter nest drops to 57 degrees F., according to Dr. E. F. Phillips, the bees form what is called the winter cluster. The cluster is compact and formed on dry comb, but if this area is too small for the size of the bee cluster the bees prefer to hang below the combs rather than cluster on honey above. The winter cluster is organized to generate and conserve heat. It needs, in winter, a temperature of from 57 to 69 degrees F. The heat is produced by physical exercise (humming or buzzing) resulting in oxidation of the carbon in the honey that the bees eat. The colder it is the faster the bees hum and consume stores. At 57 degrees F., next the cluster, they appear to be most quiet. From

observations, we find that the temperature on the edge of the cluster will be 57 degrees F. when the outside air temperature is about 40 degrees, depending on the strength of the colonies. Under these temperatures the bees are most quiet. The winter cluster of bees is surrounded by a layer of bees forming an insulating cover with their bodies to prevent the escape of heat from the cluster.

Bees in Minnesota hibernate about 140 days. In some seasons they hibernate very well, in others very poorly. Poor hibernation is evidenced by the death of many and signs of distress, as loud buzzing, roaring, flying out of the hives, spotting the hives as the result of dysentery. Many colonies perish every year in Minnesota because of unsuccessful hibernation.

Fig. 11. University of Minnesota Bee Yard at University Farm

Wintering factors.—Until recently all causes of poor wintering of bees either have not been known or their inter-relation has not been understood.

Summing up, causes of winter mortality of bees are: (1) Abnormal condition of the colony, (2) insufficient food, (3) impure food, (4) temperature, (5) humidity, (6) disturbance.

1. Abnormal colonies are those that have no queen, those that are weak in bees, such as late swarms, who for lack of bees or lack of time or interference had neither means nor time to organize their winter nest on the basis of normal colonies.

2. Insufficient food causes starvation in winter. Bees have not sufficient food if they have less than 20 pounds of honey for winter,

or if they have honey in parts of the hive that can not be reached by the winter cluster. They must have their honey stored either above or on the side of the cluster and in physical contact with it.

3. Impure winter food is honey that contains foreign matter or a great deal of indigestible matter. All honey contains more or less pollen grains, honey dew contains gummy and indigestible elements. Summer honey is good winter feed, other honeys are more or less doubtful, honey dew is known to be bad.

4. A temperature of 50 degrees or more causes the bees to dissolve the winter cluster and to begin work, which consumes their energy; if 40 degrees or less, it causes them to generate heat, which also consumes energy.

5. An excess of humidity will make the combs and hives wet and moldy on the inside, causing distress of bees; a deficiency will cause thirst and bees will fly out of the hive in a vain search for relief.

6. Disturbance will cause the bees to eat honey in excess, become heated, dissolve the winter cluster, and waste energy.

These causes kill the bees in two ways: (1) Through bodily activities their energy is consumed and they die prematurely of old age. (2) The large intestine becomes filled with undigested matter. The intestine is made to act as storage for feces for a reasonable time. When filled rapidly, because of impure food or too much food, it reaches the limit of its capacity, and dysentery, followed by death, is the result. Therefore, when bees eat abnormally or eat normally of poor food, winter mortality is the direct result.

Brood in winter.—Still another feature in hibernation of bees must be considered. When the temperature of the winter cluster rises so high that bees become active for a long period, they begin to raise brood, sometimes as early as January. This happens when bees are kept abnormally warm, or when the temperature falls abnormally low. In the latter case bees generate an excess of heat to overcome the cold and, paradoxical as it appears, they raise the heat inside the cluster to 98 degrees F. and begin brood raising.

In either case the temperature of the hive after the first eggs have been laid must be maintained constantly at 98 degrees F. on account of brood, causing enormous activity and consumption of stores on the part of the bees—and their early death.

Water for winter brood raising becomes a necessity, and hundreds of bees will fly out of the hive in search of water, only to perish of cold.

Colonies that winter well are quiet. A hardly perceptible hum may be audible to the listener at the entrance. If not, a slight knock on the hive with a pencil will be answered from the inside with a s-s-h, lasting just a second. All is well.

But when the bees' roar is loud and prolonged, when they fly out of the hive in large numbers, do not stay clustered, spot the hive around the entrance, something is wrong.

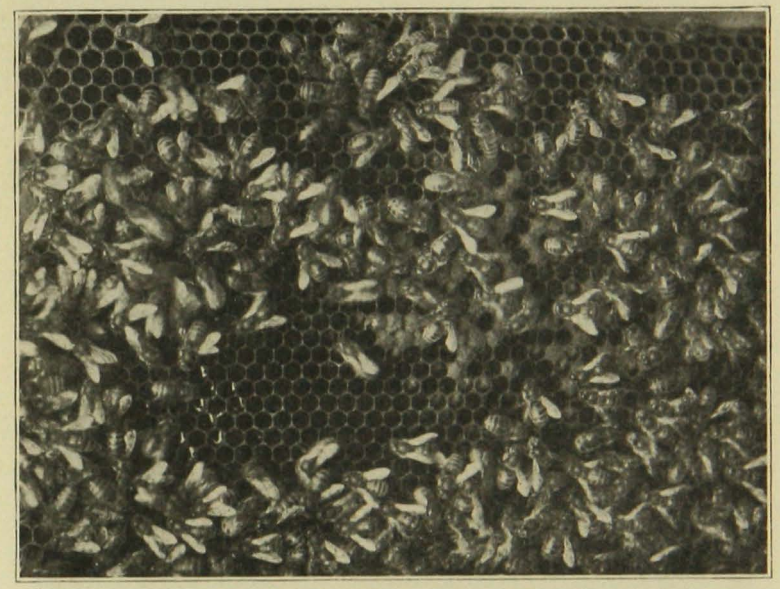

Fig. 12. Bees and Comb, Showing Sealed and Unsealed Brood

Spring

The warm days of spring awaken the bees to the activities of another season. The winter cluster is dissolved at a temperature of from 46 to 50 degrees F. between March 20 and April 10.

Cleansing flight.—The bees taking the first flight in spring locate themselves to remember their home, because all memory of last year's place has been obliterated during the winter rest. At the same time they cleanse themselves by expelling the winter accumulation of waste matter while on the wing, spotting the neighborhood for several hundred feet around their homes. This is called their **cleansing flight.** During this flight bees like to take a rest and if the ground is covered with snow they perish.

The colony organizes immediately for work. A large amount of water is carried in during the first two days. Pollen is much desired and sought by the bees. Cells are polished in the center of the old winter nest, which now becomes the broodnest, in which the queen begins to lay.

Cycle of the Year

The colony now begins to develop and grows to complete another cycle, essentially the same every year, with some changes due to weather, nectar flow, and other causes.

A practical beekeeper is one whose management of bees is based on knowledge of how his bees will react under normal conditions throughout the year, as well as how they will react under changing conditions of different seasons.

It may be stated as a general rule, that healthy colonies with a young queen and strong in bees, housed in a reasonably spacious home, provided abundantly with honey and pollen, will give excellent results the year round, while colonies lacking these will not respond to the best management with large production of honey.

Fig. 13. Short Course Students Studying the Habits of Bees at University Farm