

Fundamentals of

B E E K E E P I N G

in Hawaii



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Cover photo shows a modern apiary in a kiawe grove on Molokai.

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CONTENTS

	Page
History	5
Floral sources of nectar and pollen	7
Considerations for the beginner	8
How and when to start	8
Returns from beekeeping	8
Selecting an apiary location	9
Races of bees	10
Life history and habits of the honey bee	10
Beekeeping equipment	15
Manipulation of the hive	19
Cycle of the year	20
Seasonal manipulations	23
Production and care of queens	30
Extracting honey	37
Cleaning the combs	38
Care of cappings	38
Production of beeswax	39
Melting combs of granulated honey	40
Solar wax extractor	41
Portable honey extractor	43
Diseases affecting honey bees	44
Diseases of adult bees	48
Enemies of bees	51
Grading and processing of honey	54
Processing honey for wholesale trade	56
Marketing of honey	57
Beekeeping literature	58

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HISTORY

Beekeeping in Hawaii dates back to 1857, when the first hive of bees was introduced from California after several unsuccessful attempts to bring them around the Horn from New England. They were the German black bees, which later became well established throughout the forested areas. The first commercial shipments of honey from Hawaii were made in 1894, and within the next few years large apiaries were established. Some of this expansion was due to the cattlemen's interest in promoting the distribution and yield of kiawe, or algaroba, beans for cattle feed by getting increased pollination of the trees through the aid of the bees. It was natural that commercial honey production would develop simultaneously with the establishment of apiaries for pollination. The growth of the industry is shown in table 1. From 1905 to 1916 the average honey shipments amounted to approximately \$40,000 annually. However, with the increase in prices during World War I, shipments rose sharply to a value of \$356,536 in 1918. During the 23 years from 1918 to 1941, the average shipment of honey was 1,315,270 pounds annually, in spite of the onslaught of American foulbrood in 1933 and the low prices caused by the depression. The control of the sugar cane leafhopper in 1920 eliminated the large quantities of honeydew previously gathered by bees. Since 1941, shipments have averaged only about 1/2-million pounds of honey per year (see table 1).

Within recent months, interest has been aroused in the possibilities of increasing the beekeeping industry in the Islands. Honey production in 1950 was about 750,000 pounds, which indicates an upward trend despite the relatively low prices (table 2).

Historically, commercial beekeeping in Hawaii was developed by a few large corporations. The first was known as the Sandwich Island Honey Company, which at one time had 10,000 colonies of bees. Beekeeping was undertaken on Molokai as early as 1904 by the American Sugar Company, and in 1930 this ranch, producing nearly 500,000 pounds of honey, was reputed to be the world's largest producer for that year. The Garden Island Honey Company on Kauai engaged not only in the production of honey but also in commercial queen-rearing.

There are a few names that have been prominently associated with the beekeeping industry in Hawaii. Among these are G. P. Cooke, R. A. Jordon, E. C. Smith, O. St. John Gilbert, C. J. Day, E. F. Robinson, S. A. Robinson, L. F. Hannegan, E. G. Alfonsus, and Asakichi Goto and his sons.

Allen P. Luce, who is well trained in apiculture, became the apiarist for the Molokai Ranch at Kaunakakai, Molokai, in 1949. This ranch is making rapid strides in the rehabilitation of beekeeping.

Table 1. Annual shipments of honey and beeswax from Hawaii to the Mainland.

Year*	Honey		Beeswax	
	Pounds†	Dollars	Pounds	Dollars
1904	-----	12,787	20,605	5,187
1905	-----	39,244	20,382	5,906
1906	-----	23,503	14,614	4,589
1907	-----	27,018	17,250	5,036
1908	-----	50,189	35,636	9,719
1909	-----	37,684	35,462	10,124
1910	-----	50,627	35,953	10,869
1911	-----	36,224	20,088	5,991
1912	-----	51,256	34,172	10,020
1913	-----	37,129	44,657	14,048
1914	-----	35,153	44,238	13,691
1915	-----	40,013	60,787	14,989
1916	-----	66,592	30,664	10,034
1917	-----	125,763	27,698	10,241
1918	2,432,893	356,536	30,252	11,669
1919	1,245,336	151,677	24,364	9,217
1920	921,697	112,161	30,097	10,807
1921	1,033,350	56,891	17,248	4,960
1922	1,967,275	90,815	29,066	5,774
1923	1,372,242	77,507	25,537	5,212
1924	1,978,491	115,931	22,775	5,717
1925	1,646,744	104,070	36,268	9,937
1926	1,357,441	78,520	33,019	10,167
1927	1,237,252	65,477	23,546	7,556
1928	1,680,151	95,451	32,552	9,664
1929	1,794,853	100,278	30,055	9,229
1930	867,969	-----	25,526	---
1931	1,750,803	50,876	41,884	8,220
1932	1,653,107	49,690	42,055	5,809
1933	1,037,685	37,724	36,847	6,009
1934	1,310,844	57,192	39,899	5,935
1935	555,042	26,521	17,857	3,165
1936	768,728	35,421	18,974	3,697
1937	848,726	38,729	17,678	4,354
1938	1,083,940	44,175	19,437	3,923
1939	1,006,791	32,990	61,161	13,822
1940	1,081,053	39,685	9,609	1,995
1941	934,086	34,029	53,580	---
1942	683,680	45,723	14,000	---
1943	698,175	65,203	22,000	---
1944	657,568	66,818	10,822	3,945
1945	719,887	84,233	7,894	3,114
1946	353,622	44,593	5,663	2,215
1947	724,922	115,566	13,892	6,825
1948	652,000	52,160	17,100	6,700
1949	738,000	55,530	11,700	6,000
1950	795,000	59,625	11,900	5,600
1951	888,000	75,600	12,700	6,600

*Statistics for 1904 to 1945 compiled from December issues of Monthly Summary of Foreign Commerce of the United States and similar preceding reports; those for 1946 and 1947 from U.S. Department of Commerce Report to F. T. 800; those for 1948 to 1951 from the University of Hawaii Extension Service.

†Pounds of honey reported first in 1918.

Table 2. Summary statistics on beekeeping in Hawaii in 1950.

Island	Number of colonies*	Number of apiaries	Number inspected		Colonies with American foulbrood	Production in 1950	
			Apiaries	Colonies		Honey	Wax
Hawaii . . .	650	11	9	129	13	96,310	1,760
Kauai . . .	1,817	25	21	156	18	120,060	2,000
Lanai . . .	185	4	4	105	0	10,000	200
Maui . . .	1,906	17	11	339	10	190,560	3,175
Molokai . . .	527	15	14†	489	14	20,000	1,220
Niihau . . .	2,200	24	0	0	0	240,000	5,000
Oahu . . .	1,595	20	9	118	0	83,660	1,900
Total . . .	8,880	116	67	1,336	55	760,590	15,255

*Total number of colonies and production given by owners.

†Eight of these colonies were infected for experimental purposes.

FLORAL SOURCES OF NECTAR AND POLLEN

While honey bees gather nectar and pollen from a wide variety of plants, the major portion of the honey produced in Hawaii comes from relatively few floral sources. Algaroba, or kiawe (*Prosopis chilensis* Mol. Stuntz), is by far the most important source of honey and pollen on all the islands and is largely confined to seashore situations where it grows in a rather narrow strip down to the water's edge. The trees occur also on higher ground to a considerable extent but yield less in such locations. Pure kiawe honey is white to water-white and usually granulates within 3 or 4 weeks after it is stored in the comb.

The Java plum (*Eugenia cumini* L., Druce) probably is the next largest producer, especially on the islands of Kauai and Oahu. Honey from this source is light amber in color and is slow to granulate, but the flavor is much less desirable than that of kiawe honey. Honey obtained from ohia lehua (*Metrosideros collina* Forst.) is light amber in color and of good flavor. Large areas are covered by this tree on Hawaii and it is found on most of the islands at higher elevations. Eucalyptus (*Eucalyptus* spp.) also grows in quantity in the higher elevations and blooms profusely, producing a light amber honey that is more pleasing to the taste than Java plum but less desirable than kiawe honey.

Other plants of importance to the general welfare of the colony, some of which produce desirable types of honeys, include the following:

ae ae	dandelion	lantana	Pluchea
blackberry	goldenrod	macadamia nut	palms
black wattle	guava	monkeypod	Spanish-needles
citrus	ilima	mountain apple	yellow ginger
clovers	klu	nohu	vetch
cookoi	koa haole	oi	coffee
crownbeard	hauuoi	paintbrush (Fuller's)	cactus

In beekeeping, it is desirable to become familiar with the various plants the bees visit and the time and duration of their blooming periods as well as their value for nectar or pollen.

CONSIDERATIONS FOR THE BEGINNER

The beekeeper will gain great satisfaction if he becomes familiar with certain fundamentals before trying to manage many colonies.

The first consideration before handling bees is to determine one's reaction to their stings. Normally, the sting will hurt for a few minutes, then cause a local swelling and itch for 1 or 2 days. The average person develops an immunity to stings. Occasionally, however, the poison will cause a general systemic reaction, with dizziness and even loss of consciousness. The results may be serious unless the correct treatment is applied immediately. The victim should be given an injection of adrenalin by a doctor. Ephedrin, taken through the mouth, is slower but easier to administer, especially when a doctor is not available.

A second consideration is where to keep colonies. Colonies can support themselves wherever there are sufficient flowers to provide pollen and nectar. The quantity of surplus honey they produce will depend on weather conditions, the kind and abundance of available plants, and management of the bees. Hives should be located where the flight of the bees will not annoy neighbors or field workers.

A third consideration is the amount of the investment. One should inquire about the price of new equipment as well as the cost of established colonies sold by beekeepers. The investment may vary from \$10 to \$25 per colony, depending on the kind, amount, and condition of the equipment.

HOW AND WHEN TO START

Before acquiring bees, the beginner should become familiar with the life history and habits of bees as well as learn something of the management they require during the different seasons by consulting the published experiences of beekeepers or by securing the advice of established beekeepers in his own locality.

Two or three well-established colonies, fully equipped, can be bought from some beekeeper. The colonies should be inspected for disease, and the kind of bees and the condition of the combs as well as the amount of honey present should be noted. Each colony should have a queen, brood in all stages, and sufficient bees to form a good colony.

Another method is to assemble a hive in advance of the swarming season and then to have a swarm as soon as one is available. This usually calls for more preparation than the previous method as the beginner will have to learn how to assemble new equipment properly. There is no danger of securing diseased colonies by this method, and the beginner will have the added advantage of watching the swarm develop into a full colony.

The best time to begin beekeeping is when the plants producing the major source of nectar come into bloom. In such periods, colonies will be able to take care of themselves and will develop naturally. Hives of bees may be purchased at any time, but it is best for the beginner to start when the bees are able to gather nectar and pollen.

RETURNS FROM BEEKEEPING

The beekeeper must manipulate the colonies and equipment to meet the bees' needs in rearing their young and in producing the products of the hive. In general, the more efficiently the colonies are managed, the greater

will be the returns. The amount of profit depends largely on the availability of nectar and pollen-producing plants, favorable weather, suitable equipment and proper management, the price of honey, the manner in which it is marketed, and the costs of operation.

To earn a modest livelihood from beekeeping, a beekeeper must become proficient in handling 500 or more colonies. Beekeeping involves hard, physical work at certain seasons of the year, but equipment can be utilized to make the work possible for boys and girls as well as for grown men and women.

Bees are generally worth many times the value of the honey and beeswax they produce, for the majority of our fruit, vegetables, seed crops, and legume pastures depend on insects for cross-pollination. Growers can well afford to encourage beekeepers to locate their apiaries where the bees can have ready access to their fields.

SELECTING AN APIARY LOCATION

When bees are kept for pleasure, colonies may be located in any area where they will not be a nuisance to neighbors or to traffic on the highway. Colonies usually benefit when their hives are given partial shade during the hottest parts of the day. A distance of 50 to 100 feet from the nearest habitation or highway is usually enough when only a few colonies are involved.

Commercial apiary sites require more consideration. Bees will fly $1\frac{1}{2}$ to 2 miles or more for their nectar, pollen, and water, but in Hawaii it is desirable to locate them in or near large plantings of kiawe, Java plum, clovers, ohia, eucalyptus, or other sources producing surplus honey. Areas which provide nectar and pollen for 6 or more weeks before the main source of nectar comes into bloom are preferable. In some areas, beekeepers can take advantage of two or more locations by moving their colonies several miles at different seasons of the year, thus giving their bees an opportunity of working on different plant sources as they come into bloom. Differences in elevation and rainfall make this possible in many areas. Bees must have ready access to clean water in or near the apiary if natural sources of water are not available.

It is best to choose permanent locations where changing agricultural conditions will not require removal of the hives. This is especially true when permanent buildings are built on the apiary site. A portable extracting outfit or a centrally located warehouse will give more leeway in the selection of a site than will permanent buildings at each location.

To eliminate disturbance and destruction of colonies by ants and toads, the hives should be placed on stands with legs that can be banded with suitable materials to keep ants from reaching the combs. If toads are present, place the hives high enough to prevent toads from catching bees at the entrances. This arrangement also prevents the destruction of hives by soil-infesting termites although it does not prevent loss from dry-wood termites.

Apiaries must be protected from fire, flood, and poisonous chemicals used in the control of crop insects.

The entrances of hives should be turned away from the direction of strong prevailing winds as well as from nearby highways, walks, or cultivated areas.

RACES OF BEES

The three most common races of honey bees are the Italian, Caucasian, and Carniolan. The Italians have from three to five yellow bands on the abdomen, while the head, thorax, and remainder of the abdomen are black, covered with yellowish hairs. The Caucasian and Carniolans are black, covered with grayish hairs. These races interbreed, so variations occur where two or more races are kept. All three races when pure are likely to be gentler than their crosses, although the first generations produce desirable hybrids.

The Italian race is generally preferred, probably because of its brighter color and the greater ease in finding their queens. Selected strains are also resistant to European foulbrood and gather less propolis (bee glue) than the Caucasian race.

The Caucasian bee has the longest tongue, is more economical with its stores during periods of no nectar flow, and has many other desirable characteristics. It is gentle but a persistent stinger when aroused.

The Carniolans are the gentlest of the three races but tend to swarm most, one of their greatest faults. They are good comb builders and usually produce whiter cappings than either the Italians or Caucasians.

Many years ago a majority of the colonies consisted of black bees, but, with the introduction of the Italian race, the blacks have been gradually replaced. In some locations on the island of Hawaii, black bees predominate. Some fanciers prefer one race to the other, and the beginner should become familiar with the management of one race before undertaking to keep another. The population of a hive can be changed in approximately 8 weeks by dequeening the colony and introducing a new queen of the desired race or strain.

LIFE HISTORY AND HABITS OF THE HONEY BEE

A colony usually consists of one queen, a few hundred drones, and several thousand workers. The colony is generally stronger when pollen and nectar are available in abundance and weaker in early spring and during the winter. Drones are usually reared and tolerated when the colony needs them or in seasons when it is actively gathering nectar and pollen and is more likely to swarm. Each individual or caste has special duties to perform, but the dominating influence of the entire colony is to insure the survival of the colony rather than the individual. None of the three castes can live long without the combined influence of the others.

The Queen. A normal colony usually has only one queen, and her sole duty is to lay eggs. She does not care for the brood or make honey or wax. Her presence is essential to the proper morale or spirit of the colony, although she is in no sense a ruler. She is like an animated egg-laying machine because she is fed by the nurse bees who are part of the worker caste. The more she is fed, the more eggs she will lay, up to her capacity. In this way the worker bees control the number of eggs the queen lays. The middle portion of her body—the thorax—is larger than the workers', and for this reason she cannot go through as small openings as can the workers. Her wings are somewhat longer than the workers' but seem smaller because her abdomen is greatly elongated when she is laying normally. The queen does not have pollen baskets on her hind legs as do the workers, but her stinging, which is curved, is longer than that of the worker. The queen reserves

her sting mainly for her fights with other queens. Instances of beekeepers being stung by queen honeybees are exceedingly rare.

The queen is reared in a specially constructed cell which usually hangs perpendicular to the surface of the comb or along its sides or bottom. She develops from the same kind of egg as the worker and can be produced from any worker larva under 3 days of age by special methods. The nurse bees place large quantities of a special food, called royal jelly, in the queen cell and complete the construction of the cell as the queen larva develops. Because of the quantity and quality of the food received, the developing queen larva completes its growth in a shorter time than either the worker or drone larvae. Queen cells are usually sealed between the fourth and fifth day after the egg hatches, and the queen usually emerges 8 days later. She

Table 3. Average number of days in the developmental periods of the honey bee.

	Egg	Larva	Pupa	Total
Queen	3	5½	7½	16
Worker	3	6	12	21
Drone	3	6½	14½	24

is usually strong and ready to fight with other queens soon after she emerges from her cell. She takes one or more flights within 5 to 10 days after emerging and memorizes carefully the location of her hive before flying away to mate with a drone. Very few queens have ever been seen to mate, and it is assumed that they mate high in the air. Careful observations indicate that she may mate more than once on successive flights. After each mating, she returns to her hive with the male organs still in place, a provision of nature apparently necessary to assure insemination. The sperms from the drone are stored in a special organ of the queen, called the spermatheca, from which they are released to fertilize the worker eggs. If for any reason the queen fails to mate, she lays unfertilized eggs which develop into drones. Some unfertilized eggs of the honey bee develop into females but never in sufficient proportions to insure the survival of the colony. A newly mated queen usually begins to lay within 2 or 3 days after she returns from her mating flight.

In the act of laying (fig. 1), a queen first pushes her head into a cell to

Figure 1. A queen (arrow) in the act of laying. Her wings have been clipped. Some workers are either cleaning out cells or feeding young larvae. The workers are Italian bees, but one dark drone is in the picture.



inspect it and, finding it suitable, she passes over it and then pushes her abdomen into the cell until she can fasten the egg in an upright position on the bottom. In this manner she goes from cell to cell, laying several eggs a minute, stopping occasionally to be fed royal jelly by the nurses which are always in her immediate vicinity. A normal queen will lay only worker eggs in worker cells and eggs which produce drones in drone cells. She may lay, on the average, 1,200 to 1,500 eggs a day, the combined weight of which may exceed that of her own body.

A queen may live for 2 or more years, and, when she shows signs of failing, the worker bees make preparations to replace her by starting one or more queen cells around worker larvae. These are found on the surface of the comb and are fewer in number than when the colony is making preparations to swarm. They protect these cells from destruction by the old queen. When the first supersedure queen emerges from such a cell, she usually tears a hole in the other queen cells and stings the inmates. She frequently is not antagonistic to the old queen, so that one may find an old queen and a young supersedure queen in the same colony. When conditions are favorable, the young queen follows the previously described mating routine. A colony with both a young and an old queen laying at the same time increases rapidly in strength and has more brood than is generally present in a single-queen hive. Failure to recognize the fact that a colony may have two queens will result in the failure of attempts to introduce another queen when only one is killed.

The value of a queen depends on the stock from which she is reared, on conditions during the time she is being reared, and on her mating. The queen and the drone with which she mates transmit to the colony such factors as industry, gentleness, color, resistance to diseases, and comb-building characteristics. She is the most important individual in the colony and should be carefully protected from harm and replaced by a young queen from selected stock when she shows signs of failing. A colony having any undesirable trait should not be permitted to requeen itself.

The Worker. Worker bees are always females and lack the fully developed reproductive organs of the queen. However, when a colony becomes hopelessly queenless, certain workers assume the egg-laying habit but produce only eggs which have not been fertilized. They usually drop eggs on the sides of cells or in the bottom and may lay a dozen or more eggs in each cell. Those which hatch and produce adults in worker cells are drones the approximate size of workers. Worker bees which begin to lay eggs are called laying-workers.

The body of the worker is densely covered with hairs which collect pollen from flowers to be transferred later to the pollen baskets on her hind legs. The worker has special organs on her legs for collecting pollen and propolis. Honey and water are carried in the honey stomach in her abdomen. The brood-food glands, which secrete royal jelly, are located in her head. The wax glands are in her abdomen and open into pockets on the underside of the abdomen.

The work of the hive is orderly. Soon after emerging from their cells, the workers eat honey and pollen to gain strength and to complete the development of their organs. They clean themselves and soon, during successive periods, clean out the cells, serve as nurses in feeding the larvae and the queen, take orientation flights, process the incoming nectar and

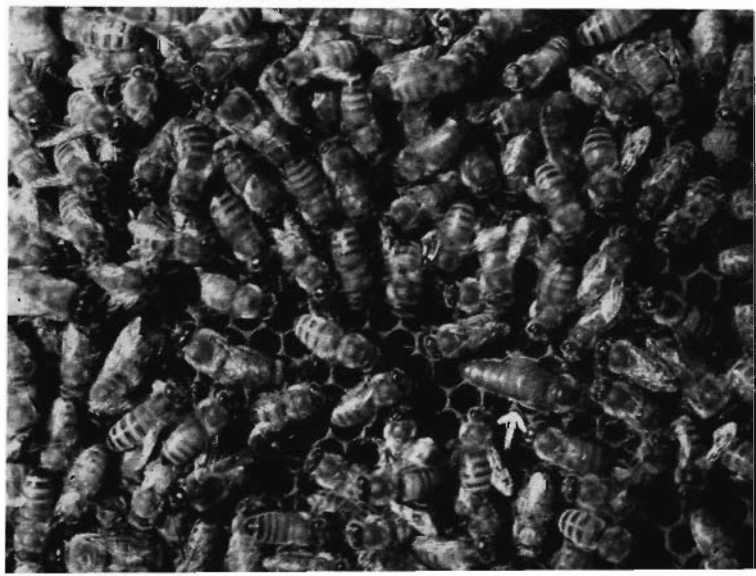
pollen, build comb, clean the hive, and act as ventilators and sentinels. This period of service varies with the needs of the colony and may last from a few days to 3 weeks. Then they engage in the outside activities of bringing in water, collecting nectar, pollen, and propolis, and acting as scouts for these materials. The normal life period of the worker, barring accidents, usually depends on conditions and the amount of work she does and lasts from 6 to 8 weeks during the active season. During the less active periods the workers may live for several months.

The Drone. The drone is larger and heavier than the worker and is not as long as the queen (fig. 2). It is usually produced only in drone cells. The large eyes of the drone cover most of its head and come together at the top. Its thorax is strongly built and larger than that of the queen, and its wings are longer and broader than those of either the worker or the queen. The drone has no sting, pollen baskets, or wax glands. Its tongue is short and functional, but the drone depends largely on being fed by the workers. It never visits flowers for pollen or nectar but simply spends its time flying in search of virgin queens with which to mate.

Its length of life approximates that of the worker. In the fall, when drones are not needed in normal colonies, no drones are produced, and the workers starve the drones and drive them from the hive. This killing of the drones is a sure sign of the end of the nectar flow. Because the drones perform no useful work in the colony, their number should be controlled by limiting the amount of drone comb in which they can be reared.

The Colony Nest. Honey bees build combs of wax consisting of a layer of hexagonal cells arranged on each side of the midrib. The cells slope upward slightly. Drone cells are larger and deeper than worker cells and, when capped with brood, extend above the surface of the worker brood. Storage cells, which are still larger than drone cells, are sometimes built by bees. When bees build their worker combs naturally, they space them between $1\frac{3}{8}$ to $1\frac{1}{2}$ inches apart from center to center, leaving a bee space of approximately $\frac{1}{4}$ to $\frac{1}{2}$ inch between the surfaces of two adjacent combs. In order to make the combs workable, Langstroth, the original inventor of the movable frame, surrounded each comb with a wooden frame and allowed a bee space on each side of the frame and between the comb surfaces. This is the main feature of our present hives. Hives provided with good worker

Figure 2. An Italian queen (arrow), a few dozen workers, and seven drones on a dark brood comb. The right wings of the queen are clipped.



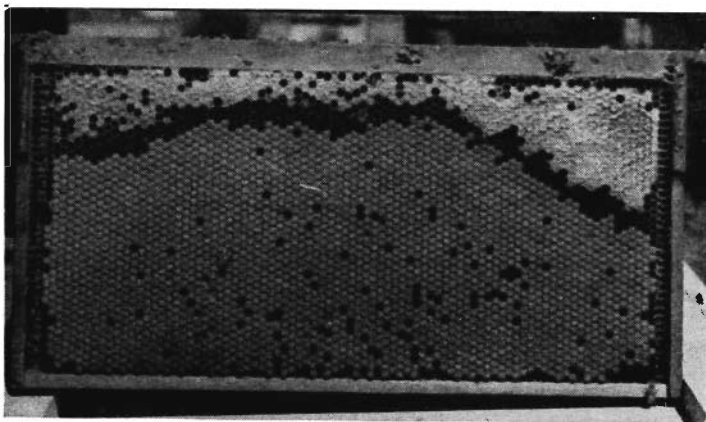


Figure 3. Good comb of worker brood with honey above. The cells between the honey and the brood may have contained pollen. No drone cells are present in this comb.

combs may have a few drone cells in the corners of some of the frames. When combs are spaced farther apart, as in commercial honey production, the bees will either build a new comb in the space between two combs or lengthen the cells in which they store honey.

Bees normally store cells of pollen (also called bee bread) next to the brood and then honey above the pollen (fig. 3). New combs are white, but they become travel stained with plant pigments or discolored by the pigments derived from pollen and the production of brood. Old brood combs gradually become darker and finally black after several years' use. When the brood nest of a colony having a prolific queen is confined to a portion of a hive by a queen excluder (fig. 4), the queen usually fills all available cells with eggs, and thus only the outside combs, or portions of them, and small corners of other combs are left for the storage of pollen and honey. This is a desirable condition for a colony during the nectar flow.

When queen excluders are used to confine the queen to the lower hive body, that portion in which the brood is reared is called the brood chamber, and the hive bodies above the brood chamber are called supers. Bees carry only a small portion of their pollen through the queen excluders into the supers. In a two-story brood chamber, the bees store most of their pollen in the lower chamber.

To limit the number of drone cells in any hive, each frame should be fitted with a full sheet of comb foundation—a sheet of beeswax with the exact size of worker cells embossed on each side (fig. 5).

Pollen varies in color according to the floral source. Bees fill the cells only about three-fourths full of pollen and do not seal them over unless they are crowded for honey storage space, in which event they fill the pollen cells with honey and then cap them over. Sealed brood varies in color from light to dark brown, depending on the newness and color of the comb. Honey cappings are usually white but may darken with travel stain.

BEEKEEPING EQUIPMENT

The modern beehive (fig. 4) has a bottom board, one or more hive bodies (called brood chambers or supers, according to whether they are used to contain the brood nest or the surplus honey), a queen excluder (frequently used to confine the queen to the brood chamber), an outer cover, and enough frames to fill each hive body. The supers may be called extracting supers or section honey supers, according to their use. Some supers are shallower than the regular-depth supers. The hives most commonly used in the Territory hold either 8 or 10 frames. The eight-frame hives are lighter in weight and are more suitable for women beekeepers and for men of small stature. With proper manipulation and adequate equipment, as much honey can be produced in eight-frame hives as in larger ones.

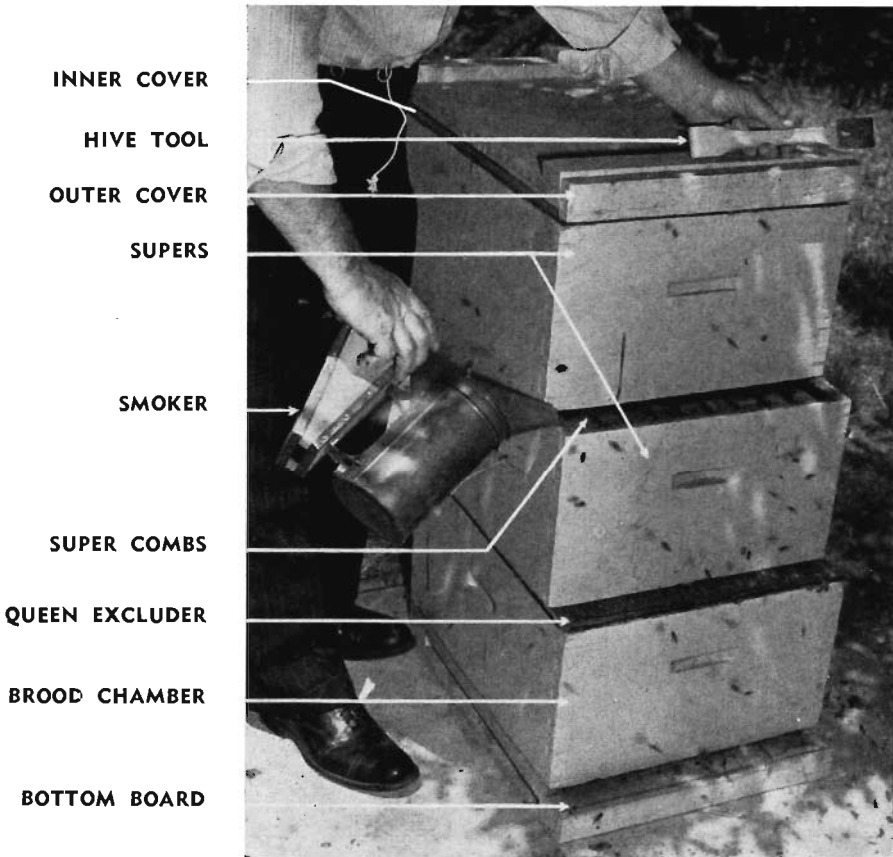


Figure 4. A three-story Langstroth hive. The inner cover is not needed but may be used to divide the hive or as a bee-escape board. (Courtesy University of California College of Agriculture.)

Frames. In assembling frames, a frame-nailing device (fig. 6) should be used to facilitate nailing and to keep the frames square. To limit the amount of drone cells and to make every comb in the brood chamber suitable for rearing worker brood, use full sheets of foundation in each frame. Each frame should be wired with 26-gage tinned wire properly embedded in the foundation, to prevent the comb from falling out when the frame is handled and the cells of the comb from stretching out of shape with the weight of honey in warm weather. A little experience will enable boys and girls to assemble such frames successfully.

Frame-wiring devices (fig. 7) are available at supply houses. The wires should be pulled tight enough to "sing" when strummed. Too much tension will cause them to cut into or through the soft pine wood. To prevent this, some beekeepers drive in staples (with a stapling machine) $\frac{1}{4}$ inch from each hole, as indicated in figure 8. The ends of the wire are fastened to tacks driven into the sides of the end bars; these end holes need no staples.

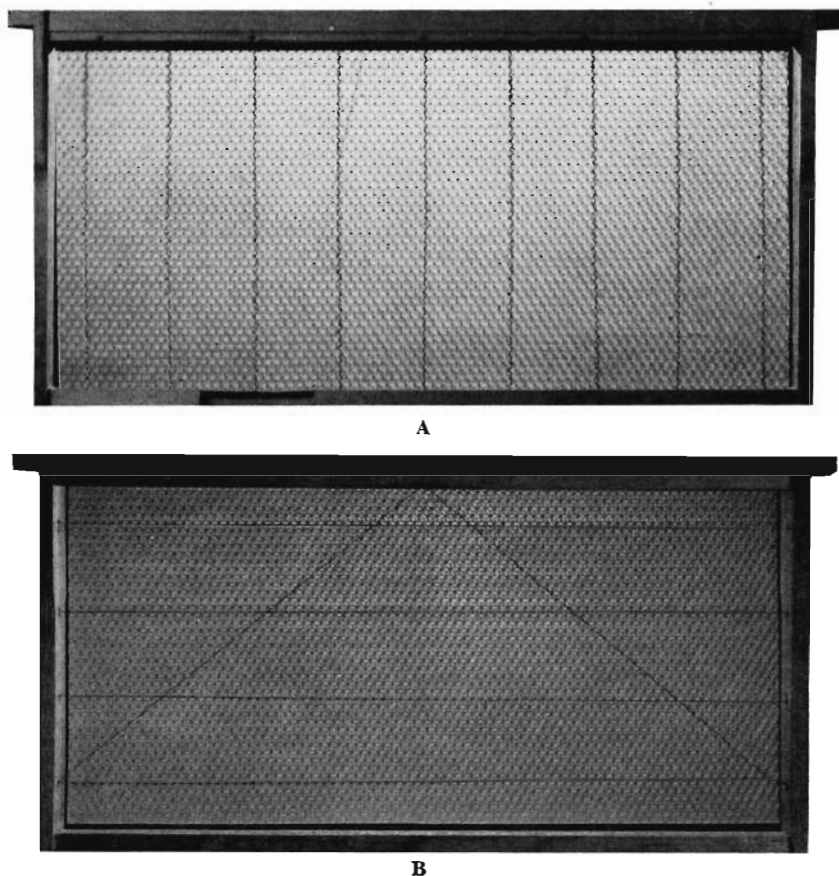
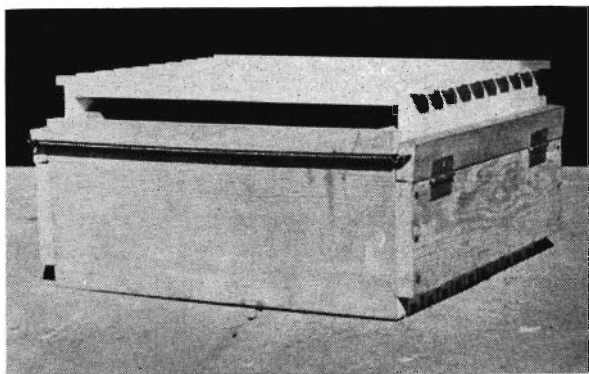


Figure 5. A, Frame with vertically wired foundation embedded at the factory; B, medium brood foundation reinforced with one diagonal and four horizontal wires. (Courtesy University of California College of Agriculture.)

Figure 6. A frame-nailing device to hold the frames square while they are being assembled.



Cross wires are used by some beekeepers, but a majority use either the four horizontal wires or a foundation in which the wires are embedded at the factory (fig. 5). In the latter case, two horizontal wires should be embedded to prevent the comb from falling out of the frame.

The most satisfactory way to embed the wires in the foundation is to heat the wires electrically just enough to cause the wires to sink to the center of the foundation, then cut the current and allow the wax to congeal around the wires. Batteries may be used for this procedure.

When electricity is not available, the wires may be pressed into the foundation by using a spur embedder. When a beekeeper is getting a number of combs drawn from foundation, it is good practice, while examining frames, to use a spur embedder to fasten any wires which may have pulled loose.

Comb foundation is manufactured in different thicknesses such as thin super, medium brood, or heavy brood foundation. Wired foundation comes with either straight or crimped wires, depending on the manufacturer. The thin super foundation is used only in the production of cut comb or section honey. The heavy brood foundation is most serviceable in warm climates, although the medium brood is satisfactory where the frames are carefully wired.

In areas where the honey granulates soon after it is stored, some beekeepers prefer not to wire their frames, making it easier to cut out the combs of granulated honey.

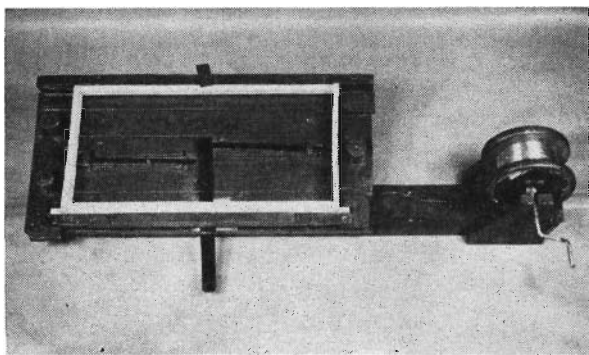


Figure 7. A wiring device used in wiring frames.

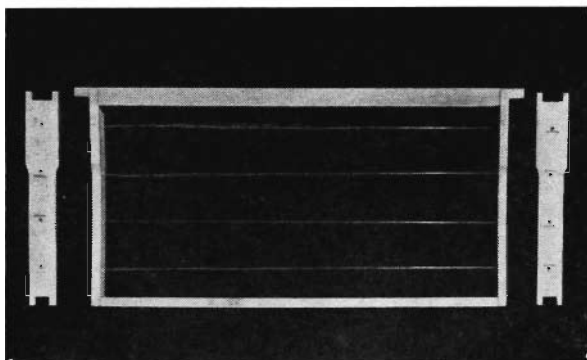


Figure 8. A horizontally wired frame and end bars with staples to prevent the wire from cutting into the wood.

Under favorable conditions, it takes approximately 8 pounds of honey to produce a pound of wax, and bees will store much more honey when given combs than when they have to take time during the honey flow to draw out (build) *all* of their combs.

To produce the better grades of honey, which command the best price, it is usually good practice to provide combs in wired frames and to preserve the combs from year to year. Such combs may also be used as brood combs to build up the strength of the colony before the main nectar flow or to replace damaged brood combs.

The Smoker and the Hive Tool. These two instruments are essential to the manipulation of bees. The bellows smoker permits application of controlled volumes of smoke to keep the bees under control, hastens manipulations, and makes working with bees much more enjoyable. The average beginner uses too much smoke, and only experience indicates the amount needed. Some colonies require more smoke than others.

Smoker fuel can be made from burlap sacks, wood, or any other substance which makes a cool, clean smoke. Kiawe wood makes a long-lasting smoker fuel, especially if the top of the smoker is stuffed with green grass after the wood is well lighted, but it has a tendency to make hot smoke and to overheat the smoker. A large smoker is to be preferred to a small one, for occasionally a good volume of smoke is a great convenience.

The hive tool is used to pry apart the hive bodies and frames as well as to scrape propolis and burr comb (excess comb which interferes with removal of the frame) from the hive and frames. It also has many other uses.

Clothes for Use in the Apiary. The bee veil is one of the most useful pieces of equipment for every beekeeper. The folding wire veil is the most serviceable. Whatever kind of veil is used, it should provide security for the face and neck and afford good vision. A black wire face to the veil is more desirable than cotton or silk as bees are less inclined to attack wire. The veil should be fastened on so no gap will be left for bees to enter when the operator bends over the hive. After years of experience, many beekeepers dispense with the use of veils during periods when the bees are busily gathering nectar and are not cross.

Shoes or boots to protect the ankles and trousers that can be fastened around the ankles are serviceable in the bee yard. Zipper fasteners are desirable, and loose-fitting clothing is preferable to tight clothes. Bees are antagonized less by light-colored cotton clothing than by wool, felt, or other

types of animal origin. Gloves and wristlets around the sleeves may also be worn. Experienced beekeepers usually do not work with gloves because they are clumsy and tend to make one careless: Bees are quite sensitive to animal odors, especially of cattle and stable. Beginners working with experienced beekeepers will usually get stung more than the experienced operator. This may be due to the fear complex which causes perspiration and certain odors that antagonize bees.

The question as to whether a beekeeper can construct his own hives is asked by many who are considering going into the bee business. Hives are not hard to make, and they need not be dovetailed, but they should be made to exact size, of well-seasoned lightweight lumber. In any case, it is best to obtain one or more standard hives to use as models. Manipulation of hive parts may be difficult unless the hives are of proper dimensions and bee spaces are provided where necessary. Bottoms and tops are not as difficult to make as the frames and hive bodies.

MANIPULATION OF THE HIVE

Every colony has a different behavior and each should be gaged correctly when the hive is first opened. First, stand at the side of the hive and blow a puff or two of smoke into the entrance and any other opening or crack to drive back the guard bees and break up the instinct of the colony to sting its disturber. Never stand in front of the entrance. If the colony to be examined is on a bench with another colony, smoke that colony too. After a few seconds, if the bees seem angry, give them another puff of smoke and wait a few more seconds. Then, in opening a one-story hive, pry up the cover slightly with the hive tool, blow a puff or two of smoke across the frames, and wait a few seconds before removing the cover. If the bees fly angrily at your hands, give them another couple of puffs, directing some of the smoke down between the frames. Do not smoke the bees enough to make them run, as this is both unnecessary and undesirable. Apply just enough smoke to keep the bees under control.

Look down between the frames and, with the hive tool, pry a frame away from its neighbor so it can be removed without rubbing the bees against the adjacent frames. If burr combs are built between the top bars, it is best to cut them loose from the top bars of the adjacent frames. This sometimes prevents injury to the queen if she should happen to be on the first frame removed. After examining the frame, set it on end against the opposite side of the hive or bench so the bees will not get around the feet of the operator. This also makes room for the removal of the other frames.

The frame should be held in a vertical position with the comb slanted slightly so the rays of the sun, falling over the operator's shoulder, will light up the bottoms of the cells, revealing their contents. A quick glance across the surface of the comb will generally reveal the queen's presence. Look also for the queen on the surfaces of the combs adjacent to the one removed before replacing it. Only the first comb need be left out of the hive while keeping the hive open no longer than necessary. Put the frames back so the shoulder of each brood frame is touching the one next to it. Then pry all the frames toward one side of the hive with the same movement and replace the first frame withdrawn. Finally, crowd both outside frames toward the center to leave a bee-space between the outside combs and the sides of the hive.

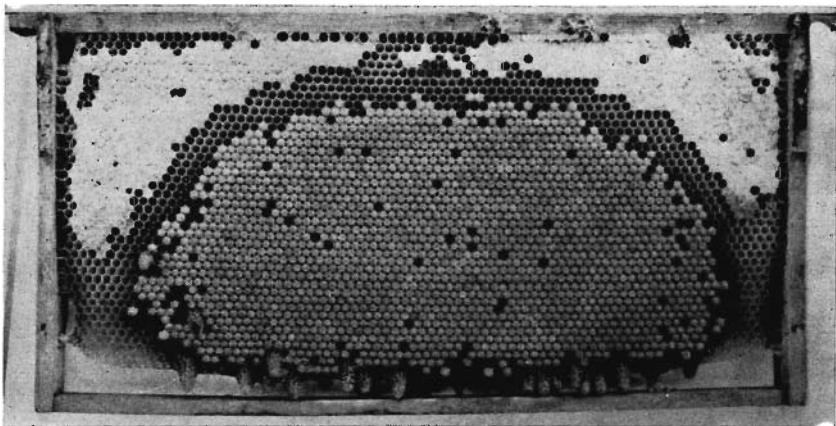


Figure 9. Queen cells built naturally under the queenless impulse. Twenty-six queen cells were built on this one comb. (Courtesy Dadant and Sons, Hamilton, Illinois.)

If a two-story colony is to be examined, proceed as described above. A glance into the super after the removal of the cover will usually reveal its contents. Place the cover on the ground, pry up the super slightly with the hive tool, blow a couple of puffs of smoke across the frames before lifting off the super, and set it carefully on the cover to avoid crushing any bees. If there is any tendency for bees to rob, keep the supers covered, and do not keep the hive open longer than necessary.

One rule for handling bees is to avoid crushing or killing them while removing or replacing frames or hive bodies; another is to operate smoothly, causing as little disturbance as possible. Don't jerk out frames or strike at bees which might be flying around. Don't remove your veil in the apiary if a bee should happen to get inside. It is probably just as anxious to get out as you are to have it out, and there may be many more on the outside trying to get in. Go to one side of the apiary or into a building and remove the bee, kill it inside the veil, or just forget it and go on with your work. Scratch out a stinger; don't pick it out with the fingers or all the poison in the adhering poison sac will be injected into the skin. The wound is so small and the skin is so impervious that nothing can be put on the spot to prevent swelling. The best treatment is to blow a little smoke on the area stung and go on with the work.

CYCLE OF THE YEAR

The behavior of a colony varies with its environment, but its reactions to heat or cold or to a continued nectar flow and fresh pollen are much the same wherever bees are found.

In areas where the bees remain active the year around, and especially where they have access to some fresh pollen and nectar during every month of the year, brood rearing continues in direct proportion to the strength of the colony and to the amount of pollen and nectar available. In the kiawe areas, for example, brood rearing and colony strength decline after the close of the nectar flow and do not increase again until more pollen is available. Bees continue to use their stored pollen and what little is

coming in to maintain a small amount of brood. If the supply of pollen becomes entirely exhausted and no fresh pollen is available, brood rearing ceases even though temperature conditions are favorable for bee flight.

At higher elevations where frosts occur or in regions where the temperatures remain low during the winter period, as in many places on the Mainland, brood rearing ceases entirely, and bees form a cluster to maintain a favorable hive temperature. Bees do not cluster unless the temperature of the hive falls below 57°F.

Brood rearing is stimulated with an increase in the available pollen and nectar and, together with the production of drones, continues to increase until the queen has reached her egg-laying ability or has filled the capacity of the brood chamber. Unless the available brood area is increased by the beekeeper, the bees usually begin preparations to swarm by starting queen cells. By this time, hundreds of mature drones are present in the hive, and the bees are usually storing honey in the super combs. Several queen cells may be started along the bottoms and sides of the brood combs (fig. 9). The queen may lay eggs in some of the queen-cell cups, and the bees may build cells around larvae in worker cells.

When the colony makes preparations to swarm, a number of scout bees search for a new home. These bees may select an empty hive, box, hollow tree, or cave as a future homesite. The nurse bees gradually feed the queen less and the number of eggs she lays tapers off; this reduces the weight of her body until she is able to fly with the swarm. More workers remain in the hive, and many bees cluster on the front of the hive and hang there while the bees in other colonies are working.

Finally, some time after the first queen cells are sealed and before the first young queen emerges, a majority of the old bees and many of the hive bees rush from the hive with a high swarm tone and whirl around in the air for some minutes. Such bees are not inclined to sting. Groups of the bees begin to form small clusters but usually collect gradually in one large cluster. It is assumed that the cluster forms as soon as the queen alights among a mass of bees, but queenless bees form clusters for short periods of time. Contrary to popular belief, pounding on pans, saws, or

Figure 10. A swarm of bees on the trunk of a eucalyptus tree. Few swarms choose such convenient places.



other objects at the time the bees are in the air has no effect in causing them to cluster.

After the cluster has formed (fig. 10), the scout bees communicate in some way to the clustering bees the location of their newly selected home; if left alone, the cluster usually breaks and flies directly to the new home-site in a dense cloud. The cluster containing a queen usually hangs in place from a few minutes to an hour or more; while clustered, it can be shaken into a box or otherwise carried to a hive, and will run in if shaken in front of the entrance. Some swarms cluster overnight before leaving, whereas a few build their combs in the open where they first clustered. Such clusters may be cross when disturbed. A 5-gallon honey can with the top cut out, nailed to a long bamboo pole, is used by at least one beekeeper on Maui to catch his swarms when they hang in the tops of trees. The hive containing the new swarm may be moved to any location, as the bees will reorient themselves.

If the wings of the queen are clipped (fig. 11) at the time the colony swarms, the bees may form a loose cluster but soon break and return to their hive. The queen may be found on the ground in front of the hive, usually with a small knot of bees around her. When hives are located on stands, such queens are generally lost or become the victims of toads, ants, or other predators. The returning bees then swarm with one or more of the young queens a few days after the latter emerge from their cells.

The first swarm from a colony is called the primary swarm. The hive from which it emerges is left with several frames of brood, many of the young hive bees, and the bees in the field at the time the swarm issued. The emerging bees soon replenish the hive with workers, and one or more of the queens emerge from their cells in due time. The colony may swarm a second time with a young queen; if it does not, the first queen to emerge usually seeks out the other queen cells, tears a small hole in each, and stings the rival queen within. The worker bees may assist the queen in



Figure 11. Proper way to hold a queen for clipping or marking. (Courtesy Dadant and Sons, Hamilton, Illinois.)

tearing open the cells and then finish the job. If the new queen succeeds in mating, she begins to lay within 10 days to 2 weeks after the primary swarm departed, and the colony is re-established.

A strong colony which does not swarm but remains working throughout the nectar flow stores far more honey than the colony that swarms. Such working colonies should be given sufficient room in which to rear brood and to store honey in order to prevent the development of the swarming impulse. Combs of honey can be removed as soon as they are sealed, the honey extracted, and the combs returned to be refilled.

As the amount of pollen and nectar becomes less, brood rearing is retarded, and the workers begin to starve the drones and drive them from the hive. Field bees begin a more diligent search for propolis with which to seal the cracks of their hives in preparation for the winter season and become more likely to rob. At this time, more water gatherers are found around watering places, as bees need water to produce brood food and to regulate the temperature of their hive. As the amount of brood decreases, the bees store more honey in their brood combs. This trait is particularly characteristic of the Caucasian race. Supers should be removed to permit bees to fill brood combs with honey for winter stores. Flight activity gradually ceases, and colony strength is reduced as the old bees die off and are not replaced by emerging brood.

Bees do not hibernate during the winter period as do most insects. In locations where the temperature of the hive falls below approximately 57°F. the bees gradually form a cluster as the hive temperature approaches this point. If the temperature goes lower, the cluster of bees becomes tighter. In this way they generate and conserve heat within the cluster until it may reach 70°F. or above, even when the outside temperature is below the freezing point. The cluster gradually moves over the combs of honey which the bees use to maintain heat and life. In the colder climates, bees will begin to rear brood some weeks before the first pollen becomes available, if they have pollen stored from the previous summer or fall. To rear brood, the cluster must maintain a temperature in the brood area that approximates 93°F. This requires the expenditure of considerable energy and the consumption of a larger amount of food than when the colony is broodless.

When bees are able to fly nearly every day of the year, the population is very likely to dwindle unless the bees can secure enough pollen and nectar to produce bees to replace those which die. This may be accomplished if colonies are moved in the fall from kiawe locations to eucalyptus groves, or if the bees can secure enough pollen and nectar from lantana or other sources.

SEASONAL MANIPULATIONS

Fall Management. The value of a colony during the spring and early summer depends largely on various conditions present in the colony during the previous fall.

Near the close of the nectar flow in early fall and before the bees begin to rob, all colonies should be checked carefully and prepared for winter. They should be inspected for American foulbrood, *and no diseased colony should be wintered over.* Poor combs should be replaced with good worker combs and honey added if not enough is present or likely to be gathered to carry the colonies until they can collect supplies in the spring. To prevent unnecessary granulation or destruction of combs by the wax moth,

all surplus honey and surplus combs not needed by the colony should be removed. If colonies are to be wintered in one-story hives, the brood combs should have about 30 pounds of honey and at least one full comb of pollen. Two-story colonies should have honey in at least three combs in the upper story and 20 pounds or more of honey in the brood combs. If the combs in the second story are good worker combs, the queen excluder can be removed so the colony can rear brood in the super combs as well as in the brood chamber in the early spring.

After the hive has been reduced to the size of the colony and provided with sufficient stores, old or failing queens should be replaced with ripe queen cells or with young laying queens. A disease-free colony having a young vigorous queen, sufficient stores of honey and pollen, good brood combs, and bees to cover 10 or more frames should produce a strong colony before the beginning of the kiawe honey flow. Each hive should have a watertight cover and should be protected from ants and other disturbing influences (fig. 12). Colonies below normal strength may have poor queens and should be united with others to protect the combs.

Feeding Colonies. Sometimes colonies require more food than they have been able to gather. This can be supplied with honey in the comb from other disease-free colonies. Bees will consume granulated honey, and such combs can be given to those requiring more honey. If no combs of honey are available, the colony can be fed as follows:

Dissolve 2 parts of sugar in 1 part of water and place it in a container on top of the frames inside an empty hive body, with the hive cover on top.

The container can be an open pan with floats to prevent the bees from drowning or a friction-top pail with several small holes in the lid. Invert the pail over the frames, and the bees will suck out the sirup.

Glass jars with small holes in the caps can be used to hold the sirup; they may be inverted over the top bars inside a hive body or placed in Boardman holders in the entrance.

Honey sirup may be used instead of sugar sirup if the honey is known to come from disease-free hives or if $\frac{1}{2}$ gram of sodium sulfathiazole is dissolved in the water used to make each gallon of sirup. (See discussion of sulfathiazole, p. 47.)

If bees are robbing when colonies are being fed, restrict the entrance of all colonies by inserting entrance blocks, and feed the colonies only in



Figure 12. An apiary on the island of Kauai with colonies protected from ants and toads.

late afternoon. Use care at all times to prevent the sirup containers from leaking, as the colonies being fed might be attacked by robbers.

Another fall chore is to clean all honey-extracting equipment, invert the honey tanks, and oil the honey gates and the bearings of all moving parts. Honey pumps, pipes, and tanks should be emptied of honey, cleaned, and protected from dust and weather.

Moving Apiaries. In some locations it may be feasible to move colonies in the fall to higher elevations where the bees can secure nectar and pollen from eucalyptus during fall and winter. Such locations may provide enough nectar and pollen to enable colonies to store a surplus or at least to gather their winter stores and build up colony strength. Under favorable conditions it may be possible to get combs drawn from foundation during the eucalyptus nectar flow or to rear queens to requeen colonies. This may not be possible in the rain belt or in rainy seasons.

Winter Management. Colonies require very little attention during the winter period if they have been prepared properly. Colonies seal all cracks with propolis, which varies in color, sometimes being as black as tar. This seal should not be broken. Each apiary should be visited occasionally to check on the condition of the hives. Any hive which has been robbed out or in which a colony has died should be taken care of to prevent further robbing or destruction of the combs by the wax moth.

Frames and hive equipment should be repaired for use during the coming season. Improve solar wax extractors, extracting equipment, and honey processing. Kill the ants, remove surplus shade in the apiary location, and attend to other details necessary for more effective spring and summer management.

Spring Management. Bees become more active as pollen and nectar become available. As soon as weather conditions are favorable and when bees are not likely to rob when hives are opened, the hives should be inspected to (1) detect disease, (2) supply additional stores when necessary, (3) determine the condition of the queen by the amount and distribution of the brood, (4) requeen any colony which has become queenless or has a poor queen, and (5) replace any poor combs in the brood nest with frames containing only good worker combs. Most of these details can be attended to without keeping the hive open very long. Queenless colonies, which are too weak to survive alone, may be given brood and bees from stronger colonies, or united with the strong colonies to save the combs.

Comb foundation should be given to colonies *only* when the bees are gathering sufficient nectar to build comb. At other times, bees tend to destroy the foundation by using the wax to seal up cracks and crevices.

When the colony has filled the lower chamber with brood, a second story should be added before the bees start to build swarm cells. Combs of granulated honey in the brood chamber should be replaced with good brood combs. The second story is usually added in the spring before the main nectar flow starts. A colony wintered in a one-story hive should be given the second story *as soon as it has brood in most of its combs*. The queen excluder need not be put on when the second story is added unless surplus honey is being produced by the colony. It is preferable to have drawn combs of worker cells in this second story. However, during a slow kiawe nectar flow in the spring, bees will draw combs from foundation.

Supering for the Nectar Flow. Some beekeepers remove the queen

excluder in the fall and winter their colonies in two-story hives so the colony can establish its brood nest in the second story in early spring. This is good policy when the colony is strong enough to guard all combs from the wax moth *but only when the second story contains good worker combs*. It is a waste of time and energy if the colony is too weak to occupy more than one story or if the combs in the second story are composed largely of drone cells. The chief value of this practice is to provide a larger brood nest in early spring in which to build a strong force of workers for the nectar flow. It also permits a manipulation of supers designed to eliminate swarming.

As soon as the colony begins to store honey in the second story and before it starts any queen cells, run the queen down into the lower brood chamber with smoke or an acid board (pp. 19, 29) and place a queen excluder over this chamber. Leave one or two combs of brood in the lower brood chamber and place the balance of the brood in the super. Then place a super of combs or of foundation on top of the original second story. This removes the congestion of bees from the brood chamber, thereby reducing one of the chief causes of swarming. As the brood hatches out, the bees fill the cells with honey; in 3 or 4 weeks the sealed combs of honey may be extracted. The bees also will draw out any frames of foundation in the second story and will have some of the combs partially filled with honey. Queen cells may be built on brood above the excluder in this operation and these should be destroyed, or the best used to make increase.

When plenty of pollen is available in the spring, colonies with vigorous young queens will increase rapidly in strength. If colonies were wintered in one-story hives, the second story should be added as soon as the colony has brood in all but two combs in the brood chamber and before queen cells are started. The two outside combs in the brood chamber can be moved to the center of the second story, and the combs which were next to the outside combs should be pushed to the side walls of the brood chamber and new combs or frames of foundation given in their place. When the colony has built up in strength to occupy both stories, the queen can be placed in the lower hive body, below the queen excluder, and a third hive body can be added either on top or in the middle, immediately above the queen excluder. If the colony strength builds up enough to require a fourth story before the first combs of honey are ready to be extracted, it can be added in the top position. When the combs in the third story are ready to be extracted, the position of the third and fourth stories should be reversed, and the partially filled combs can be concentrated in the second story. Fewer combs can be used in the supers than in the brood chamber.

The brood chambers of all colonies should be examined just before the first combs of honey are removed to make sure that each colony is free of American foulbrood. When the queen is allowed to rear brood in combs which are later extracted, or even when honey is extracted from a diseased colony, there is danger of spreading the disease by placing the extracted combs in some other colony.

In most kiawe locations, colonies must be forced to fill and completely seal the combs, as in the production of comb honey, instead of being allowed to spread unripened honey throughout a large number of combs. This is necessary because of the tendency of kiawe honey to be high in moisture

content and to granulate within 3 or 4 weeks after it is stored in the comb. If the honey is extracted every 3 weeks and the combs returned to the colonies, three-story hives may be sufficient to satisfy the colony and to provide space for the storage of honey in years of average honey production.

To Reduce Granulation in Extracting Combs. New honey will granulate more quickly *if the honey is stored in cells which contain some crystals of honey from the year before or from a previous extraction.* Combs which are built on wired frames from full sheets of foundation are too expensive to cut out because of granulated honey. *When there is no danger of spreading American foulbrood,* supers of combs of granulated honey may be stacked at one side of the apiary for the bees to rob out before the combs are placed back in the hives. Most of the honey will be stored by the bees, although some dextrose crystals will be thrown out. Newly extracted combs will be cleaned out within a short time. Obviously, the exposed combs should not be left in the open too long where they will be destroyed by mice or wax moths. The exposure of combs in this manner is illegal in California because of the danger of spreading bee diseases, but in many isolated areas in the Islands it might be a practical method of reducing granulated honey to newly stored honey in about 4 weeks and eliminating the necessity of destroying good combs.

Newly extracted combs will be cleaned of honey if placed above the second story of strong colonies and partly separated from the combs below by a piece of tar paper *which is cut 1 inch shorter than the length of the super.* Such supers can be left in place for 1 or 2 weeks and distributed at the next visit to the apiary, or they may be placed on each colony and left there until the combs of honey in the second story are ready to be extracted. If the bees need the room, they will store honey in them, but the tendency will be to fill the combs in the second story before going into the supers above the tar paper. It may be necessary to use roofing paper rather than the thinner paper used in the pineapple industry.

Extracting combs should be cleaned of honey by the bees before being stored during the winter period because of the tendency of "wet" combs to cause granulation in newly stored honey the following spring.

Swarm Prevention and Increase. Honey bees have a natural tendency to swarm in order to preserve their species. Swarming usually occurs when the colony strength is being increased under the stimulus of an abundance of incoming pollen and nectar. The tendency to swarm is inherited but may be increased by certain conditions in the hive. A crowding of the brood chamber with brood, young bees, and honey and pollen is the chief contributing factor during a nectar flow. For this reason, poor brood combs or granulated honey in the brood chamber limits the amount of comb space in which a queen can lay and causes a colony to swarm one or more times before other colonies which have adequate comb space in which to rear their brood. A lack of storage space in the supers causes bees to store honey in the brood chamber, thus creating a crowded condition which frequently induces swarming. A lack of ventilation, due to small entrances in the hive, causes bees to "hang out" during the heat of the day; this condition may cause bees to start queen cells and may retard the evaporation of excess moisture during the ripening process.

Colonies which are left to rear their own queens naturally are likely to swarm one or more times a season. This swarming trait can be reduced

by rearing queens from strains which do not tend to swarm. Colonies also may swarm when they are preparing to supersede an old or failing queen. Colonies with young queens are less likely to swarm the first season than are those with old queens.

The best swarm prevention measure is to permit colonies to use two or more brood chambers until the beginning of a main honey flow and then arrange the hive bodies so the queen is in the lower brood chamber, with most of the brood in the second or third stories. To relieve congestion in the brood chamber during active brood rearing, some of the combs of brood may be removed and replaced with drawn combs or wired frames with full sheets of comb foundation. The brood may be placed in the supers, above the queen excluder, or used for strengthening weaker colonies or in making increase.

A colony frequently starts queen cells after young brood is separated from the brood chamber by a queen excluder. It is best to examine such brood within 10 days after the separation and break down any cells which may be formed. However, if new colonies are desired, a division can be made by placing the combs of sealed brood and bees in a hive on a new stand. Such colonies can be made stronger by adding frames of brood and bees from several colonies. Some of the bees will return to their old locations, but usually enough remain to provide protection for the combs of brood. Each new colony should have one or two combs of honey, two or more combs of brood, and one or two sealed queen cells. If only a couple of frames of brood and bees are taken from each colony in making increase, the parent colonies will not be reduced materially in strength.

Another method of making increase is to move to a new stand the brood chamber and queen of a colony which is preparing to swarm and to put in its place a hive body with two or three combs of young brood and drawn combs or frames of comb foundation. This colony on the old location can be left with a queen cell or given a queen cell a few hours later or on the following day. The supers from the old colony should be left on the original stand, since most of the bees from the hive containing the old queen will return to their old location. The colony with the old queen usually tears down the remaining queen cells and can be given a super later.

Increase may be made at any time of the year if the bees can secure enough nectar and pollen to build up colony strength. It is usually best to make each division strong enough to protect its combs and to give it only such combs as it can cover adequately. At the beginning of the nectar flow, a division made of two or three frames of sealed brood and adhering bees, plus one or two combs of honey, will build up sufficiently to fill an 8- or 10-frame hive body within 6 or 8 weeks. It may then require a super. Such divisions should be given a ripe queen cell and not left to rear their own queens. If such divisions are given laying queens, they build up much faster.

Removing the Honey Crop. In humid regions, bees have difficulty in removing the excess moisture from honey during the ripening process. This is generally true in many areas of Hawaii. It is necessary, therefore, to leave the honey in the hive until the moisture content has been reduced to 17 or 18 percent. To achieve this percentage a majority of the honey must be sealed before it is taken from the bees. Under conditions of high humidity, as in early spring or late summer and fall or during a rainy period,

even sealed honey may contain more than 18 percent moisture. In addition, some honeys (especially kiawe) granulate quickly after they are stored in the comb, making it essential to extract the combs before granulation occurs. Extracted honey containing more than 18 percent moisture is likely to ferment in the can unless it is processed (to kill the yeasts which all honeys contain to some extent) and then sealed in airtight containers.

It is important to remove honey from the hive *early in the morning before the nectar carriers can bring in much raw nectar*. Unripened honey may contain 30 percent or more moisture, and it does not take much of this excess moisture to raise the total moisture content of extracted honey to well over 18 percent. The later in the day honey is taken from the hive, the greater the danger of extracting unripened honey, unless only combs of sealed honey are extracted. Beekeepers experienced in producing kiawe honey have found that they can secure honey of a desired weight if they extract each hive every 3 or 4 weeks and take only combs which are largely sealed. Honey is too green to be taken from the bees *if it can be shaken readily from the cells*.

The combs can be freed of bees by shaking and brushing, by the use of smoke, by the use of the acid board, and by bee-escape boards. Most beekeepers in Hawaii use the shaking method because they can sort the sealed from the unsealed. In using this method, it is desirable to have an extra hive body on a wheelbarrow to put the combs in as fast as the bees are shaken and brushed off. It is best to shake the bees into the hive rather than on to the ground in front of the hive. If an entire super of honey is to be taken off, place a super of combs under the one to be shaken or before the acid board or bee-escape board is put on. This will give the bees room and will not delay their work of ripening and storing honey as it comes in from the field. The majority of bees can be shaken off a comb with a quick downward and upward movement and the remainder brushed off with a bee brush. The super into which the combs are placed after being freed of bees should be kept covered when bees are likely to rob.

The fumes of carbolic acid are repellent to bees and are used by many beekeepers on the Mainland to drive bees from supers which are to be removed. Special covers, called acid boards, are used for this purpose. This board is about 1 inch deep, with the same dimensions as the top of the hive or super. A piece of hardware cloth is tacked across the top of the framework, then several thicknesses of cheesecloth, and, over all, a cover of tin which fits down over the sides of the wooden frame. The cheesecloth is sprinkled with a 50 to 75 percent solution of pure carbolic acid. Care must be used to prevent any of the solution from dropping on any part of the honey frames. Even burr combs on the tops of frames must not touch the inside of the cover. Carbolic acid is highly injurious to the skin and may cause sores which are hard to heal.

Each beekeeper can use from 10 to 12 acid boards, leaving them on only long enough for the bees to be driven from the honey super. By the time an operator has opened 12 hives from which honey is to be removed, has given the bees a puff or two of smoke over the tops of the combs, and has placed an acid board on each hive, the super on the first hive is usually ready to be removed. The first super should be set off to one side and the other supers removed before placing the acid boards on more hives. To keep the acid from coming in contact with any of the comb or honey,

the burr combs should be scraped from the tops of the frames before the acid boards are put in place. If done properly, the supers of honey can be taken from an entire apiary within a short time early in the morning before the bees have brought in much nectar. This should be done especially with kiawe honey to prevent the inclusion of unripened honey. To permit the fumes to escape from the supers before the honey is extracted, the supers may be stacked crisscross in the extracting room or honey room before extracting the combs. The honey room should be well screened. This method works best in hot weather. When the sun strikes the top of the acid board, the fumes are driven down through the combs.

Some beekeepers drive bees from the honey super by setting it on top of an empty hive body containing two rolls of smoldering burlap, on the ground near the hive entrance. Several colonies are worked at the same time in this way. As soon as most of the bees have left the supers, they are brushed off the top of the frames and the supers carried into the extracting room. Combs which are exposed too long to the smoke will absorb some of the smoke odors.

A fourth method of freeing honey supers of bees is the use of bee-escape boards. A bee which enters a bee escape cannot re-enter through the escape device. The escape is placed in the center of a board or inner cover which is inserted beneath the super of honey to be removed. It takes the bees several hours to find their way out of the supers through the escapes, so this method is not so desirable for hot climates. The escape boards should be inserted in the late afternoon and the honey removed the following morning. It is desirable to have a super of combs beneath the super to be removed. Ventilated escape boards may be used instead of solid boards.

When the supers contain combs of brood and the colonies are run in two-story hives, difficulty will be encountered with either the acid-board or escape-board method, unless the queen excluder is removed or a super of combs is placed beneath the super to be removed.

Many beekeepers who use the bee-escape method of removing supers of honey place the sealed combs of honey in the supers to be removed and the unsealed combs in supers immediately below. This eliminates the combs of unripened honey. In using escape boards, care should be taken to see that robber bees cannot get into the supers above bee escapes. If this precaution is not taken, robbing may get underway before the honey can be removed.

PRODUCTION AND CARE OF QUEENS

Since queens produce all the members of their colonies, they are largely responsible for such characteristics as color, temper, industry, resistance to various diseases, comb-building traits, longevity, swarming tendencies, and total population. Consequently, it is highly important to keep young, vigorous, and purely mated queens of selected strains at the head of all honey-producing colonies. It is not good practice to permit colonies to produce their own queens naturally, especially if the stock is poor and the colonies are weak.

Queen honey bees are reared in special cells and are produced from young larvae resulting from fertilized eggs. The natural queen-cell cups are constructed before the egg is laid in them or the cells may be built around young worker larvae. Bees rear queens under three impulses: when

they are making preparations to swarm, when the queen becomes old and the bees are attempting to supersede her, and when the colony or brood area becomes queenless from any cause. Worker larvae under 3 days of age can be converted into queens if they are reared in queen cells. Larvae which are well fed from the time they hatch from the egg and are less than 24 hours old make the best queens.

Selection of Breeder Queens. Whether the queens are reared by the use of artificial cells or are forced to build their cells by natural methods, the beekeeper should select the stock from which they are reared. This usually requires considerable time, for the beekeeper should know in advance that the queen to be selected has a colony with most of the desirable traits he wishes to perpetuate in his other colonies. The first consideration is that the queen, drones, and workers are uniformly marked and are true to their race. Then the beekeeper should know, from observations during the preceding year, that the colony is not susceptible to sacbrood, paralysis, or European foulbrood, that the queen is prolific, and that the bees are industrious, gentle, good comb builders, and are not likely to swarm. Some colonies produce more beeswax than others and some are more conservative of their stores, both desirable traits. Some colonies have a greater tendency to rob than others, a trait that should not be continued by breeding. It is helpful in selecting breeder queens to keep records of these characteristics for a number of the strongest and best-producing colonies during the season's operations.

Production of Queen Cells. Colonies usually produce queen cells if the queen is removed, if young brood is placed above a queen excluder, if a colony is preparing to swarm, or if a queen is old or injured. The beekeeper can take advantage of any of these impulses to induce colonies to produce queen cells with which to requeen his other colonies. For example, a strong colony can be made queenless by setting the queen, with one or two of her frames of brood and bees, into another hive. If necessary, additional brood and young bees can be added to the cell-building colony. All frames of young brood are removed, and a comb containing eggs and young larvae is inserted from the breeder colony. Since bees build comb and queen cells with greatest efficiency during a nectar flow when pollen is available in abundance, it is desirable to simulate such conditions by feeding the cell-builders heavy sugar sirup during the time they are building cells. If necessary, they should also be provided with an ample supply of pollen in combs from other colonies. A colony in this condition usually starts several queen cells from the young brood given to it. The largest and best can be cut out and given to queenless colonies a day or two before the queens are to emerge from the cells.

Another method is to place young brood from a selected breeder colony in the super above a queen excluder of a colony that is preparing to swarm, *after first removing all queen cells and young brood below.* The colony frequently builds a number of queen cells on the comb above the queen excluder.

The Doolittle Method. A majority of queen breeders use what is known as the Doolittle system of cell production to secure a large number of queen cells. (This system is explained in detail in books on queen rearing, which should be consulted.) This method uses queen-cell cups (fig. 13) which can be purchased or made artificially from pure beeswax and fastened

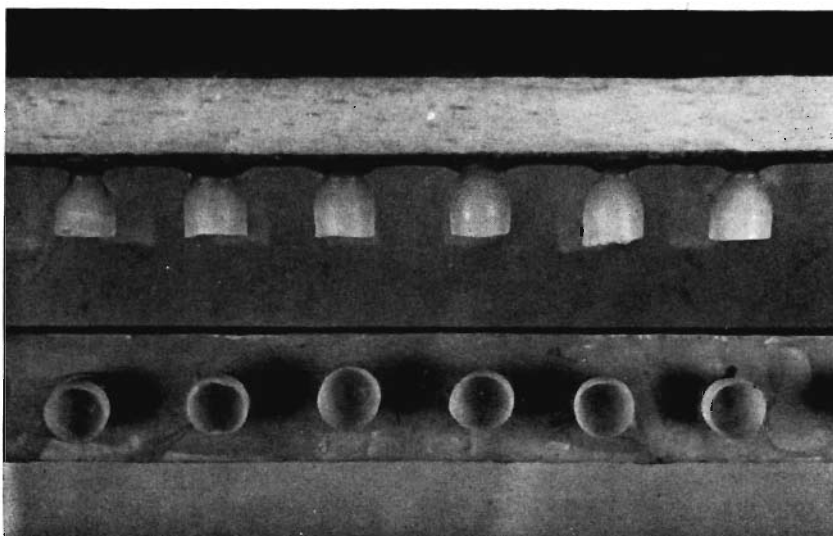


Figure 13. Wax cell cups for use with Doolittle method. (Courtesy Dadant and Sons, Hamilton, Illinois.)

to bars, as illustrated in figure 14. The cell cups are made by first soaking the molds in cold water, then dipping them into beeswax heated to just above the melting point. The cells are then transferred to the cell bars by setting the mold containing the cells on the bar and pouring melted beeswax around the cups. When the wax has congealed, the mold can be lifted out of the cups. It is desirable to coat the cell bar with a thin layer of beeswax before fastening the cups to the bar. A number of bars should be fitted with cell cups before they are needed and stored in a dust-free box.

In producing the queen cells, colonies are first conditioned to accept and finish the cells in preparation for "grafting." A cell-building colony is prepared from a strong colony which can be increased in strength, if necessary, by the addition of frames of sealed brood and bees from other colonies. It is usually made queenless by the removal of the queen. It is also desirable to feed the colony sugar sirup or dilute honey, especially when there is no steady source of nectar available. Two-story colonies are preferred, with a queen excluder between the first and second stories. Enough bees should be present to *crowd both hive bodies*. Place the unsealed brood above the queen excluder when the colony is made queenless. A colony in this condition will accept queen cells within a few hours after it is made queenless.

The queen-cell cups on the bars are then provided with a *small* quantity of royal jelly taken from a natural queen cell and diluted about half with clean, luke-warm water. Larvae which are approximately 24 hours old and well fed by their bees are transferred, or "grafted," into the cell cups from

Figure 14. Three steps in making queen cell cups. Top: dipping the molds in beeswax heated to just above the melting point. Center: fastening the cups with melted beeswax to a cell bar. Bottom: removing the molds from the cups. (Courtesy Dadant and Sons, Hamilton, Illinois.)



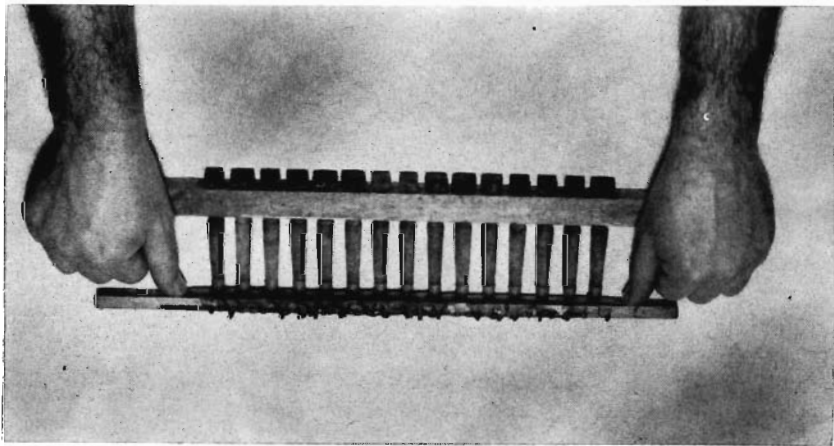
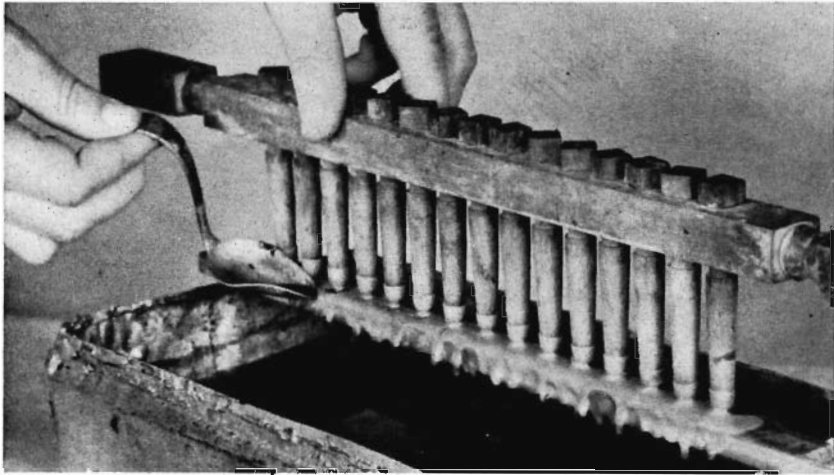
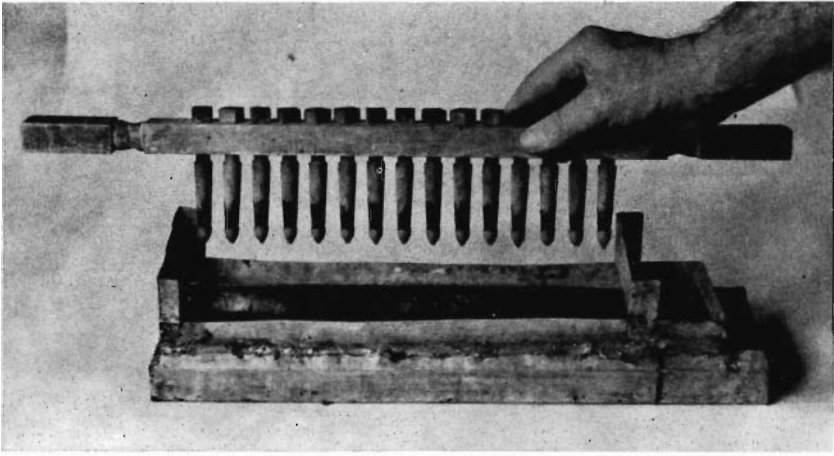


Figure 15. A type of grafting needle for transferring worker larvae to queen cell cups.

a comb taken from the breeder colony. The transfer needle can be made from wood, wire, or a darning needle in the form shown in figure 15. The small end of the needle is pushed into the food on which the small larva rests, so the larva can be lifted without injury and floated off on the small drop of dilute royal jelly in the cell cup. The larva should not be exposed to heat or to drying at any time. Experience in transferring larvae will hasten the operation and improve the number of cells accepted by the cell-building colonies.

After the larvae are transferred to the cell cups, the bars are placed in the cell frame and the frame placed near the center of the cell-building colony above the queen excluder. This body should also contain combs with a good supply of pollen. The colony is fed continuously as long as it is building cells. A good cell-building colony can be given from one to three bars of cell cups every 4 days, at least three times or more, if the number of young bees in the colony is increased by adding frames of emerging brood from other colonies. It is desirable to place a comb containing young brood next to the frame of cell bars each time the colony is given a new lot of cells. (Queen cells should be destroyed in the lower brood chamber if any are started there.)

Care of the Cells. Ten days after the larvae have been grafted into the

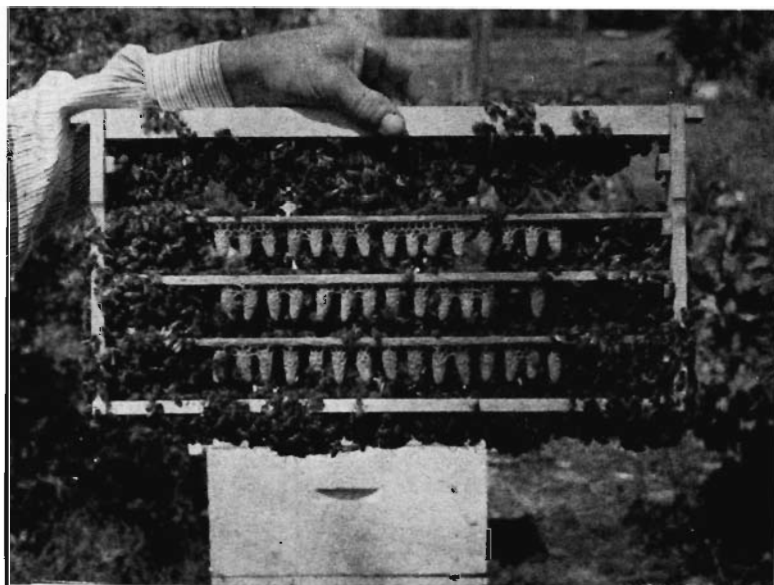
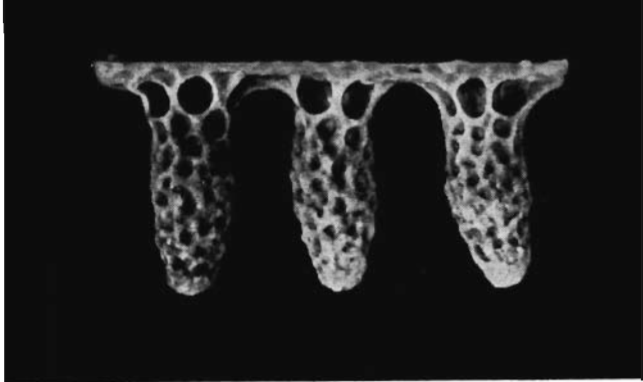


Figure 16. A frame of well-built queen cells, showing the strength of the colony in which they were built. (Courtesy Dadant and Sons, Hamilton, Illinois.)

Figure 17. Three ripe queen cells cut from a cell bar, with the base support of beeswax. (Courtesy Dadant and Sons, Hamilton, Illinois.)



cell cups, the cells are said to be "ripe" (fig. 16) and should be removed from the cell-builder. The cells should be handled carefully at all times and never shaken or dropped. Brush the bees gently from the cells with a soft bee brush.

Remove the bars from the frame holder and lay them on their edges on a table. Cut the whole strip of cells (fig. 17) from a bar with a thin-bladed knife, then cut each strip into individual cells ready for the queenless colonies. Keep the cells warm and handle them carefully. In carrying them from one apiary to another, place them in a box on cloth or padding to prevent injury from jarring or exposure to the sun.

Introduction of the Queen Cells. Colonies which have been queenless for 1 or 2 days usually take cells without tearing them down. Quite frequently it is desirable to make up nuclei to receive the cells with two or three frames of brood and bees in divided hives or hives with entrances reduced to only a small opening. It is best to make up these divisions the day before the cells are ready and to see that each nucleus has sufficient bees and stores to make it self-sufficient until the young queens have time to mate and start a brood nest. The cells can be hung between the top bars of two frames containing brood or gently pushed into the comb near sealed brood. The strip of beeswax at the base of the cells serves to hold each cell between two frames or in the comb.

It is difficult to introduce cells successfully when conditions are such that bees are likely to rob weak colonies. It also is best not to disturb the colony to which a cell has been given until the queen has had time to mate and to begin to lay—a period of 10 to 12 days.

How to Requeen a Colony. The first step taken to requeen a colony is to make the colony queenless. Queens are found usually on combs containing eggs and young larvae if the colony has not been disturbed too much. If a queen excluder is in position above the brood chamber, a queen is found in many instances by smoking the colony through the entrance to force the bees to run up through the queen excluder. The queen may be found trying to get through the excluder and frequently will be on the under side of the excluder when it is removed. The colony should be left queenless for a few hours or until the next day before a new queen is introduced.

Queens are generally introduced by the cage method. One compartment of the cage is provided with queen-cage candy, and the bees in the colony must eat a hole through this candy into the other two compartments before the queen can be released. The cage containing the queen can be hung between two frames in the hive with the candy end up and the screened

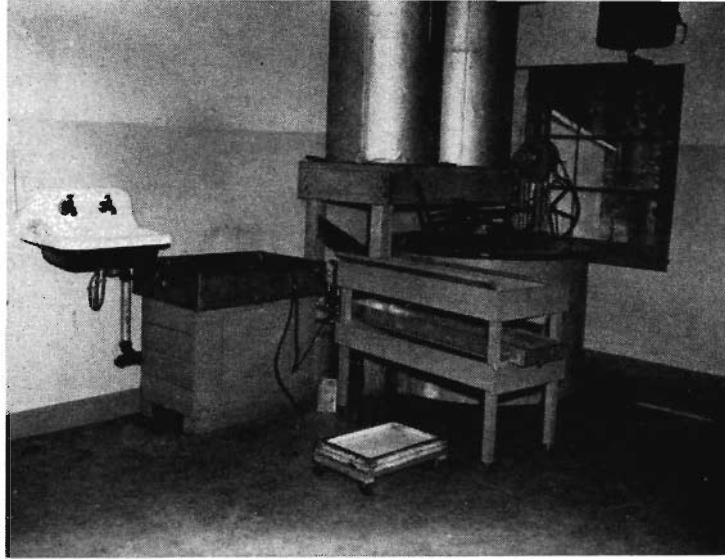


Figure 18. A small extracting plant incorporating most of the facilities of a well-equipped honey house. The steam boiler is located in the shed seen through the window. The honey is further processed in the adjoining room. The wax separator is at the end of the cappings melter and concealed by the movable table next to the radial extractor.

side of the cage exposed, so the bees of the colony can feed the queen through the wire and become acquainted with her. It usually takes the bees several hours to release the queen by this method; in that time, they will have become accustomed to her presence in the hive and will generally accept her. A laying queen, just removed from a nucleus, is easier to introduce than one which has been confined for days in a queen cage.

If queens are removed from nuclei in the beekeeper's own yard, they may be introduced by the same method if the candy compartment is filled with granulated honey. Queens are accepted more readily by queenless colonies during a nectar flow than during a shortage of nectar. Under favorable conditions, the queen in a colony can be removed and another introduced immediately by setting in two or three frames of brood and bees from a nucleus, being sure that the new queen is between two of her combs of brood and bees. The frames should be placed next to one wall of the brood chamber.

Sometimes a queen is reared from a ripe cell in a super separated from the colony below by a double screened or solid division board. The super should contain three or four frames of emerging brood and bees from the colony below, and should be given an outside entrance. The queen cell is given to this division the day after it has been made, and the colony is left undisturbed for 10 days or 2 weeks, by which time the young queen should have emerged, mated, and started to lay. The colony can be run as a two-queen colony until the new queen has a well-established brood nest. A super can be added to the colony below, being placed on top of a queen excluder, and a second queen excluder can be inserted in place of the division board. When it is desired to unite the two brood chambers, the upper hive body containing the young queen and her brood nest is placed on top of the lower brood chamber without a queen excluder between the two. The old queen need not be located and she usually disappears within a short time but may continue to be of service with the young queen for several weeks.

Best Time to Requeen. Queens can be reared at any time of the year when drones are present in queen-right colonies and climatic conditions are favorable for bees to fly and queens to mate. Colonies can be requeened

at any time of the year that the colony can be manipulated for that purpose, but it is more difficult to introduce queens or to rear them successfully when floral conditions are such that bees are inclined to rob. Queen rearing and requeening can be combined to best advantage with the making of increase and with swarm control measures in spring and early summer. Requeening in the spring or fall, while the bees are gathering nectar and pollen, usually interferes least with colony strength and hive manipulations. Queens are easier to find in early spring when colony populations are not so large, and colonies headed by young queens swarm less frequently than those having older queens. Colonies should be requeened at any time the queens show signs of failure.

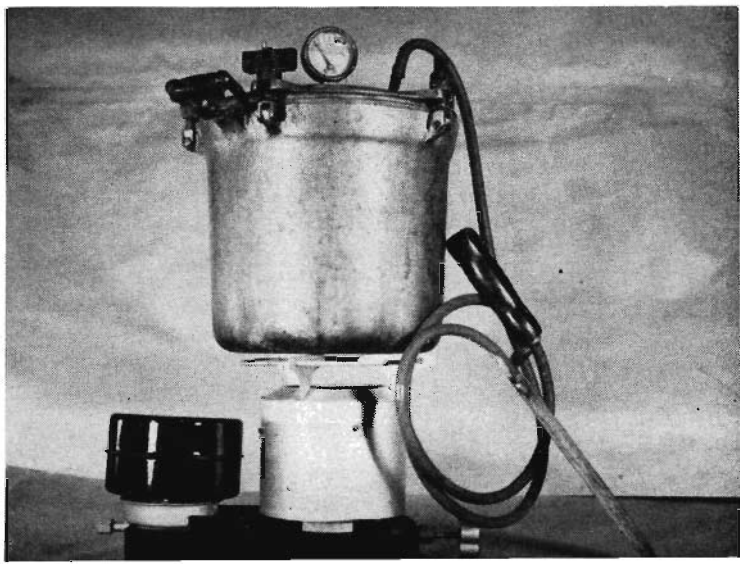
EXTRACTING HONEY

A well-equipped honey-extracting room (fig. 18) contains an extractor, a steam or electrically heated knife or an automatic uncapping machine, a table or rack to hold the combs after they are uncapped, capping equipment, sufficient honey tanks, a honey sump between the extractor and the honey pump or tanks, a washable floor, *screened doors and windows*, running water or an ample water supply, and a gastight storage space for supers of combs. Such facilities usually require a centrally located extracting plant to which the combs can be hauled. They are seldom available where honey is extracted at out-apiaries.

The extractor is a machine holding from 2 to 50 or more frames and may be operated by hand or power. The larger machines, holding more than four combs, are usually operated by an electric motor or gasoline engine. Machines which are operated mechanically should be equipped with adjustable speeds to prevent combs from being broken by excessively high speeds. Combs built in wired frames from full sheets of foundation are much more durable than combs in unwired frames. The honey is extracted by centrifugal force and is easiest to extract before it loses the warmth of the hive.

The combs are first uncapped on both sides with a sharp knife preferably heated by steam or electricity, the cappings being allowed to fall into a whirl-dry, melter, tank, or box. After the combs are uncapped, they are placed in the extractor and whirled until empty. Radial extractors remove honey from both sides of the combs at the same time, whereas the basket types must be reversed to get the honey out of both sides. To

Figure 19. A small steam outfit made from a pressure cooker and a small kerosene stove.



prevent breaking the combs, the speed of the extractor should be increased gradually so most of the honey will be extracted from one side before the top speed is reached.

A steam boiler with a suitable capacity is very useful in the honey house or extracting room as the steam can be used as a source of heat for rendering wax as well as processing honey. A small boiler heated by a kerosene or gasoline stove (fig. 19) will provide sufficient steam for the uncapping knife in a small outfit.

CLEANING THE COMBS

When the combs are extracted for the last time in the year, they may be placed on a limited number of colonies to permit the bees to clean the cells of honey. If they are stored in a fumigation room without being cleaned, the honey remaining in the cells will granulate and some of the granules will become mixed with the new honey the following year, causing it to granulate more quickly in the combs and in the honey tanks. As soon as the bees have cleaned the combs, the combs should be stored in a gastight room where they can be protected from the wax moth by fumigation.

A few beekeepers in the Territory melt their surplus combs at the close of the honey flow, increasing the amount of wax produced by the bees and eliminating the need of fumigation during the winter season. This system increases the amount of beeswax secured and is practical when the price of beeswax is high and the relative price of honey is low.

CARE OF CAPPINGS

The cappings cut from the combs contain a considerable amount of honey which should be removed before the cappings are melted, without exposing the honey to a destructive amount of heat. One of the simplest methods most commonly used by the smaller beekeepers is to uncap the combs above a box or tank and permit the cappings to fall on a screen raised above the bottom of the tank. The cappings are left to drain for 1 or 2 days and are then melted in a solar wax extractor or in a steam vat.

The Peterson Cappings Melter and the Brand Cappings Melter (see bee supply catalogs) are devices for melting cappings when they are cut from the combs. The honey and melted wax from the Peterson Cappings Melter are separated by gravity in a separator which permits the honey to run out of one compartment and the wax out of another. The Brand Cappings Melter is so constructed that honey is siphoned from the bottom of the melter and the wax runs off from a higher outlet. Both devices require some form of heat during the uncapping process, and both methods may darken the honey and affect the flavor *unless the temperature of the honey is kept well below 160°F.* Even then, some of the coloring elements in the cappings, released by the melting process, may add a certain amount of color and flavor to the honey. When properly done, however, the honey from the cappings melter can be run directly into the tanks with the other honey. This also tends to cool the honey and to raise slightly the temperature of the entire volume of honey extracted.

Another method of removing honey from the cappings is by using centrifugal force. Wire baskets to hold the cappings are placed in a radial honey extractor and the cappings whirled until a majority of the honey

has been removed. Whirl-dry honey separators are now being manufactured and sold for this purpose.

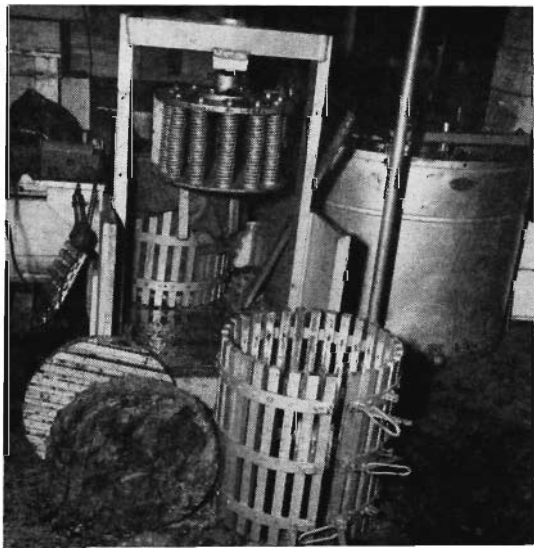
A fourth method of removing honey from the cappings is by pressure. One such device (fig. 20) resembles a cider press. This rests on a tray, catching the honey as it is pressed through burlap sacking which lines the press and prevents the cappings from coming through the crevices. Another type uses a reinforced metal tank, well-supported on the bottom to withstand pressure and lined with deeply grooved planking. Burlap sacking is draped inside over the sides and bottom of the tank and the cappings are allowed to fall from the combs into the tank. At the close of the day's operations, the burlap is folded over the top of the cappings and a heavy board is placed on top. Pressure is exerted on this board by a hydraulic jack pushing against heavy truck springs above to maintain even pressure. It is usually necessary to add additional blocks and additional pressure to press the cappings into a compact cake containing not more than 1 percent honey. The next morning the cake is removed and placed in a solar wax melter or converted by other means into commercial wax.

PRODUCTION OF BEESWAX

Beeswax is produced by the honey bee from the digestion of honey or sugar sirup. The wax is formed in eight special glands as small white disks on the under part of the abdomen. The bees form their combs from these disks. Wax production can be stimulated by feeding the bees sugar sirup or honey. The consumption of pollen plays no part in wax production. Commercial beeswax is produced by melting the combs and the cappings removed during the extracting process. Investigators have shown that bees must consume several pounds of honey to produce a pound of wax, the amount depending on the physiological condition of the bees, age of the bees, temperature conditions, and other factors. Bees secrete wax involuntarily when they are converting large quantities of nectar into honey, and it is possible that they produce wax more economically during a nectar flow.

At the close of each year's honey harvest, all drawn combs should be examined, and those which have too many drone cells should be rendered into wax. If the frames are wired, the combs can be melted from the frames in boiling water or with live steam. One method is to use a covered

Figure 20. One type of press used to remove honey from cappings. One press is in place for cappings and the second is dismantled to show the wax cake and the construction of the press. Tractor springs are fastened between two steel plates to maintain pressure of the screw above.



vat in which combs can be hung above boiling water. The combs melt and drop into the water, after which the frames can be removed and cleaned by dipping in boiling lye water. The wires may need tightening before foundation is embedded again.

Melted wax may be dipped from boiling water into molds and the comb residue, called slungum, run through a press to remove the remainder of the wax. The silken cocoons in brood combs hold the melted wax in little silken bags. To get the maximum amount of wax from melted combs, the slungum must be passed through a wax press while still at the boiling stage. The pressure on this material should be applied and released alternately, causing the melted wax to come to the surface. To do this efficiently, the press must be lined with a good grade of closely woven burlap which, when filled with the melted comb, is folded over the top of the wax before the press plate is put in place. When the wax press is deep, three or four of these "cheeses" are made with perforated press plates between each one. This adds strength to the mass and prevents the burlap from breaking under pressure.

If wax is kept melted for several hours in an insulated vat, without the application of additional heat, most of the impurities will settle to the bottom. Then, if the wax is dipped or run off into molds while still about 160°F. and allowed to cool slowly, it will congeal without cracking. The bottom and sides of metal molds should be coated lightly with a soap solution or with honey to prevent the wax from sticking. Cakes of commercial wax are usually enclosed in two thicknesses of burlap for shipment.

The amount of beeswax produced per colony can be increased by the careful saving of all burr combs cut from the frames. These scrapings should be placed in containers instead of being thrown on the ground, and transferred each day to a solar extractor. Additional wax can be produced by forcing the bees to build thicker combs, by placing only 6 or 7 combs in an 8-frame super or 8 or 9 combs in a 10-frame super. The bees will store as much honey in such combs as if the supers contained a full number of frames and will produce more beeswax if the combs are cut even with the frames when they are extracted.

Each hive which is operated for extracted honey should produce about 1 pound of beeswax for every 50 to 60 pounds of honey produced. When beeswax is relatively high in price, it may be economical to cause bees to build combs by feeding them on capping melter or low-grade honey at times when they are not producing honey of table grade.

MELTING COMBS OF GRANULATED HONEY

When honey granulates in the comb, most beekeepers melt the combs to remove the honey in marketable form. Some beekeepers uncapping the combs with a hot uncapping knife and then put the combs back on colonies for the bees to remove the honey. If these combs are dipped in clean warm water before they are given to the bees, most of the honey will be removed and restored. If the frames are not wired, they can be cut out completely and refitted with foundation before being returned to the hives.

When frames are wired and fitted with sheets of comb foundation, it may be desirable to substitute such combs of granulated honey for poorer combs in the brood chamber in the fall. The bees then use the granulated

honey during the winter and spring, after which the combs are used in the production of brood.

If wired combs of granulated honey are to be melted without cutting the wires, the frames can be placed in a metal tank or small room in which the heat can be regulated by steam or hot water circulated in pipes. If a tank is used, the heated coils can be placed on the sides of the tank. A frame covered with fine-screen wire and one or two thicknesses of cheesecloth can be placed on the bottom of the tank to hold the honey and comb until they are completely melted. A tight-fitting cover will shorten the time required for melting the combs from the frames. To prevent the honey from being darkened by excessive heat, the honey and wax can be run from the tank as soon as they are melted. They can be separated by a gravity separator as soon as they run from the tank. If a hot room is used, the frames can be suspended above trays which permit the honey and wax to run into a separator and out of the room without too much exposure to heat.

SOLAR WAX EXTRACTOR

The solar wax extractor (fig. 21, top) is a glass-covered, metal-lined box containing a screen-covered frame for holding pieces of comb or cappings beneath the glass. The heat of the sun through the glass melts the comb and permits the wax and what honey the comb might contain to run through the screen. Beekeepers frequently place clean burlap cloth or layers of cheesecloth on top of the screen to hold the pieces of comb and to strain the melted honey and wax. Many solar extractors in the Islands are so deep that the wax congeals beneath the screen. If this depth is reduced until the frame holding the pieces of comb or cappings rests on the bottom of the metal lining, and if the bottom is insulated, the honey and wax will run from the melter and can be separated in a gravity strainer in a separate glass-covered box on the outside of the melter (fig. 21, bottom).

Cappings run through a press or a whirl-dry separator may contain only about 1 percent honey. If the solar wax melter is kept clean and no brood combs are melted, the honey should be of fair quality after it leaves the melter. It is best, however, to keep such honey in separate containers.

The residue from melting combs, or cappings cut from combs in which brood has been reared previously, will remain on the cloth. This slumgum should be saved and melted at a later time. It may contain as much as 50 percent wax and so should not be thrown away. To prevent the honey from absorbing both color and off-flavors from the slumgum, the melter should be kept clean and the cloths changed and cleaned before any considerable amount of honey is run through the melter. Some beekeepers simply roll up the cloths and store them in barrels of water until the material can be boiled and pressed in a deep wax press to remove the wax. (The water prevents the slumgum from becoming infested with the wax moth.)

The glass cover on solar wax extractors must be kept clean and sealed against the wooden frame. Wire-reinforced glass is the most durable. Since bees occasionally remove the putty used in sealing the glass, strips of wood can be tacked over the putty to keep the glass air- and watertight.

A wax and honey gravity separator for the solar wax extractor can be made out of a metal tray about 5 or 6 inches wide, 12 inches long, and 5 or 6 inches deep. A baffle plate or partition is soldered across the tray

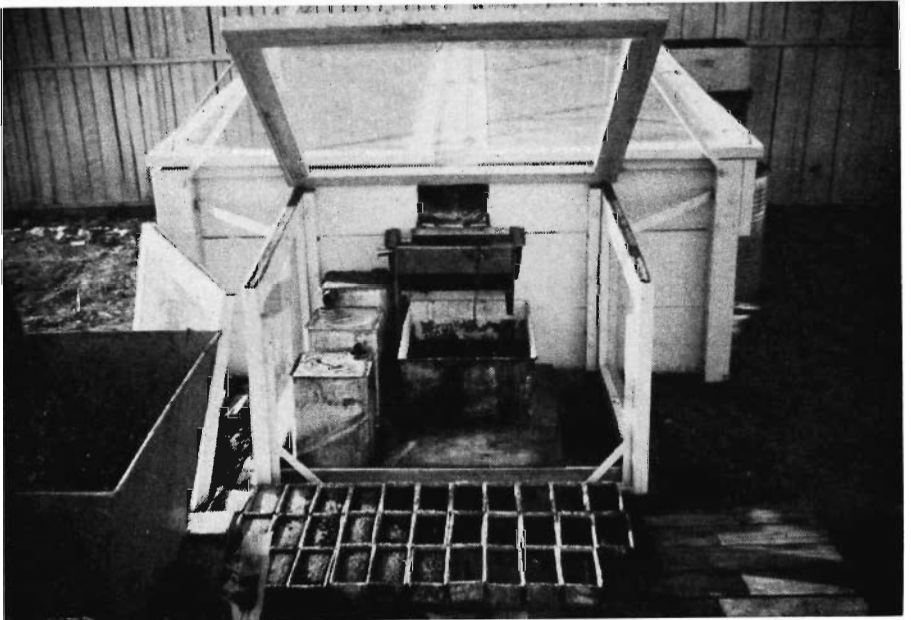
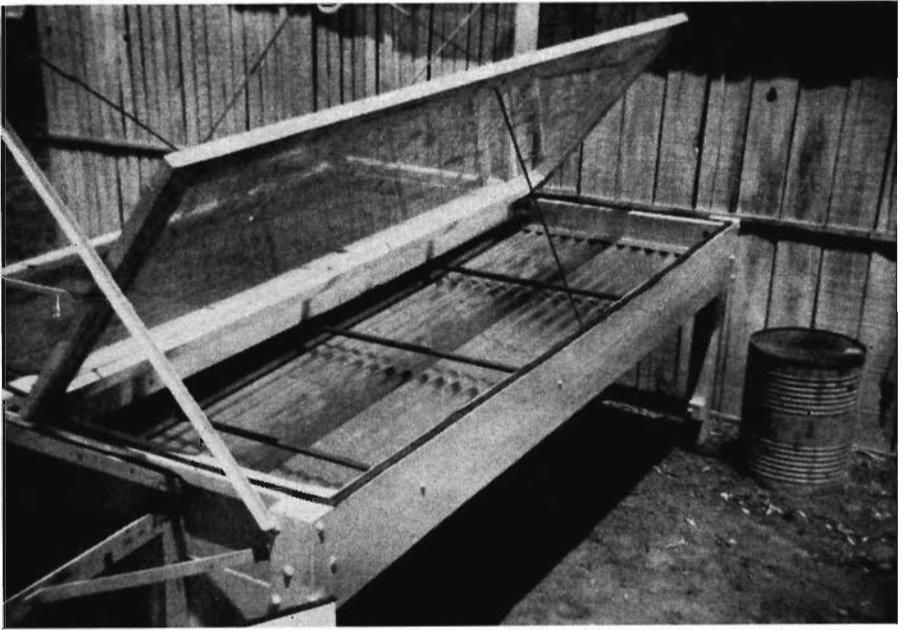


Figure 21. Top: side and top view of a solar wax melter, with the top lifted to show the construction of the melter. Corrugated aluminum is used on the bottom. This is slanted toward the center so that honey and wax run into the glass box in front. Bottom: front view of the same melter showing the honey and wax separator tin, the wax mold, and the honey tins to receive the honey. This melter is used in conjunction with a wax press which removes all but about 1 percent of the honey from the cappings before the wax is placed in the melter. The boxes in front are molds of wood into which the melted wax can be dipped.

Figure 22. A portable honey extracting outfit used in 1951 by Molokai Ranch, Ltd.



about 4 inches from one end and about $\frac{1}{2}$ inch from the bottom. The wax, being lighter than the honey, collects in one portion while the honey runs under the partition and fills the other division of the tray. Outlets for the honey and the wax should be made in their respective compartments, with the wax outlet about $\frac{1}{4}$ inch higher than the honey outlet. The wax can be run into molds and the honey into 5-gallon tins so arranged that when one tin is nearly full, the honey will run through a funnel opening cut in the side of the can into another 5-gallon container. If the honey containers are shaded, the honey cools faster and does not take on extra heat. The wax usually congeals overnight. The gravity separator should be emptied of honey and wax each morning before another run of cappings or combs is started.

PORTABLE HONEY EXTRACTORS

Many beekeepers in Hawaii maintain extracting and storage houses at each apiary site, a practice which has become costly in many cases. Changing agricultural conditions may either alter the value of the location or require the abandonment of the site. In addition, many of the super and brood combs are unwired, making it difficult to haul combs of honey to a central extracting plant without considerable breakage. The present practice is to move the honey extractor and equipment from one apiary to another and to set it up temporarily for each extraction.

A more efficient method is to use a portable extracting outfit, fully equipped with all essential equipment permanently mounted in a dust-proof trailer which can be hauled from one apiary to another as needed. An outfit of this type is illustrated in figure 22. The sides and doors are fully screened but can be closed and buttoned tight while not in use or while being hauled from one apiary to another. This outfit contains an eight-frame extractor run by a gasoline motor, a steam generator heated by butane, a cappings press for pressing honey out of the cappings at the end of each day's operations, an automatic uncapping knife, an attachment for a steam-heated hand uncapping knife, a table to hold the combs for the extractor, a water-jacketed honey sump, a honey pump, and sufficient room for the temporary storage of honey supers. The honey runs from the extractor into the sump under a baffle plate and then is pumped by the motor into a tank which can be mounted on the truck used to haul the trailer. Supers are passed into or out of the trailer through a sliding door on either side or through the screened door at the back. Steam can be generated and the whole outfit made ready for operation within a few minutes.

The use of such an outfit requires a road through the apiary so the trailer can be hauled readily into place. With proper care, an outfit of this type will last for years.

In California, a crew of four men working together has extracted 100 60-pound tins of honey a day with the portable extracting equipment which can also be operated by a 2- or 3-man crew. The honey and cappings are hauled back to the central warehouse each night, the honey transferred to storage tanks, and the cappings pressed and placed in the solar wax extractor. The centralization of the honey and wax processing promotes greater efficiency. The floor of the trailer must be scrubbed and cleaned after each day's operation and the pump and honey lines cleaned to prevent the accumulation of granulated honey in the system.

The outfit pictured in figure 22 was operated by the Molokai Ranch apiaries in 1951, and some changes had to be made to prevent the clogging of honey lines, honey sump, and cappings press with granulated honey. Alterations can make this outfit operate smoothly under most conditions found in various portions of the Islands. Improvement in roads and the use of wired combs may make the central extracting plant as feasible as in most portions of the Mainland.

DISEASES AFFECTING HONEY BEES

The honey bee is subject to certain diseases which, if not recognized and controlled, can be a threat to the survival of the colony. Some of these diseases affect the brood of bees while others attack the adults. Those which affect the brood are hidden within the hive, necessitating a periodic inspection of the brood combs to recognize their presence. Every beekeeper must become familiar with the symptoms of the diseases affecting bees and also must inspect the brood combs of each colony at least twice a year to keep any disease from being spread to other colonies. (See fig. 23.)

Brood diseases are specific in character and can be distinguished from each other by their gross or microscopic symptoms. There are three principal types of brood diseases—American foulbrood, European foulbrood, and sacbrood. A fourth brood disease, known as para foulbrood, is present to a limited extent in some of the southeastern states on the Mainland.



Figure 23. One hive is all that remains of a once-flourishing beekeeping location ruined by American foulbrood and neglect.

American foulbrood and sacbrood may be present in colonies in different parts of Hawaii, and it seems probable that European foulbrood also may be a possible source of trouble at some future date.

American Foulbrood. This disease has been found recently on all the Hawaiian Islands except Niihau and Lanai and should be considered an ever-present threat to the welfare of the beekeeping industry throughout the Territory. It is caused by a spore-forming bacterium, *Bacillus larvae*, which attacks the larva at an early stage but seldom kills it until after the cell is sealed and the larva is extended on the lower side of the cell. The first symptom seen by the beekeeper is one or more cells with sunken, perforated, and greasy-looking cappings (fig. 24). Such cappings are later removed by the bees and reveal the dead larva, or sometimes the pupa, in various degrees of decay. An infected larva turns a light brown soon after it dies and loses its plumpness, gradually flattening out on the lower side of the cell. The color then progresses through dark brown to black. If the cell contents are stirred with a toothpick or match stem when the remains have reached the dark-brown stage, the contents are seen to be quite viscous and string out 1 to 4 inches as the piece is slowly withdrawn. The odor is foul, similar to that of heated glue. The final scale adheres tightly to the cell wall. Sometimes the tongue of the dead pupa will extend upward across the cell opening (fig. 25). The disease attacks worker brood primarily, rarely the drone and queen larvae.

American foulbrood spores can survive in honey for an indefinite period and the disease is spread primarily by bees robbing honey from diseased combs and by the interchange of used equipment between hives. Its spread has never been traced to foundation made from wax secured by melting diseased combs.

Control. The most practical method of controlling American foulbrood is to kill the diseased colony with calcium cyanide (Cyanogas) and then to burn the bees, combs, and frames in a deep hole, covering the ashes with at least 18 inches of soil. The bottom, hive bodies, and top can be scraped clean of propolis and burr comb and then scrubbed with a stiff brush and water. Some beekeepers flame the inside of the hive, but this is not necessary if the inside portions are scraped and washed clean.

When several colonies of bees are involved and an efficient method of boiling and pressing the combs is available, control can consist of destroying the bees, melting all the combs, and sterilizing the frames by boiling them in lye water. This method conserves the wax and frames but should not be employed unless the work is done inside a double-screened wax room to prevent bees from getting to the combs before they are converted into wax. The water and honey used in the melting process should be run into a cesspool and kept from the bees.

Some colonies on Molokai, and possibly on some of the other islands as well, have developed immunity or partial immunity to American foulbrood. An attempt is being made to increase this immunity, or resistant factor, by the selection and inbreeding of desirable strains. The bees will have a better chance to develop this resistance naturally, however, *if susceptible strains are not brought in from outside sources*. It would seem desirable, therefore, for the beekeepers in the Territory of Hawaii to cooperate in a breeding program to improve the better strains of bees and to incorporate resistance to American foulbrood.

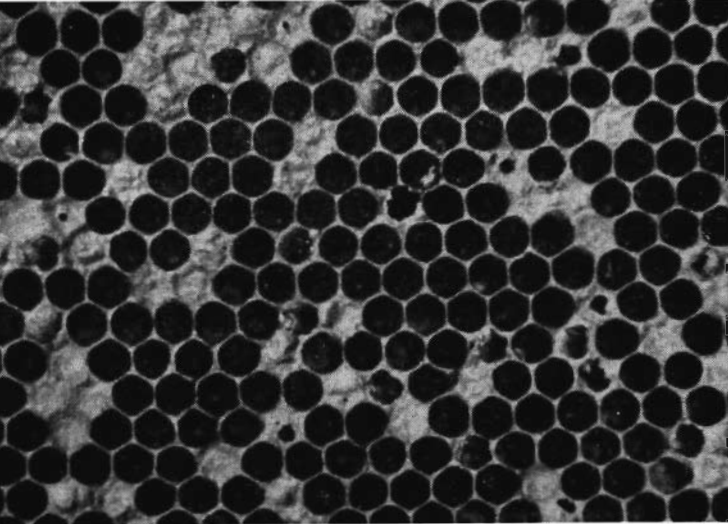


Figure 24. A section of comb of diseased brood, showing sunken cappings and irregular perforations of the caps.

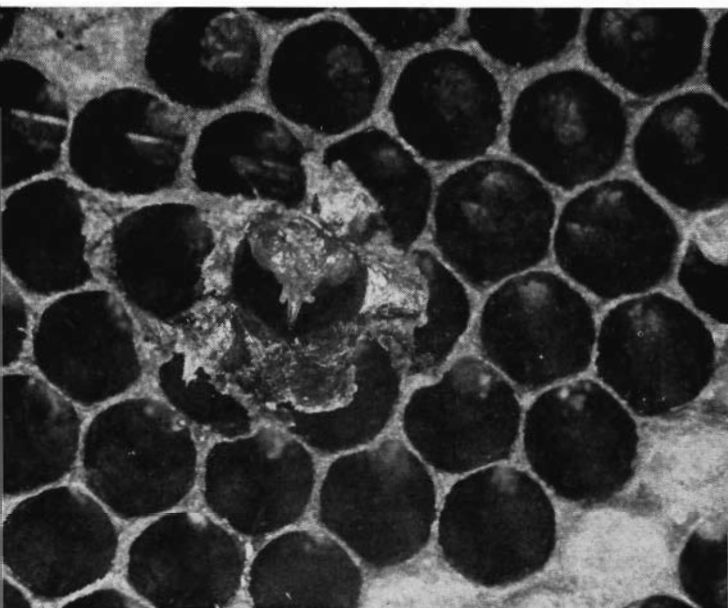


Figure 25. Pupa killed by American foulbrood.

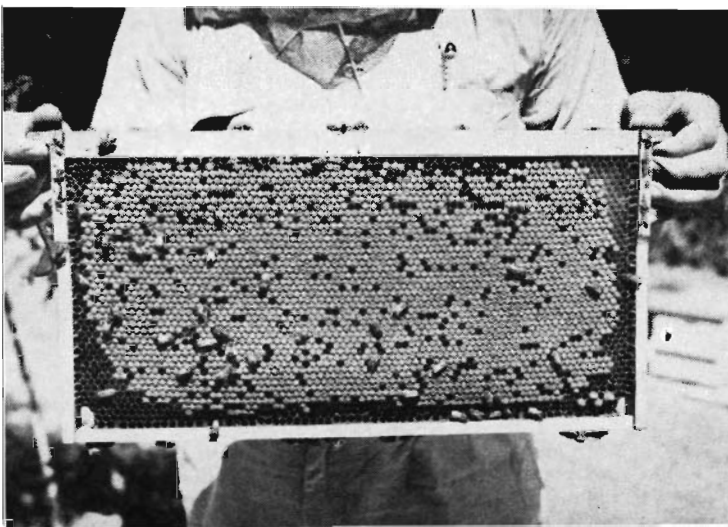


Figure 26. Many open cells among sealed brood often point to disease, but in this comb the cause was a poor queen with a lack of vitality in her brood.

The present evidence of resistance in the strains examined, while encouraging to the queen breeder, is not sufficient to permit any neglect in making periodic inspections of each colony for the presence of brood diseases. These inspections can be made in early spring and late summer when colonies are examined for the condition of the queen, combs, and stores.

Sulfathiazole and Its Relation to American Foulbrood. For a number of years beekeepers have been experimenting with the use of sulfathiazole in the treatment of colonies infected with American foulbrood, with varying degrees of success. When sulfathiazole is present in the food fed by nurse bees to bee larvae, it apparently inhibits the development of *Bacillus larvae* and thus prevents the occurrence of the disease. The difficulty lies in feeding the bees sufficient sulfathiazole sirup *at the right time* to either prevent or control the disease without contaminating the honey which may later be extracted from its combs. It is also impossible to blend sulfathiazole with the bee food in the brood chamber without first extracting all the honey from every comb in the hive and then diluting it, adding $\frac{1}{2}$ gram of sulfathiazole to the gallon of sirup, and feeding the medicated sirup back to the bees.

The labor involved in treating colonies with sulfathiazole and in caring for the colony during a quarantine period of one season may be greater than the cost of replacing a diseased colony. Unless sulfathiazole is used properly and efficiently, it may cause beekeepers to become careless with American foulbrood and thus cause its spread to other colonies.

Colonies cannot be fed sulfathiazole sirup during or immediately before a nectar flow as the bees will mix the sirup with incoming nectar and thus adulterate any honey produced.

For these reasons, the use of sulfathiazole is not recommended for general use, and most beekeepers are of the opinion that it is best to destroy all diseased colonies and their combs as soon as the disease is discovered, thereby leaving no doubt about the eradication of the disease.

European Foulbrood. This form of brood disease usually attacks and kills the larvae while they are still coiled in the bottom of their cells. In a small percentage of cases, some of the infected larvae do not die until they are extended in their cells and are sealed over, as in American foulbrood. One must examine various symptoms of the dead larvae in such cases to distinguish between the two diseases.

European foulbrood appears to be caused by a mixed infection or by one of several different organisms rather than by a single bacterium. At least five organisms have been associated with this disease by various investigators, and for this reason the symptoms are more variable than in American foulbrood. For example, when the diseased larvae are extended in the bottom of their cells, the larval contents are not as viscous and will not string out as far as with larvae dead of American foulbrood. The odor is also less pronounced but the color is somewhat the same in the later stages. The segmentation of the larva usually is distinct and the scale is removable with ease.

Control. When European foulbrood is present in an area, it usually becomes evident in the spring during a dearth of nectar but may continue during dearth periods later in the year. It may be present in a few colonies in an apiary or may occur in epidemic form in many apiaries in the same general area. The disease usually disappears with the beginning of the

nectar flow, unless the colony is badly infected and greatly weakened. Purebred strains of bees appear to be more resistant to European foulbrood than are hybrid strains, although selection and breeding for resistance offset this apparent difference.

Strengthening the diseased colony by the addition of emerging brood from uninfected colonies, dequeening for a period of from 5 to 10 days to permit a break in the brood cycle and to give the bees a chance to clean out their dead, and requeening with purebred strains of resistant bees are the methods most commonly used to combat this disease. The combs containing diseased brood need not be destroyed but may be placed on strong colonies to be cleaned out during a honey flow.

Sacbrood. This brood disease is caused by a filterable virus which kills the larvae while they are extended in their cells just before the pupa stage. For this reason, the cells are usually sealed and then cut open irregularly or the cappings removed entirely before its presence can be determined. The dead larvae are never brown, as with the foulbroods, but are more of a grayish black. The tip or head end of the dead larva turns black first and sticks across the opened part of the cell. The skin of the dead larva remains intact, and, if the larva is removed carefully from its cell, the body contents are watery and flow to the lower end, causing the remains to resemble a small sack of water.

This disease seldom kills more than a small percentage of the brood, and some cells of sacbrood may be found in most colonies at some time during the year. In some cases, however, it may kill as much as 25 percent of the brood.

Control. This disease needs no radical control measures, and, when it does occur in substantial quantities, requeening with a young, vigorous queen is all that is necessary. One should never choose a colony as a breeder which has any cells of sacbrood and should not permit such a colony to rear its own queen. A comparison of the symptoms of these diseases is given in table 4.

Chilled, Starved, or Poisoned Brood. The brood of bees is subject to such injuries as chilling, starving, and chemical poisoning. Sometimes the symptoms of these injuries are confused with those of bee diseases. In all such situations large quantities of the young brood will be killed at the same time, so the symptoms need not be mistaken for those of the various diseases.

Drone Brood in Worker Cells. When colonies are hopelessly queenless, a number of worker bees will assume the egg-laying habit in an attempt to prolong the life of the colony. Many of the larvae which hatch from these eggs will die and should not be mistaken for those killed by disease.

Scattered, open cells may also be due to a faulty queen (fig. 26).

DISEASES OF ADULT BEES

It is not at all unusual to find a collection of dead bees in front of one or more colonies in a large apiary at some time during the year. In some instances an abnormal death rate may be traced to a killing-off of the drones, a bad case of robbing, or starvation. There are only two specific causes of the untimely death of adult bees which are common to the United States; one is caused by what is known as paralysis and the other by an internal protozoan parasite, *Nosema apis*. The Isle of Wight disease, com-

Table 4. Summary of symptoms of brood diseases of bees.*

Symptom	American foulbrood	European foulbrood	Para foulbrood	Sacbrood
Causative organism	<i>Bacillus larvae</i>	<i>Bacillus pluton</i>	<i>Bacillus para-alvei</i>	Filterable virus
Age of larvae attacked	Usually die after cell is capped	Usually die while coiled in the cell, before cell is capped	Mostly unsealed, but more in sealed cells than with European foulbrood	Usually die after capping of cell
Appearance of brood combs	Cappings become sunken and perforated. Dead brood in capped or perforated cells, or in cells uncapped by bees	Brood becomes spotted; many open cells with yellowish to dull-gray larvae. Few cell cappings may be perforated	Resembles combs with European foulbrood, although more sealed cells affected	Slightly irregular; ordinarily only few cells affected. Dead mostly in perforated or uncapped cells
Position of infected form in cell	Sticks to lower side and bottom of cell, stretched lengthwise in cell	Various positions; may be on side or bottom near opening of cell	Usually irregular, as in European foulbrood, or may be fully extended	Stretched lengthwise of cell, head prominently raised
Color of infected forms	Light brown to coffee brown; finally become dark brown to almost black	Yellowish white; finally change to brown or black	Reddish brown to dark brown. Scales in unsealed cells lighter in color	Grayish to straw yellow, becoming grayish black to black; head end usually black
Odor	Typical glue-pot odor, especially in ropy stage	Sour like that of decayed meat; not always in evidence	Slight in unsealed cells but very putrid in sealed cells	Slightly sour
Cuticle	Becomes soft and loses form	Remains entire, but becomes translucent with tracheae showing through	Becomes soft and may be translucent	Remains entire and tough while contents are watery.
Consistency	Sticky, roping out 2 to 4 inches in viscid stage	Unsealed larvae watery or pasty, seldom sticky; occasional sealed larvae may rope slightly	Dead larvae often become soft and watery. Sealed dead may be ropy	Does not adhere to cell. Watery to granular; never ropy
Pupae	Sometimes affected so the tongue sticks up across the opening of the cell, a sure sign of the disease	Rarely affected	An occasional pupa is killed, but not as many as in American foulbrood	Seldom affected
Characteristics of the scales	Dark brown in color. Adhere tightly to cell wall; cannot be removed easily by the bees. Brittle	Segmentation and tracheae often visible. Dark brown to black, easily removed on drying. Tough and rubbery	Easily removed from the cells. Segmentation and tracheae sometimes visible	Tough, brittle, easily removed. Head end remains prominently tilted upward
Sex of larvae attacked	Usually only worker brood; rarely drone and queen larvae	All sexes	Generally worker and drone	Mostly worker; occasionally drone brood

*Courtesy University of California, Berkeley, California.

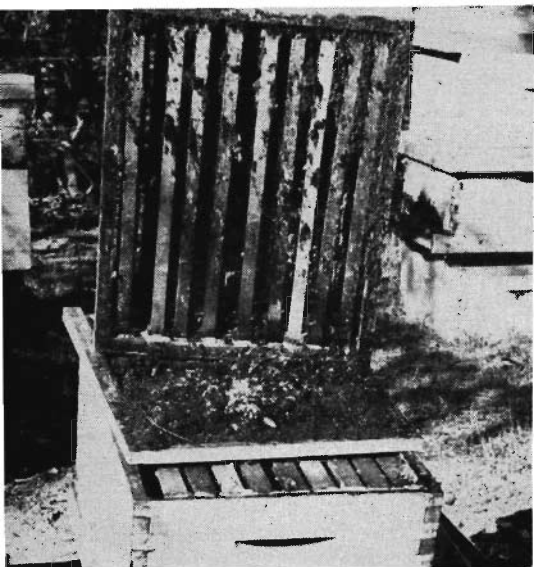


Figure 27. Combs riddled and destroyed by the wax moth as a result of American foulbrood and neglect.

mon to parts of Europe, is not known to be present in Hawaii or in other parts of the United States.

Paralysis. Bees affected with paralysis usually lose their hair, become greasy looking, have swollen abdomens and cloudy wings, and lose the power of sustained flight. The affected bees tremble and shake at intervals and fall over on their backs. Numbers of sick, dying, and dead bees collect in front of the hive unless they are removed by birds, ants, or toads.

No positive cause or cure for this disease is known. If a diseased colony is given sealed brood from healthy colonies and then requeened with a young and vigorous queen, it will improve in strength, and the number of affected bees will decrease. Many of the sick bees in a colony are eliminated if dusting sulfur is shaken liberally over the tops of the frames, shoulders of the hives, frame rests, and on the entrance.

Nosema Disease. This disease is caused by a small parasite which develops in the lining of the midgut of the bee and tends to shorten its life by days or weeks. It is usually most serious during the spring months and gradually disappears with warm weather. It is present in portions of the Mainland and is probably widespread throughout the Territory, being more serious in some places than in others. It has never been serious in California.

Badly infected bees usually are found in numbers in front of the hives, trembling and crawling aimlessly, probably unable to fly, and with many of the symptoms described for paralysis. This disease may affect a few or a majority of the colonies in an apiary.

If the affected bees are pulled apart, the midgut frequently is swollen with accumulated material and is usually dull grayish in color. The tissues are softer and more easily crushed than in healthy bees.

There is no known cure for this disease. Some colonies seem to be more susceptible than others, so a change in the strain of bees may be helpful. Colonies can be strengthened by the addition of brood from stronger colonies to protect the combs of a badly infected colony from the ravages of the wax moth. Fresh running water can be provided for the bees, and stagnant pools of water can be filled in. The best care of colonies in the fall of the year, in preparation for wintering, should offset some of the serious effects of this disease.

ENEMIES OF BEES

Honey bee colonies are subject to the depredations of wax moths, ants, toads, and a variety of wasps, spiders, dragonflies, lizards, and other predators. Wax moths, ants, and toads cause the greatest economic loss in Hawaii.

Wax Moths. Both types of the wax moth occur in the Territory, but the greater wax moth, *Galleria mellonella* (L.), is of far greater importance than the lesser wax moth, *Achroia grisella* (F.). The larval forms of the greater wax moth burrow through the cells, consuming the wax, pollen, and waste products and constructing silken tunnels as they work. The larvae of the lesser wax moth construct smaller tunnels and confine their feeding and webbing more nearly to the surface of the combs.

Each adult female of the greater wax moth lays nearly 300 eggs in cracks and crevices of the hive or on the combs. She usually works late in the afternoon or after dark. The eggs hatch in 5 days or more, depending on temperature conditions. The larvae are ravenous feeders and can reduce a set of combs to a mass of webs and waste products (fig. 27) in a matter of days, depending on the number of larvae and the temperature. The fully grown larvae spin their tough cocoons in the partially destroyed comb or migrate to the walls of the hive or to the frame parts, where they gnaw out a shallow groove in the wood and spin a cocoon in which they pupate.

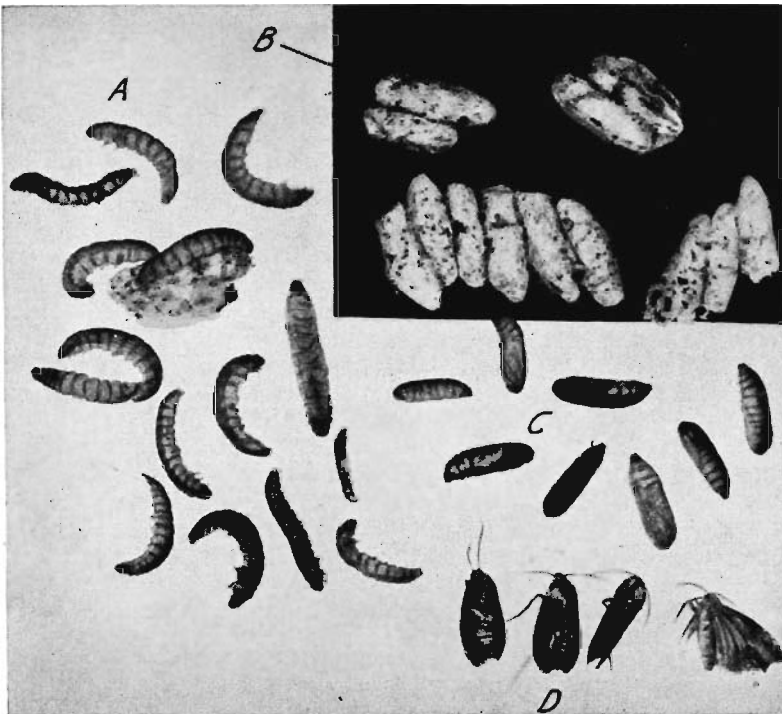


Figure 28. Greater Wax Moth. A, Larvae; B, pupal cases; C, pupae; D, adults. (Courtesy University of California College of Agriculture.)

The length of the life cycle of these moths depends on the quantity and quality of the food they eat and the temperature at which they develop. There are several generations a year during the warmer seasons, with development continuing more slowly during fall and winter temperatures. Under cold conditions, this insect winters in the late larval or pupal stage (fig. 28).

When wax moths are numerous in an apiary, a few of their larvae can be found in practically every hive; but strong colonies police their combs and keep the destruction down to a minimum. However, the moth larvae may get such a strong start in unprotected combs of a weak colony as to destroy a majority of the combs in a relatively short time. Since the temperature conditions in the Islands are generally favorable for the development of the wax moth throughout the year, it is desirable to restrict the number of combs in each hive to those the bees can protect.

Drawn combs can be protected from the wax moth by keeping them on colonies so strong that the bees destroy the wax larvae before damage results. Wax moth larvae will destroy brood combs and those containing pollen before they will attack new honey combs. When combs are stored away from the bees, they should be fumigated to kill the eggs and larvae. The combs should be stored in gastight rooms or in stacks and fumigated as soon as they are taken from the bees and again at intervals during the storage period.

The type of fumigant used depends on how the combs are stored. In a gastight room, sulfur fumes, methyl bromide, and calcium cyanide can be used. Of these three chemicals, methyl bromide and cyanide are deadly poison to man and should be handled with great care. Only methyl bromide gas kills the eggs of the wax moth in one fumigation; all other fumigants have to be used twice or more, at short intervals after the first application, to kill the larvae which hatch from eggs already laid on the combs. Powdered sulfur is the safest fumigant and can be burned safely if the firepot is set in a larger vessel containing water or sand.

When supers are stacked in piles and made airtight by pasting strips of paper around the cracks between the hive bodies, the combs can be fumigated by placing 2 or 3 tablespoons of PDB (paradichlorobenzene, or Paracide) on pieces of paper placed on the frames between every other hive body. Carbon disulfide can also be poured into a pan placed in an empty super on top of the stack. The gas is heavier than air and will sink to the bottom of the stack. This gas is highly explosive when brought in contact with air and a flame; therefore, the beekeeper should not light a cigaret or smoke while handling this fumigant. The combs may have to be fumigated at intervals during the fall and winter and more frequently during warmer portions of the year, to prevent wax-moth reinfestation.

Protection against Ants. Ants are particularly destructive to bees because they disturb and kill the adults and carry away their stores and brood. *Pheidole megacephala* (Fabr.), or the big-headed ant, is the most widely distributed of the various ants which attack bees. The Argentine ant, *Iridomyrmex humilis* Mayr, is less common but even more injurious when it occurs in great numbers, often where army camps were situated during World War II. It is highly probable that they will spread gradually and develop into a major pest of both man and bees.

As a protection against ants, hives should be placed on stands treated with grease (fig. 29). An even more effective barrier results when chlordane

Figure 29. An apiary on Lanai protected from ants. The ground was raked and the stands greased.



is mixed with the grease. This barrier must be replaced at intervals, most frequently in areas where the Argentine ant is numerous. Ants can be controlled also by the use of poison baits, fumigants, and contact insecticides. Bees which normally die in an apiary furnish a large amount of food for ants and the beekeeper should watch constantly as ants will bridge the barriers or take advantage of leaves, dirt, or grass to gain access to the hives.

Thallium sulfate ant sirup is one of the better poisoned baits for both the big-headed ant and the Argentine ant. Place such poisons in containers where bees, children, and pets cannot reach them. The bait tins, to be most effective, should be placed about 10 feet apart throughout the apiary. Change the poisons as often as they are depleted or become unattractive to ants. It also is helpful to change the positions of the tins every week in order to attract ants from other nests.

Many beekeepers attempt to eradicate the ants in an area before placing the hives on their locations. The ground should be raked clean of debris and then sprayed with a 5 percent solution of chlordane in oil or with a suspension of the wettable powder in water. If this is done 10 days to 2 weeks before the hives are placed on their stands, the bees should not be affected by the chlordane and the numbers of ants should be greatly reduced. A water suspension of chlordane can be applied to the ground while the bees are on the location if the hive entrances are a foot or so above the ground.

Toads. When apiaries are located near places where the toad, *Bufo marinus* L., is able to multiply, such as streams or moist places, the colonies are weakened by toads eating great numbers of bees. In some cases, hundreds of toads may be seen in or around an apiary. The hives should be placed on stands higher than the toads can jump, between 18 and 24 inches high, and precautions taken to reduce the number of toads or to fence them out of the apiary.

Termites. The two forms of termites, the dry-wood and the soil-infesting forms, tunnel into various parts of the hive, including the bottoms, tops, hive bodies, and frames. Soil-infesting termites can be kept from the hives by maintaining a barrier between the ground and the hives, but no serviceable method has been found to prevent injury from the dry-wood form. Termites do less damage to redwood, but when this is used the hives are subject to injury from the boring activities of carpenter bees.

Other Enemies. The Mediterranean flour moth, *Ephestia kuhniella* Zell., and the Indian meal moth, *Plodia interpunctella* (Hbn.), sometimes destroy

the pollen in cells of stored combs, but they confine their work to individual cells and do not destroy the wax.

Rats and mice are very destructive to combs not protected by bees and may even invade hives during the fall and winter periods. Stored combs should be protected from their depredations.

GRADING AND PROCESSING OF HONEY

Honey may be defined as the sweet, viscid secretion of the nectaries of plants, elaborated by bees, and stored in their combs for food. It is a carbohydrate food consisting primarily of a solution of the invert sugars—dextrose and levulose. Its moisture content depends on the temperature and humidity of the atmosphere, the degree of ripening at the time it is extracted from the comb, and subsequent changes which take place in the extracting, storage, and processing for market, but generally averages 20 percent or less. Honey also contains a small quantity of sucrose (seldom more than 8 percent), many essential minerals, enzymes, vitamins, aromatic oils, plant pigments, acids, and other components.

The chemical and physical properties of honey depend chiefly on its floral source but are also influenced by such factors as climate, soil, altitude, method of production, and preparation for market. While the honey bee works on one major source at a time, it may gather nectar from two or more sources before the honey is extracted or removed by the beekeeper, thus producing a blend.

Honey is always stored as a liquid, but crystallization or granulation may take place over a period of time. honeys which have a high levulose content in relation to the amount of dextrose present tend to granulate much more slowly than those in which the ratio between the two sugars is closer. Algaroba, or kiawe, honey is relatively high in dextrose, which causes it to granulate within a few weeks after it is stored in the comb.

Many prefer to eat honey in the finely granulated state, and "creamed" honey is finding an increasing demand in the retail market. Creamed honey is produced by adding, or "seeding," liquid honey with finely granulated honey and mixing them together thoroughly in the ratio of about 1 part of finely granulated honey to 10 or 12 parts liquid honey. The mixture is then stored in a cool place (around 57°F.) for a few days to hasten a uniform set of the crystals before they can separate.

Comb honey is produced and sold as section-comb, cut-comb, and bulk-comb honey, depending on whether it is produced in wooden sections, is cut from the frames and wrapped, or is packed in glass or tin with extracted honey around the comb. When comb honey is cut and wrapped, the cut combs are allowed to drain or the pieces are whirled in an extractor to remove the honey from the cut cells along the edges.

Honey will run slowly through fine mesh strainers when it is cool, but will strain freely when heated to 120°F. or above. Honey processed for the retail trade is usually heated to 160°F. for a short time and then allowed to cool to 135°F. before it is bottled. This heat treatment liquefies any crystals which may be present, kills all yeasts and prevents fermentation, and keeps the honey from granulating for some weeks or months. It also permits the honey to clarify, as a majority of the bubbles, incorporated during the extracting and handling processes, will rise to the surface faster in warm honey.

Honeys from different floral sources vary in degree of color change when they are heated to facilitate clarification, straining, or blending in preparation for the retail market. The speed of granulation of various honeys also differs with the floral sources, the moisture content, and the manner in which the honey is handled during the bottling process. To test the effect of heat on color change and on granulation of kiawe honey, a sample that graded 1.9 or white on the Pfund Grader and contained 17 percent moisture was poured into 12 2-ounce screw-capped vials and placed in an electric oven at 160°F. It took approximately 2 hours for the honey to reach the temperature of the oven, after which two jars were removed every 4 hours. One set of six jars was opened after the jars had cooled and was graded for color on the Pfund Color Grader, the honey replaced, and the vials capped. The other set of vials was left sealed. The individual jars which were exposed to 160°F. for 2, 6, 10, 14, 18, and 22 hours, changed in color from 1.9, to 2.1, 2.3, 2.3, 2.3, and 2.6, respectively. (The limits of the white and extra-light amber colors on the Pfund Grader are for white, 1.7 to 3.3, and extra-light amber, 3.3 to 4.8.) The honey was heated on February 20, 1951, and a few crystals had formed in all the jars that had been opened by March 12, 1951, regardless of the length of time heated. A few crystals appeared on May 11, 1951, in the 2-, 6-, and 10-hour sealed jars but the 14-, 18-, and 22-hour sealed jars were still liquid on January 7, 1952, or 11 months after being heated.

Kiawe honey, therefore, seems to be a rather stable honey when heated to 160°F. up to 18 hours, providing it is cooled quickly thereafter. The factor of granulation, however, does not seem to be linked directly with the degree of heat applied, but may be affected by air bubbles incorporated during the bottling process. Honey bottled hot forms a vacuum in the jar when the honey cools and this aids in clearing the honey of fine bubbles.

Honey will retain heat for a long time if stored in large tanks after being heated or if placed in 60-pound tins stacked closely together. All honeys turn dark in color over a period of years even at room temperatures until, after about 5 years, most white honeys will be light amber or amber in color. To prevent undue discoloration of honey through the application of heat, honey should be heated only indirectly or in jacketed tanks, and the heat applied should be approximately that to which the honey itself is to be heated. Mechanically stirring honey while it is being heated distributes the heat and prevents a portion of the honey from being overheated.

Honey Grades. The present specifications (which are subject to change) from the Production and Marketing Administration of the United States Department of Agriculture, divide honeys into four grades: U.S. Grade A or Fancy, U.S. Grade B or Choice, U.S. Grade C or Standard, and U.S. Grade D or Substandard. These proposed grades are based on a system of evaluating flavor at 50 points or less, absence of defects at 40 points or less, and clarity at 10 points or less. Since there is no exact measure of flavor between judges, the proposed grading standards should be changed to meet the variety of conditions under which honey is produced and packed and to differentiate between definite floral sources and blends. The specific differences between the grades should be secured directly from the nearest office of the U.S.D.A.

At present, to qualify as U.S. Grade A, or Fancy, a honey must contain

not less than 81.4 percent soluble solids (with a refractive index of 1.4900, a specific gravity of 1.4129, and a moisture content of not more than 18.6 percent) and must possess a good flavor, be free from defects, be at least reasonably clear, and score not less than 90 points when scored on the above values.

U.S. Grade B, or Choice, contains not less than 81.4 percent soluble solids, possesses a reasonably good flavor, is reasonably free from defects, is at least reasonably clear, and scores not less than 80 points under the above values.

U.S. Grade C, or Standard, is honey for reprocessing that contains not less than 80 percent soluble solids (with a moisture content of not more than 20 percent), possesses a fairly good flavor, is fairly free from defects, and is clear enough to score not less than 70 points under the above values.

U.S. Grade D, or Substandard, fails to meet the requirements of U.S. Grade C, or Standard.

The soluble solids in honey may be determined directly from readings on a refractometer or from the refractive index and then referring to tables which give the specific gravity and moisture content for each index reading.

Good flavor is defined as "a good, characteristic honey flavor and aroma. Such honey is free from caramelized or objectionable flavor, including but not limited to flavors caused by fermentation, smoke, or chemicals."

Absence of defects refers to the degrees of cleanliness and of freedom from particles of comb, propolis, or other defects which may be suspended or deposited as sediment in the container.

Clarity is a term used in reference to the degree of freedom from air bubbles, pollen grains, or fine particles of any material which may be suspended in the product.

PROCESSING HONEY FOR WHOLESALE TRADE

Honey as it comes from the extractor contains bits of comb, air, and possibly other foreign particles incorporated in the extracting process. These should be removed before the honey is put up for the wholesale trade in either 5-gallon tins or in steel barrels. Kiawe honey may also contain some crystals of granulated honey which tend to hasten the granulation of the liquid honey. To command the highest price, honey should be brought up to U.S. Grade B standards before it is placed in wholesale containers.

The simplest way to remove most of the air bubbles and coarser particles of wax from liquid honey is to leave the honey in a tank for several days after it comes from the extractor. Most of the coarser particles of wax can be removed from the honey if it is allowed to run through a sump before it is pumped, pushed by compressed air, or otherwise transferred into the tanks. If the sump is water-jacketed so the temperature of the honey is raised to 120°F., the honey can be strained through a fine-mesh nylon or wire cloth to remove the rest of the foreign material as it enters the tank. Most honey processors prefer to have honey unheated and to process it themselves for their retail trade.

A honey sump can be made from a rectangular tank by fastening one or more partitions or baffles across the tank about $\frac{1}{2}$ inch above the bottom so the honey runs under the baffles. Since wax is lighter than honey in weight, any particles of comb in the honey will rise to the surface between

the partitions and can be removed by skimming. The level of the honey in the sump is determined by the height of the honey outlet. The partitions can be either solid or of course to fine screen wire. Honey sumps should be drained each night and kept free of crystals if kiawe honey is being extracted from combs which may contain some partially granulated honey.

Air is incorporated in honey during the extracting process and also when honey is allowed to fall some distance into a tank. A pump that leaks, or is pulling air and a partial load of honey, also will mix air with the honey. Therefore, it is desirable to allow honey to run down a pipe or trough when transferring it from one receptacle to another. Honey pumps should be used only when they can be run full of honey.

Thin honey rises to the surface of the honey tank, and honey drawn from the bottom of a tank usually contains less moisture than that drawn off last. Honey is usually permitted to stand in tanks for several days until some of the excess moisture evaporates and the honey is clarified of bubbles and particles of wax. This process is feasible only when the atmosphere is dry enough to absorb the moisture. In a humid atmosphere, honey exposed in this manner may absorb additional moisture unless it is heated to drive off the excess water as vapor. Heating must be done carefully not to injure the color or flavor. Honeys which granulate soon after they are extracted cannot be left in unheated tanks for more than a few days without danger of having the entire tank of honey granulate solid. It is desirable, therefore, to equip tanks with steam coils to heat the honey or to liquefy it in case it granulates. Sometimes the heating units, such as steam coils, are placed under the tanks instead of inside.

MARKETING OF HONEY

Honey is marketed wholesale in 5-gallon tins or, to a lesser extent, in steel drums or barrels. When the 5-gallon tins are shipped by freight, they must be encased in wooden or protective fiber cases or cartons. Both cases and cartons must be strapped or wired when shipped by boat. When honey is prepared for the wholesale market, it should remain in tanks to clarify long enough to remove a majority of the bubbles and particles of comb introduced during the extracting process. As stated previously, most honey processors prefer to have the honey unheated.

When honey is sold in retail packages, it should be heated and strained as previously described, and properly labeled. When honey is labeled as to its floral source, or sold under a trade name, it should be as uniform as possible in all physical properties. The labels should contain the name of the packer, the U.S. Grade, and net weight of the honey. If the floral source is mentioned, it should be true to that floral source or should at least have its predominating flavor.

The baking industry uses a considerable amount of honey in bread, cracker, and cake mixes to impart sweetness and delicate flavors and to improve the keeping qualities of the finished product. The darker colors and stronger flavors can be used in some baked goods, although the milder flavored and table grades of honey are also used, especially in the lighter colored products. The baker requires honey that is processed for his trade; it should be of Grade B quality, free or reasonably free of defects and air

bubbles. Bakers would use more honey if they could be guaranteed a continuous supply with a uniform flavor and uniform moisture content and processed to remove all foreign particles and excess air.

In selling honey to processors or to manufacturers, the producer or jobber usually submits samples. If the beekeeper separates the different colors and flavors and can secure an official certification as to the quantity and quality of his honey, according to samples, it is easier for the producer to secure payment for his honey through his local bank upon the surrender of the shipping receipts. The buyer can also buy with greater confidence if this procedure is followed. It is not good business practice for the producer to sell on consignment.

Every beekeeper should be a booster for honey and for baked goods in which honey is used. If the annual consumption of honey could be increased to as little as 3 pounds per capita, there would be far less difficulty in selling honey and in getting the price this produce deserves.

BEEKEEPING LITERATURE

Beekeepers should subscribe to one or more of the beekeeping journals in order to keep in touch with current developments in the industry. It is also desirable to have at hand some reference books dealing with the general aspects of colony management. Some of the books listed below may be secured through local libraries or through the bee journals.

Beekeeping Periodicals

American Bee Journal, Dadant and Sons, Hamilton, Illinois.

Beekeepers Magazine, Lansing, Michigan.

The Bee World, Brockhill, London Road, Camberly, Surrey, England.

Gleanings in Bee Culture, A. I. Root Co., Medina, Ohio.

Modern Beekeeping, Walter T. Kelley Co., Paducah, Kentucky.

Beekeeping Books

ABC and XYZ of Bee Culture, by A. I. and E. R. Root, The A. I. Root Company, Medina, Ohio.

American Honey Plants, by Frank C. Pellett, American Bee Journal, Hamilton, Illinois.

First Lessons in Beekeeping, by M. G. and J. C. Dadant, American Bee Journal, Hamilton, Illinois.

The Hive and the Honey Bee, by Roy Grout, Dadant and Sons, Inc., Hamilton, Illinois.

Starting Right with Bees, The A. I. Root Company, Medina, Ohio.

Queen Rearing, by H. H. Laidlaw, Jr., and J. E. Eckert, Dadant and Sons, Inc., Hamilton, Illinois.

INDEX

- American foulbrood, 26, 27
 - control of, 45-47
 - resistance to, 10, 45-47
 - symptoms of, 45, 46, 49
 - sulfathiazole in relation to, 47
- Ants, protection against, 52, 53
- Apiary
 - clothing to use in, 18, 19
 - moving of, 25
 - protection of, 9
 - selecting a location, 9
- Beekeeping
 - considerations for the beginner, 8
 - history of, in Hawaii, 5
 - number of apiaries, 7
 - number of colonies, 7
 - returns from, 9
- Beekeeping equipment, 15
- Beekeeping literature, 58
- Beeswax, annual shipments of, 6
 - extraction of, 41-42
 - production of, 39, 40
- Bee veil, 18
- Brood, worker, 13-14
- Brood chamber, 15
- Brood rearing, 21
 - stimulation of, 21
- Cappings, care of, 38
 - cutting from combs, 37
 - removable of honey from, 38, 39
- Carniolan race of bees, 10
- Caucasian race of bees, 10
- Colony, cost of, 8
 - feeding of, 24, 25
 - increase of, 27-28
 - location of, 9
 - value of, 23
- Comb, 13, 14
 - cleaning of, 38
 - melting of, 40
 - uncapping of, 37, 38, 43
- Comb cappings, 38
- Comb foundation, 16, 17
- Cycle of the year, 20
- Diseases of bees
 - American foulbrood, 45-47, 49
 - European foulbrood, 47, 49
 - Nosema, 50
 - Para foulbrood, 49
 - paralysis, 50
 - sacbrood, 48, 49
- Drone, 13
- European foulbrood
 - control of, 47, 48
 - symptoms of, 49
- Frames, wiring of, 16, 17
 - nailing of, 16, 17
- Grades of honey, 55, 56
- Granulated honey, melting of, 40, 41
- Granulation of honey, 27, 54, 55
 - reduction of, 27
- Hive, manipulation of, 19-20
- Hive parts, 15
- Hive tool, 15, 18
- Honey, annual shipments of, 6
 - grades of, 55, 56
 - grading of, 54-56
 - granulation of, 27, 54, 55
 - marketing of, 57
 - moisture in, 28, 29, 54
 - prices of, 6
 - processing of, 54-57
 - removal of crop, 28-30
- Honey bees
 - distance flown for food, 9
 - feeding of, 24, 25
 - habits of, 10, 20-28
 - handling of, 18-20
 - life history of, 10-13
 - races of, 10
 - removal from combs, 29-30
 - stings of, 8
 - value of, 9
- Honey extractors, 37-39
 - portable, 41-42
- Indian meal moth, 53, 54
- Italian race of bees, 10
- Marketing of honey, 57
- Mediterranean flour moth, 53, 54
- Mice, 54
- Nectar, sources of, 7
- Nosema disease, 50
- Para foulbrood, 49
- Paralysis, 50
- Pollen, sources of, 7
 - storing of, 14
- Portable honey extractor, 43, 44
- Processing honey, 54-57
 - for wholesale trade, 56, 57
- Propolis, 13
- Queen
 - egg laying, 11, 12
 - length of life, 12
 - production of, 30
 - selection of breeder, 31
 - value of, 12
- Queen cells, 11, 20
 - care of, 34, 35
 - introduction into colony, 35
 - production of, 31-35
- Queen excluder, 14, 15
- Queen rearing, 30-35
- Races of honey bees, 10
- Rats, 54
- Requeening a colony, 35-37
- Robbing, prevention of, 24
- Sacbrood, 48, 49
- Seasonal manipulations, 23
 - fall management, 23, 24
 - spring management, 25
 - supering for nectar flow, 25-27
 - winter management, 25
- Slumgum, 40
- Smoker, 15, 18
- Solar wax extractor, 41-42
- Sulfathiazole, 47
- Super combs, 15
- Supering for nectar flow, 25
- Supers, 15
- Swarming, 8, 21-23
 - prevention of, 27, 28
- Termites, 53
- Toads, 53
- Water, 13
- Wax Moths, 51, 52
 - greater wax moth, 51
 - lesser wax moth, 51
- Worker, 12, 13
 - length of life, 13

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