BEEKEEPING

BY

E. F. PHILLIPS

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Frontispiece. — The apiary of the Bureau of Entomology, Drummond, Maryland.

BEEKEEPING

A DISCUSSION OF THE LIFE OF THE HONEYBEE AND OF THE PRODUCTION OF HONEY

BY

EVERETT FRANKLIN PHILLIPS, Ph.D.

IN CHARGE OF BEE CULTURE INVESTIGATIONS, BUREAU OF ENTOMOLOGY, UNITED STATES DEPARTMENT OF AGRICULTURE

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To

M. H. G. P.

PREFACE

The present book is the result of an effort to present a logical discussion of the various phases of the complex subject of beekeeping. It was not planned as a book of rules to which one may go for directions for each day's work, for beekeeping cannot be treated correctly in such a way. The activities of bees vary during the seasons and no two localities present to the bees and their owners exactly the same environmental conditions, so that the successful beekeeper is one who has a knowledge of the activities of bees, whereby he can interpret what he sees in the hives from day to day, and who can mold the instincts of the bees to his convenience and profit.

It has seemed desirable in the early chapters to discuss bees as they exist without man's interference, thus giving the foundation on which the practice of beekeeping rests. The beekeeper is not especially interested in the anatomy of the bee and, while it is necessary to use illustrations of various organs and to describe them briefly, an effort has been made to treat the bee as a living animal and to have the discussion deal with physiology and especially with activities, in so far as investigations have thrown light on these processes. In the preparation of the chapters devoted to the management of the apiary, an effort has been made to present the various systems of manipulations in such a way that the underlying principles shall be evident, rather than to attempt to describe each system as if it were separate.

The author has been helped by the facilities of the office of the Bureau of Entomology with which he is connected and is

under obligations to Dr. Jas. A. Nelson and George S. Demuth for friendly advice and assistance. To F. V. Coville, of the Bureau of Plant Industry, thanks are due for assistance on the chapter on the sources of honey and to Dr. C. C. Miller for counsel on spring management and comb honey, on which subjects he is the highest authority. Especially to his wife, the author would express his gratitude for most valuable help.

The illustrations with a few exceptions were either drawn for this book from material gathered from many sources or have been borrowed from publications prepared in the office of bee culture investigations of the Bureau of Entomology. The new drawings are by J. F. Strauss. A few illustrations copied directly from other sources are credited individually.

In presenting a book to American beekeepers, the author would express the hope that it may be as helpful to them as the cordial assistance and coöperation of many of them have been to him in his work.

E. F. PHILLIPS.

WASHINGTON, D.C.,
March, 1915.

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BEEKEEPING

BEEKEEPING

CHAPTER I

BEEKEEPING AS AN OCCUPATION

The keeping of bees for the pleasure derived from studying them and also for the profit arising from their products is the vocation or avocation of many thousands of people in all sections of the United States and Canada. In former times, the beehive, or more properly the skep, "gum" or box-hive (Fig. 1), was found on almost every farm, in importance occupying a place similar to that which poultry does to-day. Then as now, beekeeping was usually not the sole business of those interested. The number of farmer-beekeepers is now being reduced in most parts of the United States and bees are no longer quite so commonly seen in the country as in earlier days.

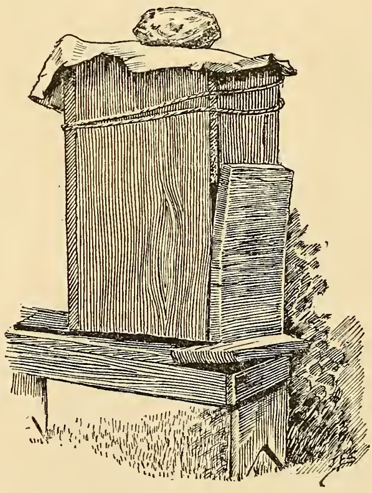


Fig. 1. — A primitive box-hive.

Two classes of beekeepers.

By one of those curious shiftings which are so frequent in human activities, beekeeping is coming more and more to be restricted to two rather distinct classes of beekeepers. Of these the more important numerically is composed of the so-called amateur beekeepers, who keep a few colonies primarily for recreation and only incidentally for honey for home use and perhaps a little to sell locally. The amateur ranks are now made up to a large extent of dwellers in towns, cities and suburbs. The other class, on which the honey-consuming public must chiefly depend, is that of the professional or specialist beekeeper, whose chief if not sole business is honey-production, and who is often a resident of a town or city. Various factors, to be discussed later, make it increasingly desirable that commercial honey-production be carried on by experts, by men who are mentally equipped and trained to get maximum results. While the present tendency is, of necessity, toward the keeping of bees by professional beekeepers, there will always be thousands belonging to the amateur class, and it is by no means intended in the present discussion of the subject to leave out of consideration the enthusiast who desires to keep a few colonies for pleasure. It is probable that the larger part of our present professional beekeepers began as amateurs, rather than as farmer-beekeepers, and, in all likelihood, the extensive producers of the future will be recruited from the suburbanites and nature-lovers who now keep bees for the enjoyment they get from them, with little present thought of future gain.

This source of future commercial beekeepers seems all the more probable since it is difficult to begin beekeeping on a large scale. The many minor details which go to make up success in getting maximum crops cannot come solely from reading nor can the needed information be bought with the apiary. A small beginning is strongly to be advised and, as the novice grows in experience, the colonies may be increased in number. It is a commendable plan to make the bees pay for themselves, almost from the start, as well as for the additional apparatus needed in increasing the apiary. This they will do in the average locality, as well as show some profit. If the work then proves congenial, the transition from amateur to professional is often so gradual as scarcely to be recognized.

Those beekeepers who are also engaged in general farming or who specialize in one or two farm crops are usually too busy elsewhere to give the bees the necessary attention at the time when they most require it and consequently few of this class of beekeepers rise to the ranks of the specialists. This is not so true of amateur beekeepers, since some of the many occupations which they follow usually permit the time and study necessary to the making of the proficient beekeeper.

No genuine beekeeper will admit that any other occupation is more interesting than the care of bees. In fact, beekeepers are, in a sense, bound together by a common tie in their interest in bees, and this sense of union finds expression in their conventions, in the fraternal tone of their articles in the journals devoted to bee-culture and in their intimacy with each other. This sympathy arises from the fact that they recognize the fascination in the study of the bees and possess in common an absorbing interest in an insect which from the earliest times has aroused the curiosity of mankind. For the amateur beekeeper, this study has the marked advantage of being a recreation which pays its own way and, under proper conditions, produces no mean profit.

Beekeeping is from its very nature one of the minor branches of agriculture. It is the means of conserving for human use the nectar of the multitude of flowers, which is usually so abundantly secreted in all sections of the country, and which, if not collected by the bees, is immediately lost.

The raw material of honey costs the beekeeper nothing. The proper care of the bees in order to obtain the maximum crop and the preparation of the product of their labors for market take time and study, but for these the beekeeper is well repaid by the returns.

Extent of beekeeping in the United States and Canada.

It is usually not realized that beekeeping has so many followers. Unfortunately, no thoroughly reliable data are available as to the number of persons engaged in this pursuit, but careful and seemingly conservative estimates place the number at about 800,000 in the United States. The average number of colonies owned is small, probably not more than ten, so that many of these persons are interested to only a slight degree. However, the aggregate crop is sufficiently great to cause surprise to one unfamiliar with the industry. The value of the average annual crop of honey in the United States amounts to at least $20,000,000 while the beeswax produced is valued at about $2,000,000. It should be emphasized that these estimates are conservative.

The Census figures for Canada are seemingly as faulty as those for the United States. For example, the 1911 Census shows 124,237 colonies in Ontario, whereas, according to Morley Pettit, provincial apiarist, the number should be about 300,000. The total value of the honey and wax crop, according to the Census of 1911, is given as $713,250, but it is seemingly safe to state that Canada now produces a crop about one-tenth that of the United States. The industry is steadily growing, especially in the provinces where the beekeepers are helped by inspection and instruction, as they are in Ontario.

There is unquestionably great opportunity for the further development of the industry. Various writers have ventured estimates as to the amount of nectar now out of range of sufficient bees to gather it. These guesses have varied enormously, some stating that perhaps half the nectar secreted is wasted, while others, perhaps nearer the truth, have claimed that not more than one-twentieth is saved. In all the country, there are but few places where too many bees are kept and it is doubtless conservative to venture an estimate that ten times the present honey crop could be produced with profit.

There is a fear commonly expressed by professional beekeepers in their conventions and elsewhere that the honey market will be overstocked if any greater crops are produced. This fear is ungrounded. A few dealers are now attempting to supply their customers with honey throughout the year, although usually the honey crop is sold so quickly that it is found on the market only between the time of harvesting the crop and the holiday season. It must also be remembered that in many families honey is almost unknown as a food, not because it is not relished but because the present supply is so limited that it never comes to the attention of the housewife. Furthermore, bakers and confectioners are using an increasing amount of honey for manufacturing purposes, especially honeys of the darker grades. With such conditions of the honey market, there need be no fear of overproduction, even though the beekeepers take full advantage of the nectar supply, in so far as it is profitable.

Fig. 2. — A bee and apple blossoms. Bees are valuable as agents of cross-pollination.

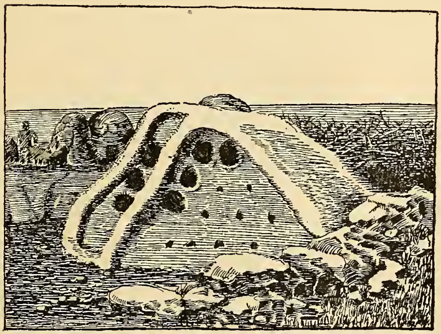


Fig. 3. — Mud hives in Palestine.

In addition to the value of the honeybee as a honey-producer, it has a value to agriculture which is probably far greater. Peculiarly enough, the beekeeper is usually not the one who receives the greatest profit from the presence of his bees in the community. The honeybee is one of the most beneficial of those insects which carry pollen from one flower to another. Such cross-pollination is frequently essential to the production of fruit and, among all the insects which serve the fruit-grower, the honeybee occupies a unique position. In the spring, the time when their services are most needed, other insects are often few in number and there is no way of propagating them. In the case of the honeybee, however, it is relatively easy to carry to the orchard thousands of insects, which are ready, in favorable weather, to aid the fruit-grower in return for the small amount of nectar obtained (Fig. 2). In many orchards the

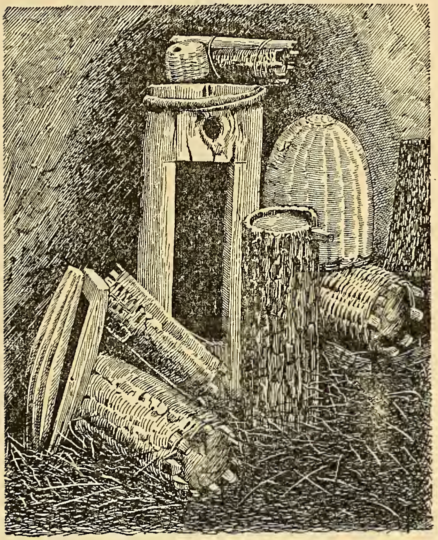


Fig. 4. — Group of Caucasian hives.

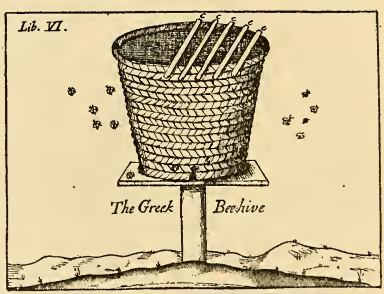


Fig. 5. — An old Greek hive.

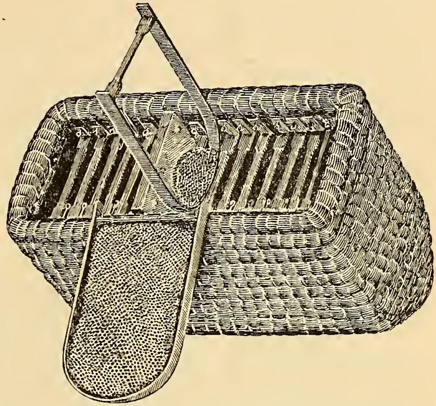


Fig. 6. — Gravenhorst hive, a combination of skep and frame-hive.

greater part of the fruit set is the result of the labors of the honeybee, and many fruit-growers are taking up beekeeping solely for its usefulness in this regard. It is conservatively estimated that the honeybee is more valuable to American agriculture in its work of cross-pollinating than it is as a honey-producer. In all matters pertaining to the advancement of the beekeeping industry the beekeeper should therefore find a warm ally in the fruit-grower.

Relation of apparatus to the development of beekeeping.

It may perhaps be considered as characteristic of human endeavor that when a new piece of apparatus is invented it is first made as complex as possible and, if it becomes widely adopted and is used commercially, much of the later development is in the direction of simplification. This is certainly true of the apparatus used by the beekeeper, and the stage of the development of the industry in any country may be approximately judged by the complexity of the apparatus used.

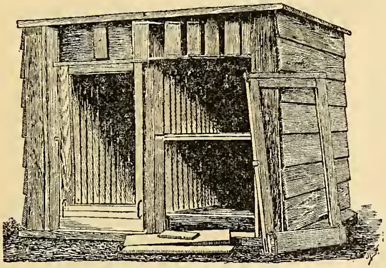


Fig. 7. — German hive, opening at the rear.

The primitive method of keeping bees consisted simply of giving them some kind of cavity in which to live. Such hives are exemplified in the mud hives of the Palestine beekeeper (Fig. 3), and the straw skeps of the old-time European beekeeper. The interesting collection of hives shown in Fig. 4 is drawn from a photograph sent the author by J. de Dieterichs, Nucha, Caucasus, Russia, these hives being types used in that country. To our discredit, it must

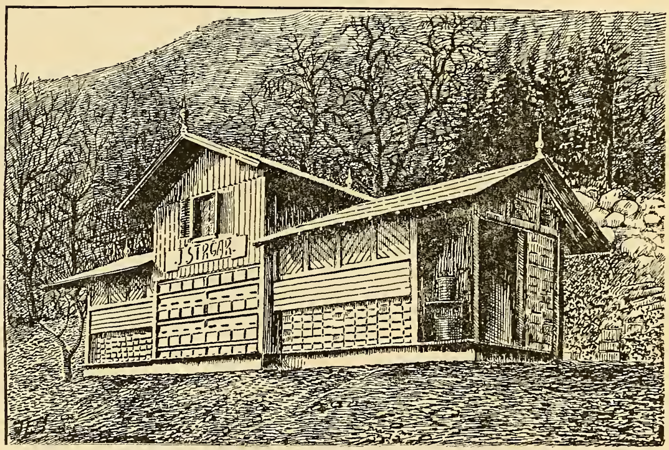


FIG. 8. — Bee-house in Carniola, Austria.

be admitted that in parts of America the box-hive (Fig. 1) or "gum" has not been eliminated. With such crude equipment, beekeeping as a business is not possible.

With the invention of the movable-frame hive by Langstroth, around which so much of this book centers, the development of practical beekeeping began. This type of hive was promptly adopted by German beekeepers, since the previous rediscovery of the bar-hive by the great beekeeper Dzierzon had prepared them for it. The bar-hive had, however, been used centuries before in Greece (Fig. 5).

To utilize the principle of the frame-hive without departing too radically from the skep, the Gravenhorst hive (Fig. 6) was adopted by many Germans. Its deficiencies are at once obvious from the illustration.

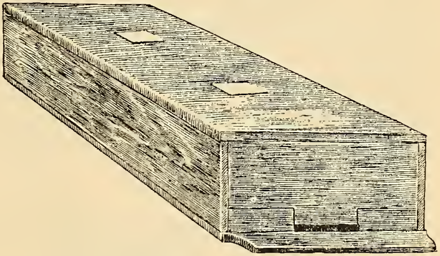


Fig. 9. — Carniolan hive.

With the adoption of the fundamental principle of the frame-hive, the types of hive developed along two main lines. The original frame-hive of the German beekeepers, following the example of Dzierzon, opened at the rear, and this type (Fig. 7) is still much used. Its construction prevents adequate expansion of the brood-chamber and of the room for surplus, which are of such vital importance with modern American manipulations. Such hives are ill suited to American conditions and are apparently losing ground abroad.

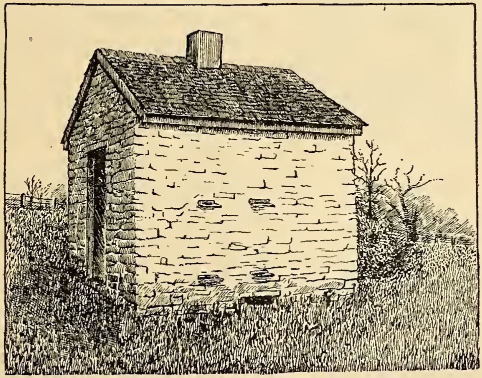


Fig. 10. — Bee-house mentioned in "The Hoosier School Boy."

In connection with these hives as well as with some other local types, the German, Austrian and Swiss beekeepers often keep their bees in elaborately ornamented bee-houses (Fig. 8), each colony of course having its own hive (Fig. 9). This has been tried to a limited extent by American beekeepers, and bee-houses may still be seen in parts of the country. The accompanying illustration (Fig. 10) is drawn from a photograph by Geo. S. Demuth of the bee-house in Eggleston's "Hoosier School Boy," still standing near Madison, Indiana. For a time the author was obliged to use such a house, far less elaborate however than those often built by the bee-enthusiasts of Europe. The house-apiary is cozy and for certain manipulations, such as queen-rearing, is convenient, but the extensive American beekeeper would find it impossible to produce his large crops in such quarters. The house-apiary, as usually constructed, like the hive opening at the back, limits the expansion of the hive and is therefore disadvantageous.

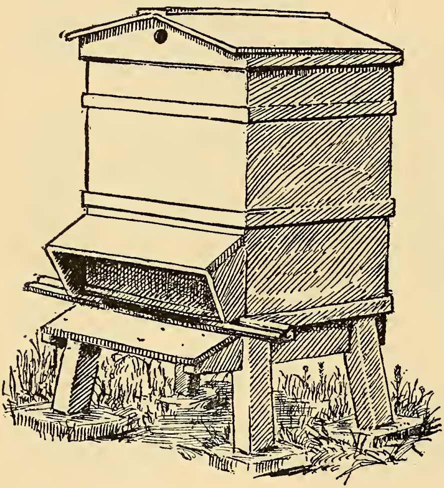


Fig. 11. — W.B.C. hive of England.

The other type of hive, opening at the top, has been extensively adopted in Europe, as exemplified by the W.B.C. hive (Fig. 11) of England, the C.D.B. hive (Figs. 12 and 13) of Ireland and the modified Dadant hive so much used on the continent of Europe. It will be seen from the illustrations that these hives are less simple than those used in America. The chief objection, as viewed from American conditions, is a lack of room for expansion, although the complexity of these hives would seriously interfere with the work of an extensive American beekeeper when in the middle of a heavy honey-flow. The type of hive which we may properly call typically American (Fig. 20) is a simple box, with freely movable but accurately spaced frames, capable of any amount of expansion. It is a most efficient tool for the beekeeper and as fine a home for the bees as any hive ever made. It is readily moved, easily packed for the winter and these and other advantages come chiefly from the severe simplicity which is demanded by business beekeepers. The American beekeeper has, therefore, no reason to envy his coworkers abroad their elaborate and often attractive hives.

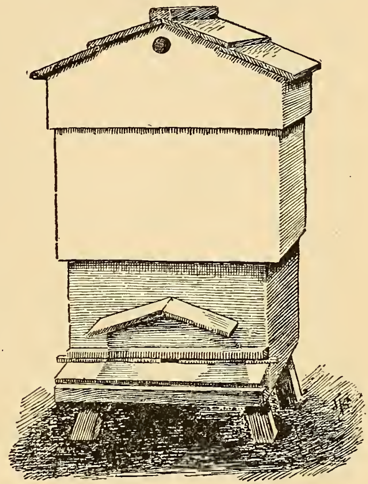


Fig. 12. — C.D.B. hive of Ireland.

This comparison of equipment serves to make clear why beekeeping as a profitable business is possible in the United States and, in turn, the simplicity of the hive is doubtless due to the demands of practical men. The original Langstroth hive was much more elaborate than our present hives and, with the advance of the industry, all the superfluous parts of the hive have been removed one by one. The present hive, therefore, typifies American apiculture of the present day. There are still some hives used in the United States which

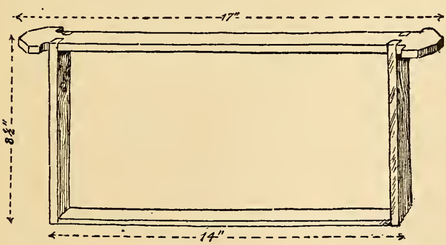


Fig. 13. — Frame of C.D.B. hive.

are less simple than the hive here mentioned, but such hives are usually of brief popularity or are adapted for a limited number of beekeepers.

In future references to apparatus in this book, emphasis is placed on the fact that tools alone do not suffice but that the prime essential to business beekeeping is knowledge of the bees. However, it is only just to give credit to our apparatus as the best lot of tools ever devised for beekeeping work. The American manufacturers of beekeeping supplies are to be commended for their efforts to make the apparatus simple and to a large degree standard. The American beekeeper is to this extent far in advance of beekeepers elsewhere. The American apparatus is standard in Australia.

These remarks are not intended as derogatory of European beekeeping. The American beekeeper owes much of his scientific knowledge of bees to European investigators and beekeepers. It is nevertheless true that commercial beekeeping is an American institution.

Who should be a beekeeper?

Beekeeping is a peculiar occupation in that it can be followed in town or country, by young or old, by rich or poor. Many women are numbered among the ranks of beekeepers. To the professional or business man, it offers a change from the confinement of office or laboratory. To the mechanic, it serves equally as well for recreation. Many teachers find it a desirable occupation during vacation, at which time it adds not a little to the meager incomes provided by parsimonious school-boards. Lawyers, artists, farmers, ministers, merchants, brokers, professors in universities and laborers are numbered among its devotees. Several old men known to the writer are kept mentally alert by their work and interest in the bees, while one boy friend of eight summers is a veteran in enthusiasm. Among the ranks of professional beekeepers are found well-educated and uneducated men of all ages and with all the mental and physical defects or advantages in the category.

With such an array, it may seem fruitless to ask who should be beekeepers. The care of bees is not, however, equally well suited to all persons, and it would save much disappointment, both financial and otherwise, if this question were more frequently asked before embarking on this business. First of all should be excluded those persons who are seriously affected by the poison of bee-stings. To some people, this is a serious matter and, unless it is imperative that they care for bees, it is better for them not to undertake it. To practically all beginners, the stings are annoying, and the experienced beekeeper, however much he may brag of his indifference to stings, still suffers as much pain from the prick as he did at first. With time and numerous stings, an immunity to the poison is developed which eliminates the after-swelling, which is the most annoying feature of the stinging. Nervous persons who cannot take stings without excitement would do better to keep away from bees, as there are times when the best of beekeepers will be punctured.

To carry on beekeeping with interest and profit requires an intimate study of the bees and a detailed knowledge of their needs. It further requires a knowledge of the plants from which they gather nectar so that the necessary steps may be taken to get the colonies in proper condition for the work required of them. To be a good beekeeper, one must read and re-read the books and journals pertaining to the subject, for each reading, accompanied by additional experience among the bees, brings out some new point which proves important in the practical work. Furthermore, the beekeeper cannot work by rule of thumb. Bees are living, lively animals and may be "expected to do the unexpected," as beekeepers so often express it. For this reason, it is necessary for the beekeeper to know the behavior of bees in all its phases and in so far as they have been determined, which is not far, the causes of their various activities. Obviously, the successful beekeeper is a naturalist and such persons are born, not made successfully. Patience, power of concentration and sympathetic understanding of the bees are essentials and, as a result, the bees become pets rather than beasts of burden to the true bee-crank. Persons who fail to appreciate bees from this point of view will probably find it more pleasant and profitable to let them alone. Like all general statements about bees, there are exceptions to this one. Some who are financially successful beekeepers are totally devoid of sympathetic interest in bees and have learned to handle bees as it were by force. Such men are out of place as amateur beekeepers and indeed fail to reach the highest success as professionals.

The ardent bee-man finds pleasure in comparing experiences and observations with his co-workers, in conventions and out, and some of the best "conventions" are those in which two or three experienced beekeepers spend half or more of the night in talking over their latest ideas. They discuss new and supposedly improved apparatus and all the latest systems of manipulation, for there seem to be styles and fads in beekeeping as in clothes. The man who fails to find pleasure in such an interchange of views will find himself out of place among bee-enthusiasts.

Not only is a knowledge of what to do necessary to success with bees, but it is equally necessary that the right thing be done at the right time. To put on comb-honey supers too late, to delay the necessary steps in swarm control or to neglect the preparation of bees for winter, all mean loss in bees, honey and money. In the make-up of the beekeeper must be promptness to do the things which his experience teaches. In the hands of the wise, the bees need remarkably little attention. They should not be manipulated daily and the hive is better unopened unless some change is called for. The beginner errs almost universally in over-manipulation. It must not be forgotten, however, that the reduction in handling which comes with experience is not neglect, and the beekeeper must know daily whether the condition of the nectar-secreting plants or of his colonies calls for any manipulation. This requires experience and observation and finally promptness in doing what is necessary.

Instead then of being an occupation fitted for everyone, beekeeping is well fitted only to the minority. The array of human excellences here enumerated are not all necessarily present in perfection, but the nearer the approach of these qualities to that happy state, the more satisfactory will beekeeping be found as a vocation or avocation. It is to be hoped that these formidable requirements will not deter the potential bee-crank from making a beginning.

Beekeeping for women.

A question much discussed in books and journals on bees is that of beekeeping for women. Many women can and do handle bees (Fig. 14) with marked success. In those parts of the business which require delicacy of touch and minute attention, such as queen-rearing, women often surpass men in proficiency. As amateur beekeepers they are at home. The question which usually presents itself, however, is whether beekeeping is suitable for women as a means of earning a livelihood and repeatedly has the writer been asked for advice on this subject. Professional beekeeping on a scale sufficiently large to supply an adequate income requires long hours of work in the hot sun, heavy lifting and unremitting physical endurance. On a small scale these

Fig. 14. — A woman beekeeper.

obstacles may be overcome, but in a commercial apiary the work must be done promptly, for delay means loss. While some women have found pleasure and profit in commercial beekeeping, it emphatically cannot be recommended for the majority of women, and this should be made clear to avoid disappointment for those who may be attracted to it. Of course, this applies only to those women who have no man in the company to do the heavy work. Many a professional beekeeper has received assistance of incalculable value from the women of the family. It should be made clear that the obstacles to the commercial success of women beekeepers are physical ones only.

Advantages in extensive beekeeping.

Several references have been made to the desirability of encouraging professional beekeeping, and this should be explained to avoid misunderstanding. Everyone who desires to keep bees, of course, has that privilege, so long as by so doing he does not interfere with the rights of others. By common consent, a man's bees are not considered as trespassing when they go outside his land for forage and consequently a beekeeper cannot legally or morally claim the exclusive right to keep bees in a locality. The beginner, therefore, is not considered as overstepping his rights in getting bees. Taking a broader view of the subject, however, the professional beekeeper by his knowledge of the subject is able to produce larger crops, thereby utilizing the available nectar more economically. By this same knowledge and his better equipment, he is able to produce a better quality of honey. It is therefore evident that from the standpoint of conserving a resource to the best advantage there is reason to encourage the extensive beekeeper.

In case a brood disease breaks out in a community, then there is every reason for taking sides with the professional beekeeper. The man with a few colonies is not financially interested to an extent which will compel him to care for the disease and in disease control it is usually necessary that there be some incentive to compel action, the financial incentive being most efficient. The small beekeeper usually becomes a menace to the industry in such an outbreak and not until most of these men lose all they have is much progress made against disease.

The most economical development of the larger honey markets for the beekeepers of any region can come only through co-operation in buying necessary supplies and in selling their products. So long as there are so many thousands of beekeepers with small financial interest in the industry, such co-operation is rendered virtually impossible and the industry is thereby retarded. In some of the western states, beekeeping is carried on chiefly by extensive beekeepers and they have found co-operation practical and profitable, while the beekeepers of the east still fight their battles individually, co-operation being made practically impossible because of the thousands of beekeepers who could not be reached by such a co-operative movement.

Similarly, it is difficult to bring about concerted effort in having desirable laws passed for the protection of the industry or in instituting any agency for the advancement of the industry unless there are a number of men whose financial interest is sufficient to induce them to spend time and money in working for the things they need as beekeepers. Beekeepers are very human people, and "money talks" in this business as well as in other lines of human endeavor. There is therefore adequate reason in the view that the development of beekeeping to its true place in American agriculture depends on the making of a large number of professional beekeepers and this in turn implies the elimination of the beekeeper with a few colonies, little interest and still less of willingness to work for the industry.

While the number of professional beekeepers is increasing in a way to give satisfaction to those interested in the best development of the industry, a word of caution may not be amiss. Some beekeepers feel that as professionals they must engage in no other business, whereas for certain months they are not occupied for more than a small fraction of the time. Without entering into a moral discussion on the virtues of industry or the various things that Satan is said to find for idle hands to do, it is obvious that the professional beekeeper may use other occupations to add to his income just as the amateur beekeeper uses his bees. As the beekeeper becomes more proficient he eliminates all unnecessary manipulation so that the care of a goodly number of colonies may take a relatively short time. When the crop is off and sold he has little to engage his attention until the next season, especially if his bees are wintered out of doors.

Where bees may be kept.

It has been the pleasure of the writer to visit apiaries on the roofs of city buildings (Fig. 15) and in the almost desert valleys of California (Fig. 166), in city backyards (Fig. 16) and in the mountain wilds, in small towns, on farms, in Canada and in the tropics (Fig. 17). In diversity of location these apiaries are as varied as their owners. While recruits to the ranks of beekeepers may be found in all ages and conditions of men, so bees may be kept in places which would at first appear utterly unproductive, as well as in places which are obviously abundant in their nectar supply. The uninformed observer may fail utterly in his estimate of the value of a location from the standpoint of the bee. Most of the valuable nectar-secreting plants do not have

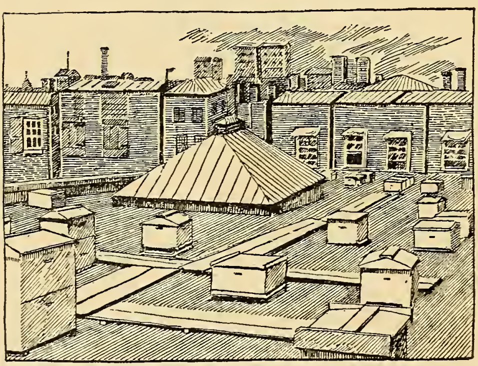


Fig. 15. — Roof apiary in lower New York City.

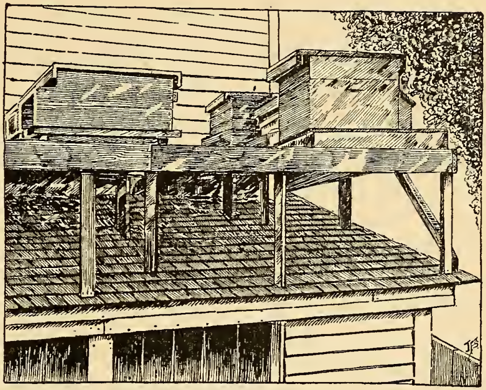


Fig. 16. — Apiary on shed roof, to economize space.

large highly colored flowers, and the cultivated varieties of the flower garden are of insignificant value. Bees fly for two or three miles for forage and may go even farther in emergency. In choosing a location, it is therefore necessary that in the range of flight there be an adequate supply of nectar-producing plants. The ideal location is obviously one in which the nectar supply is near so that it may be obtained without the loss of energy incident to long flights.

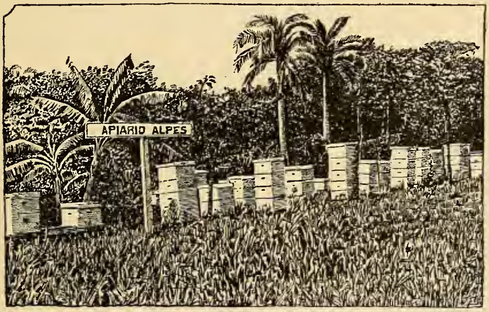


Fig. 17. — Tropical apiary, San Sabastian, Porto Rico.

Results to be expected.

The stories sometimes told of the crops that have been obtained from single colonies or of the rapidity with which the number of colonies may be increased are apt to mislead the beginner. While several hundred pounds of honey may at times be obtained from a single colony in a season, this is by no means usual. In apiaries managed for comb-honey production, it is perhaps fair to estimate the average annual crop at 25 to 30 sections. For extracted-honey, larger averages may be expected, perhaps of 40 to 60 pounds. The financial returns depend entirely on the market and the method of selling the honey. If sold by the beekeeper direct to the consumer, a pound of extracted-honey brings from 10 to 20 cents, while a section of comb-honey sells at 15 to 25 cents. If sold to dealers, the return is less but there is less liability of financial loss and less time consumed in selling. Naturally these estimates must be dependent on the quality of the product and on the neatness of the final package. In addition to the labor there will be other expenses for supplies such as comb-foundation, sections and occasional new hives and fixtures, not counting the apparatus used in increasing the apiary. These may cost from 50 cents to $1.00 for each colony in a season. Estimates such as these are really of little value since the returns differ so greatly according to the kind of honey obtained and the facilities for marketing. For example, the white clover honey of the North brings a higher wholesale price than the amber honeys which come from most regions of the South but, on the other hand, the southern beekeeper enjoys a longer nectar-secreting season and usually obtains larger crops from each colony.

Another factor which must not be overlooked is the beekeeper. Anyone may reap a heavy harvest in the season when nectar is abundant but in the lean years, which come more often than desired, only the good beekeeper makes the most of the nectar at hand. And then come years of practically total dearth of nectar, when feeding is necessary to keep the colonies alive.

Taking all these factors into consideration, it may be justly concluded that a successful beekeeper is usually well repaid for the time he spends in his work, if he considers the return in the sense of wage. He may also consider that he has received the interest on his original relatively small investment. He usually averages little more than this, however, so that beekeeping is in no sense a "get-rich-quick" business. Its advantage as a recreation over most other occupations of a similar character is that it is a means of occupying time not otherwise engaged to a financial profit and the returns therefore often add that part to the income which brings comforts and pleasures.

Beekeeping yields a quick return on the investment, for frequently in a good year a colony will pay for itself. In fact there are few branches of agriculture which on so small an investment will yield as great a return. It may at least be said for the person who decides to try out beekeeping that he does not stand to lose much. This chance calls to mind a conversation with a western friend. In recounting the present advantages and past glory of his beautiful city, he recalled the former gambling days when everything was "open." After a vivid description of those halcyon days and of some of the men of that time, he said, "I knew some of those men well. They were personal friends of mine and they saw nothing wrong in gambling. And I can appreciate their point of view — for I'm a beekeeper myself."

In discussing the financial results, it is far from wise to overlook the other benefits. Beekeeping, to an enthusiast, means out of doors and intimacy with these interesting insects which have been studied for centuries and still remain an unsolved riddle in many of their activities. It may mean health to the person confined to an office. It means to a congenial spirit association with bee-enthusiasts, than whom no more optimistic and warm-hearted people exist. If these things make an appeal, then may apiculture be classed as yielding the greatest profits that can be conceived.

If now we attempt to decide for the questioning prospective beekeeper whether he should take up bees, from the previous discussion the whole question is solved: if he will like beekeeping, he should take it up; if not, he would better never have considered it. And this is about as reliable and lucid a prophecy as is usually possible.

CHAPTER II

APPARATUS

Before discussing the phenomena observed in the activities of bees, on which the practical manipulations rest, it is desirable that some description be given of the hives and equipment used in beekeeping, since frequent references are made to these things in the chapters dealing with behavior as well as in those concerning the practical work of the apiary. Since this subject is to be introduced early, it seems best to complete the discussion here, except for certain pieces of apparatus used in special manipulations.

Relative importance of equipment and skill.

It is important that the relation of the equipment of the apiary to the needs of the bees be understood. A hive is not only a home for the bees but it is, especially, a tool for the beekeeper and, being only a tool, it is of far less importance in apiary management than the skill and experience of the beekeeper.

By many beekeepers, especially among beginners, the apparatus of beekeeping is given undue importance and the interest aroused by the work of putting together the carefully manufactured supplies is really quite excusable. In the American literature on beekeeping the description of apparatus plays too prominent a part. Tools alone do not make the mechanic. It is therefore proposed here to give only a brief description of the general equipment of beekeeping, leaving for the chapters on special phases of beekeeping, the description of the apparatus used in these manipulations. For greater detail, the reader is referred to catalogues of supplies which manufacturers are quite willing to furnish.

It would be interesting to trace the evolution of the various implements used in beekeeping, but this is beyond the scope of this book. For certain appliances, discussed in later chapters, such a method of treatment has seemed desirable and, in fact, to discuss all of the present apparatus in that manner would make the reasons for their construction clearer. There should some day be prepared a book on the evolution of hives and the beekeeper's equipment, if for no other purpose than to show the ardent inventor, who is usually a beginner, the steps that have already been taken and passed by and to prevent the repeated re-discovery of abandoned apparatus. In recent times, the industry is relatively free from the exploitation of worthless apparatus but, at about the time of the invention of the Langstroth hive, the beekeeping industry was well-nigh buried in bizarre hives. The industry has not ceased to advance, but beekeepers have outgrown the belief that success depends on tools. The recognized essentials of beekeeping are knowledge of the bees, skill in manipulation and simplicity in apparatus.

The supplies of the beekeeper have few prerequisites. They must be simple in construction, strongly built and, above all, interchangeable throughout. The manufacturers of beekeeping supplies in the United States have done much to simplify the equipment. The best materials are usually employed.

Apiary house.

In the main or home apiary, it is desirable to have a workshop, usually known by beekeepers as the "honey-house," where supplies may be prepared and the crop cared for and perhaps stored for a time. This house should be below the bees if the ground slopes (p. 292). It is perhaps needless to give plans for an apiary house since the experienced beekeeper will easily construct one that fits his individual needs and the beginner will use what he has at hand. One suggestion is perhaps not amiss, if one may judge from the honey-houses usually seen. The house should be large enough to permit the storage of the surplus fixtures out of season and of the crop until it is shipped. Beekeepers frequently fail to provide adequate space for these uses.

Fig. 18. — Honey-house door. The wooden door rolls clear of the opening and the screen door swings both ways.

Windows and doors[1] should be thoroughly screened to prevent the entrance of bees. The door should swing freely both ways (Fig. 18) so that the beekeeper may pass through with his arms full. The window screens are best made by tacking wire-cloth to the outside of the window casings, allowing it to extend about six inches above the opening. The upper border should be held out one-quarter of an inch by narrow wooden strips to provide abundant exits for bees which accidentally get into the house. Bees rarely enter such openings and those which fly to the screens from the inside immediately crawl upward and go out, promptly clearing the room of bees. Bee-escapes (Fig. 19) may be used at the corners of ordinary framed window screens but

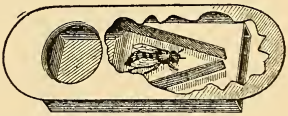


Fig. 19. — Porter bee-escape.

[1] A. C. Miller has recently called attention to the desirability of a solid door to the apiary house, so that bees will not be attracted to this opening by the odor of honey. The suggestion is good and the desirability of having such a door swing both ways still exists.

these are less effective. The best arrangement of windows is to have the sash slide horizontally on runners so that the openings may be entirely free from glass. By this arrangement, bees are not imprisoned on single window panes and in hot weather the beekeeper appreciates all the breeze that may be allowed to enter the house.

Benches, cupboards and racks for small supplies and tools can be arranged to suit individual needs, but these too should be large and roomy. It is a good plan to provide racks for surplus combs, the frames being hung in strips of wood properly spaced.

The kind of honey produced determines the other features of the house. For comb-honey production, a well-supported second story is recommended for the storage of honey. In extracting, it is desirable that the extractor, uncapping boxes and tanks be so arranged that it is not necessary to lift heavy supers and cans and so that at no time the honey must be lifted by hand. Honey is best stored in a warm place and a second story or attic is ideal also for extracted-honey. By the use of a honey-pump, the honey can be raised to a high level and it can then be moved by gravity in future bottling or packing. While general advice on the construction and arrangement of honey-houses is difficult to give, it will profit the beekeeper carefully to study his needs in drawing his plans, so that labor will be reduced.

For the out-apiary, a smaller house will serve and many beekeepers do not have any house in such yards. The portable extracting outfit is one solution, and for comb-honey production it is as easy to haul home in the supers as in shipping cases. For extracted-honey production, a small extracting house is usually preferable.

If bees are wintered in a cellar (p. 353), this may be built under the apiary house. It is desirable to provide a cook stove, which is a comfort in chilly weather and is serviceable in wax-extraction. Running water in the honey-house will be found a great convenience.

Hive stands.

The arrangement of the hives will determine the character of the stand. A wooden frame, bricks, tile (Fig. 20), concrete blocks or flat stones are equally good to raise the bottom board of the hive above the ground so that it will not rot. It is sufficient to raise it only a few inches to allow air to circulate freely under the bottom. In a permanent apiary, it is convenient to arrange the hive stands in the desired order and to number them by the system used in numbering the colonies for purposes of record.

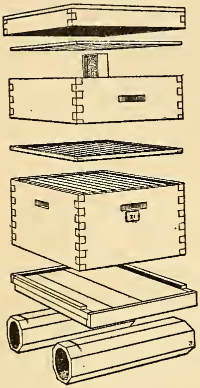


Fig. 20. — Ten-frame Langstroth hive with queen-excluder, comb-honey super and telescope cover.

Hives and hive parts.

The hive which opens at the top and in which the combs are built in freely movable frames is the one generally used in America. It was invented by Rev. L. L. Langstroth, the Father of American beekeeping, in 1851. From this date, the development of modern beekeeping begins. The original Langstroth hive has been somewhat modified as the result of the experience of later years, but as now used (Fig. 20) it consists of a plain wooden box holding frames hung from a rabbet at the top (Fig. 21) and which do not touch the sides, top or bottom. The box is usually dovetailed and is commonly made of white pine dressed to $\frac{7}{8}$ inch.

The greatest advance of the Langstroth hive is not so much in the movable frames as in the free space (Fig. 21) all about them. The size of this space is of the greatest importance, it being such that bees pass through it freely but do not build wax nor deposit propolis in it. The manufacturers of beekeepers' supplies make this space a quarter of an inch.

The plain box rests on a bottom board, so made that there is an entrance space (Fig. 20), and over the hive is a cover which can be entirely removed to permit the removal of frames. There are various types of bottoms and covers, with no marked advantages in one over the others. The telescope cover over a thin inner cover is a good type (Fig. 20).

The size of frame standard in America is that of the Langstroth (or L) hive, $9\frac{1}{8}$ high by $17\frac{5}{8}$ inches long. Frames of other sizes, but having the same method of hanging, have been devised and a larger size has much to commend it, but the desirability of uniformity outweighs the advantages of the odd sizes.

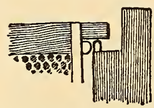


Fig. 21. — Diagram showing spacing of frame and rabbet in Langstroth hive.

The number of frames in the hive is determined by the character of the locality and the kind of honey produced. Many comb-honey producers in the white clover region prefer the eight-frame hive while the majority of extracted-honey producers use the ten-frame size. Some prefer a twelve-frame hive. The sales of supply dealers indicate a growing preference for the ten-frame size among all classes of beekeepers. In deciding which size of hive is preferable, the usual method is to determine the amount of brood that can be reared by a strong colony and to calculate the requisite number of combs from their area. This is not an entirely reliable criterion for the following reasons: (1) the outside combs are frequently unavailable for brood-rearing, because of inaccurate spacing, (2) the top rows of cells in combs built on comb-foundation usually sag, reducing the area available for brood by a depth of one to two inches, (3) there is frequently considerable drone comb or irregular comb. The comb area needed for brood depends on the character and time of the honey-flow and on the system followed. For example, if the main honey-flow comes early in the season (*e.g.* white clover in the North), it is desirable to build up the colony with great rapidity. This may be done by stimulating breeding, and since more space is then needed it can be supplied by giving two hive-bodies for the brood. Later, when brood is less to be desired, the breeding space may be reduced.

Another type of frame is sometimes used and should perhaps be mentioned, although its use is decreasing. These frames have end-bars wide enough so that they touch each other and the bees cannot pass around the ends of frames. The chief advantage stated is greater warmth in winter. Some frames of this type are suspended from the top, others from the middle of the end-bar and some are supported from below.

Frames of any description must be spaced so as to give room between the combs to allow brood to be reared in the cells and also to provide space enough for the bees between the combs. The spacing usually adopted is $1\frac{3}{8}$ inches from center to center but some beekeepers prefer $1\frac{1}{2}$ inches.[1] The closed-end frames when brought together are properly spaced. While the larger number of beekeepers do not use the closed-end type, various devices are in use for the spacing of open-end frames. The frame most commonly used has the end-bars wide enough for a short distance so that they touch at the top (Hoffman frames, Fig. 22). The metal-spaced frame is possibly an improvement. Some honey-producers object to spacing devices because they interfere in uncapping, and this objection is largely overcome by the use of staples in the side of the end-bar.

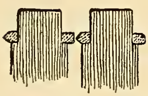


Fig. 22. — Spacing of Hoffman frames.

To obtain regular cells in the comb, comb-foundation, a thin sheet of pure beeswax embossed to correspond with the bases of cells, is placed in the frames. On this as a guide, the bees build the side walls of the cells, utilizing to some extent the extra wax in the foundation. Foundation is made in various thicknesses, the thinnest being used for comb-honey, and in both worker and drone cell size.

[1] The English frames are $1\frac{9}{20}$ inches from center to center.

To strengthen the combs, it is customary to wire the frames with fine (No. 30 gauge, tinned) wire. The wires are generally stretched horizontally, and most frames as they come from the manufacturer are pierced for wiring. After the wires are stretched tight, the foundation is fastened to the top of the frame and the wire is imbedded in the foundation, usually by pressure. The spur imbedder (Fig. 23) is generally used but is not especially good. Heat generated by a weak electric current is sometimes used, but perhaps the best method is to run along the wire a small warm soldering iron with a notch in the point.

Fig. 23. — Spur wire-imbedder.

Whatever style of hive is adopted, the parts must be accurately cut so that the bee-spaces are of the right size and so that the apiary equipment may be interchangeable throughout. Hives or frames of different sizes or of improper dimensions are perhaps the worst inconveniences that can be found in an apiary. The materials used should be the best, for the equipment is often used for many years. As a rule, it is better to buy hives and frames and, in fact, practically all the necessary supplies from the regular manufacturers of such articles. This advice is not given as an advertisement for the manufacturer but is based on the recollection of ill-spaced, inaccurately cut, home-made outfits which have been encountered in traveling among beekeepers. Obviously, an expert wood-worker can do as well as the regular manufacturer, but even then the cost of home-made supplies usually exceeds the price charged by the dealers, when one considers the time consumed.

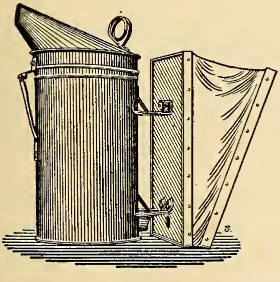


Fig. 24. — Smoker.

The outside of hives should be painted to protect them from the weather. It is most important that the joint or dovetail be painted as decay starts there in unpainted hives. White paint (white lead and raw linseed oil) is to be preferred as it makes a cooler hive than dark colors. For the sake of the appearance of the apiary, all hives should be of the same color. This is also important if one wishes to interchange hives in the apiary.

The hive, as it has been discussed so far, is essentially the home of the bees and is occupied by them throughout the year. This portion is usually known as the brood-chamber. For surplus honey, on which the beekeeper depends for his profit, additional parts are needed and these are discussed in connection with the production of the various kinds of honey.

Equipment for handling bees.

A few special tools are necessary in handling bees. A good smoker (Fig. 24), consisting of a tin or copper receptacle in which to burn rotten wood or other materials, with a bellows attached to force a draft, is indispensable. The medium-sized smokers are best for the beginner and the professional beekeeper may learn by experience what size is best suited to his needs. The German beekeeper often uses a specially constructed pipe (Fig. 25), which is naturally a dual-purpose tool.

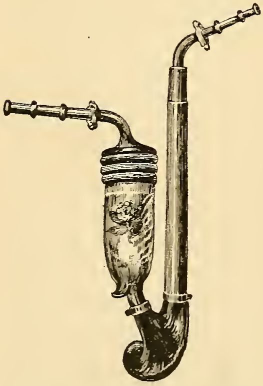


Fig. 25. — German beekeeper's pipe.

A veil of black material, preferably of cotton netting with a silk tulle front (Fig. 26), is needed to protect the face from stings. Even a seasoned beekeeper, who sometimes likes to brag that he never uses a veil, may find it convenient to have a veil thrown back on his hat, which can be brought down when the bees become annoying. Black wire-cloth veils are often used and, while they are a better protection than the cloth veils, they are less convenient as they cannot so easily be thrown back.

Fig. 26. — Cotton netting veil with silk tulle front.

A steel tool of some kind is needed to pry up covers and to loosen and separate frames. A screw-driver will answer but some specially devised tools (Fig. 27) may be found preferable.

Gloves of cloth or leather are sometimes used to protect the hands. The handling of frames is less impeded if the finger ends are cut out. Gloves are hot, usually sticky or stiff, and are as a rule abandoned after the early stages of bee-keeping are passed.

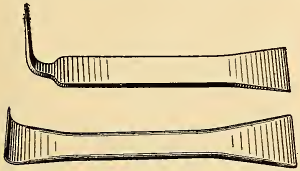


Fig. 27. — Hive tools.

A brush to sweep bees from the combs is a convenience, especially in removing bees while taking frames from the hives at extracting time. The German brush with white bristles (Fig. 28) is perhaps the best of those manufactured, but a turkey feather, a long whisk broom or a bunch of weeds pulled as needed are as good.

Fig. 28. — German bee brush.

A tool box or portable seat (Fig. 29) and a wheelbarrow or cart for carrying supplies and honey are among the other conveniences used in handling

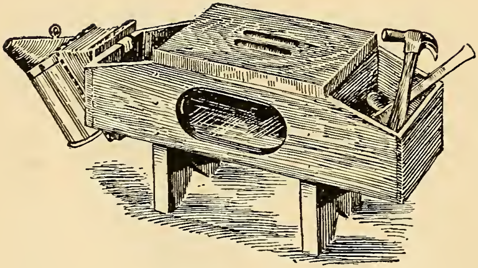


Fig. 29. — Tool-box seat.

bees. A hive cover on edge makes a good temporary seat and has the advantage of being where it is needed, and when needed is not otherwise occupied.

Other equipment.

There are some additional appliances which may be useful in any apiary and which may be mentioned briefly. For making changes in supplies and in devising parts for special uses, the apiary equipment should include some carpenter's tools, among which may be mentioned hammers, saws (including a keyhole saw), brace and bits, square, planes and a good supply of nails of assorted sizes. Cement-coated nails are the best for most purposes

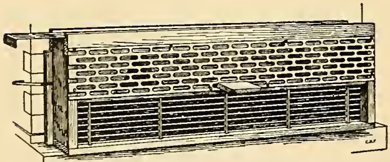


Fig. 30. — Alley queen and drone trap.

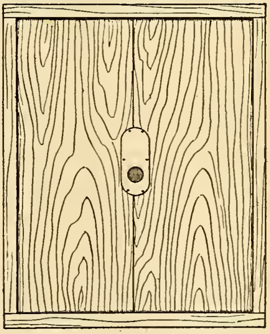


Fig. 31. — Bee-escape board.

in the apiary. Queen and drone traps, usually known as Alley traps (Fig. 30), are useful in catching undesirable drones or in preventing the escape of a queen at swarming time (p. 273). Bee-escapes (Figs. 19 and 31) are used in removing bees from supers of honey, especially comb-honey, before it is taken from the hive. An observatory hive with glass sides will be found instructive and entertaining to the beginner and even to the more experienced beekeeper, if placed where the bees may be watched frequently. A comb-foundation cutter (Fig. 32) is convenient and better than an ordinary knife. If the beekeeper desires to make his own comb-foundation, there are various machines that may be obtained for that purpose. It is usually cheaper to buy foundation. In case it is necessary to feed colonies in order to stimulate brood-rearing or to provide stores for winter or during a period when no nectar is available, various types of feeders may be used. The construction of these is indicated in the illustrations (Figs. 105, 106, 107 and 108), given in connection with the discussion of feeding (p. 240). Clamps for holding the parts of the hive together (Fig. 33) are convenient in moving, but the wide ($1\frac{1}{2}$ inch) staples sold by dealers in beekeeping supplies are as good.

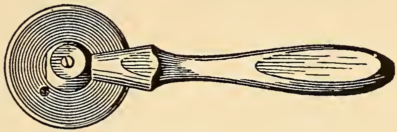


Fig. 32. — Comb-foundation cutter.

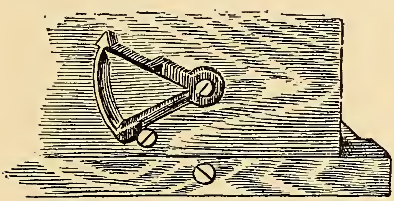


Fig. 33. — Van Deusen hive clamp.

CHAPTER III

THE COLONY AND ITS ORGANIZATION

In the proper management of bees, all manipulations must be based on their normal activities. Bees are creatures of instinct and are limited in their ability to adapt themselves to changes in their environment. While in certain activities they show evidences of memory, learning, association and adaptive responses, in general they may be considered as responding to their environment in a "machine-like" manner. Because of the nature of most of their activities, it becomes necessary to know their normal behavior even more than would be the case were they more adaptive. In giving directions for handling bees, the systems of manipulations and apparatus are usually emphasized, but in the present book the normal activities will be made more prominent so that the reader may better understand the reasons for the usual rules and systems. Again, most of the American literature applies especially to the white clover region and the rules fail to apply elsewhere, so that there seems to be additional justification for a discussion of the more fundamental factors in beekeeping.

It frequently happens that a supposedly new plan or system is published which is old, except that it is a new adaptation of well-known principles to slightly changed conditions. The success or failure of these plans when tried by others is often attributed to peculiarities of the various localities where they are tested. The word "locality" is called upon to cover a multitude of defects in our knowledge of bee activities. Bees respond to stimuli in but one way and wherever a given stimulus is applied, the result is the same. If one's knowledge of the circumstances surrounding his bees is not adequate there seems to be comfort in attributing to "locality" one's failure in the application of rules.

Point of view.

It may be worth while to extend these introductory remarks to explain the point of view held in the present discussion of bee activities. There are several distinct angles from which one may view the actions of a colony of bees and, since they lead to unreconcilable conclusions, they cannot all be correct. First to be mentioned among those who write concerning bees is the so-called student of nature who seemingly tries to find in bees a type of intelligence even higher than that possessed by man and who attributes to these insects thoughts and passions to which only the poetic may hope to attain. The complex colony life of bees offers to such a type of mind unlimited opportunity for speculation, which leads nowhere and is in fact a detriment to legitimate investigation. Allied to the just mentioned enthusiasts over nature are the amateur philosophers who hold up the bee as a brilliant example of industry. To all such speculative fancy, we may with profit turn our backs.

In studying the behavior of any lower animal, there is but one source to which one should go for information. This is found in the actions of the animal in response to stimuli of its environment. If the bee makes a visible movement in response to a stimulus arising in its environment,[1] that visible movement and nothing else is of value in forming a conclusion. If there is a movement or other response inside the animal or otherwise invisible, or if the bee perceives the stimulus but does not move in response, then the observer has a negative result. It is frequent in bee literature to find

[1] The environmental factor may be inside or outside the hive, or even inside or outside the individual bee. For example, pathogenic microorganisms or irritating foods are inside but not part of the animal and are therefore environmental factors.

the words "think," "know," "suppose" and the like applied to bees. As a figure of speech such a form of expression may perhaps be admissible, but if used in its absolute sense then it is not warranted. It would result in a marked diminution of the literature on bees, and a great improvement therein, if such material could be wiped out of existence.

Danger from poor work.

There is but one source of erroneous theory more dangerous than those mentioned and that is the observer who makes false observations and unwarranted deductions. Here too the bee has not escaped. Because of the wide interest in bees there has been a demand for scientific information concerning them and this has induced several untrained or poorly trained men to undertake observations on the structure or behavior of bees, for which they were not equipped. Such work, being frequently presented in a more popular and attractive form than genuine scientific work, has had much influence among beekeepers so that, in attempting to present the results of thorough work, it is first often necessary to show the inaccuracies of work done by unqualified writers.

Advantage of experience in behavior investigations.

It must not be supposed that our present knowledge of the behavior of the bee is complete. It is, in fact, woefully meager. It is probably true, however, that a well-informed beekeeper has a wider and more accurate knowledge concerning bees than have many students of animal behavior concerning the species with which they work. The intimate acquaintance of the beekeeper with these insects results in a knowledge of their activities which, while faulty at times due to a lack of training in observation, is as a whole quite accurate. While this information is often fragmentary and is usually acquired without any special realization of the general principles of behavior, at the same time the data acquired through years of contact with the bees are perhaps as reliable as those obtained by the experimenter on other species in the course of a relatively brief investigation. A new worker in bee behavior should hesitate before denying the belief of the beekeeper until he is sure of his ground.

Zoological position of the honeybee.

The honeybee belongs to the order of insects known as Hymenoptera, to which belong also many parasites of other insects, the solitary and social wasps, ants and the entire group of bees, from the solitary species through various stages in the development of the bee colony to the honeybee. The honeybee is the highest of these colonial forms, highest because most specialized in its behavior and least able to exist alone. Yet, while it is highly specialized in its behavior, it is not so strikingly modified in its structure as are some of the other Hymenoptera, such as the Ichneumonidæ. Among the Hymenoptera there are three groups of social insects, wasps, ants and bees, and the type of colony found in these three groups is fundamentally the same. The only other true colonial insects are the termites, "white ants," of a distinct order and with a quite different type of colony.

The genus Apis to which the honeybee belongs also includes the species *indica, florea, dorsata* and *zonata,* all of which are natives of the far East and none of which is as useful to man as the species *mellifica.*[1] These are briefly discussed in Chapter IX.

[1] One of the cases of confusion originating from the application of the law of priority in scientific nomenclature is the attempted change of the name of the honeybee from *mellifica,* by which it has been known for so many years, to *mellifera.* In the 10th edition of Linnæus' "Systema Naturæ" (1758), the boundary of the prehistoric for the taxonomist, the name *mellifera* was used, while Linnæus himself used *mellifica* in later years. The name *mellifica* is found in a vast literature, it is the scientific name by which the bee is known to most zoologists and beekeepers, the name which Linnæus preferred and, last but not least, it is a correctly descriptive name. It should be recognized in taxonomy, as well as in civic legislation, that a law to be effective must be backed by public sentiment. It might therefore with propriety be suggested to the taxonomic purists that they cultivate public sentiment by allowing the zoologist, dealing in things not names of things, to live in peace among his old friends.

Bees not domestic animals.

Bees have been kept by man from an early stage in the development of human civilization, yet it cannot be said that they are domesticated. In all of their activities, bees under the care of man do not differ from bees in a wild state. The bee has been modified by breeding in various ways but, in so far as the natural instincts are concerned, it is doubtful whether any appreciable change has been brought about and in the greater number of phases of bee life no change has even been attempted. An escaping swarm takes up its abode in a hollow tree and the bees are often then spoken of as "wild," but this adjective is just as applicable to the bees in the apiary. Certain animal trainers become proficient in handling savage animals through their knowledge of the ways of these beasts. Similarly the beekeeper, by studying the behavior of his bees, comes to know their habits and is governed by this knowledge. This comparison of bees and wild animals must be construed not as intended to inspire fear in the uninitiated but to point out that the beekeeper actually is dealing with animals unmodified in their instincts by their long association with man. By the proper use of smoke and especially by the way the colony is handled, the beekeeper can seemingly do with his bees as he pleases. The fact is, however, that he cannot overstep the bounds set by the instincts of these animals. It is therefore an incorrect conception of the ability of the beekeeper to state, as did Langstroth, that bees are capable of being tamed. In view of these facts, the necessity of a thorough knowledge of bee activities is most evident.

Necessity of colonial life.

Bees cannot live alone. Their structure and instincts fit them for life in a colony or community, where the various duties are divided among the individuals according to struc-

Many zoologists refuse to take taxonomy seriously and there seems every reason for disregarding its laws in the present case.

tural fitness and age. While an individual worker bee may live if forcibly isolated from its mates, it cannot reproduce itself, fails to care for itself adequately and soon dies. Most insects have the ability to hibernate in winter but the honeybee seems to have lost that ability. Since at low temperatures the bee becomes numb and finally dies, it must have the ability to make its own environment, so far as temperature is concerned. This makes a colony necessary in winter so that the bees may mutually and collectively warm each other. Efficiency, if not necessity, demands that the work of the colony be divided and such a division of labor tends to develop into a condition demanding the maintenance of the colony. The honeybee is further modified for the defense of the colony rather than of the individual. The barbed sting is used but once and is more effective because it is left behind while the former owner dies. Such a weapon of defense is of no service to the individual.

Size of the colony.

This varies according to the season, the smallest number being usually found at the close of the winter in the North, when the number may be reduced to 10,000 or even much less. At the height of the season, the number may reach 70,000, and while a larger number may be possible it is unusual. Swarms sometimes issue which contain 35,000 individuals. Such numbers usually surprise the uninitiated. It is not, however, necessary for bees to exist in such large numbers to constitute a colony. A mere handful of bees (perhaps 200) may constitute a small colony (usually called a nucleus [1]) and if favorable conditions were to continue such a nucleus would become a full-sized colony.

TYPES OF INDIVIDUALS IN A COLONY

A normal colony at the height of the summer season of activity is composed of three kinds of individuals, (1) the

[1] The unusually small colonies are known among beekeepers as "baby nuclei."

queen (Fig. 34, *b*), of which there is normally only one, the mother of all the other bees of the colony (except just after a

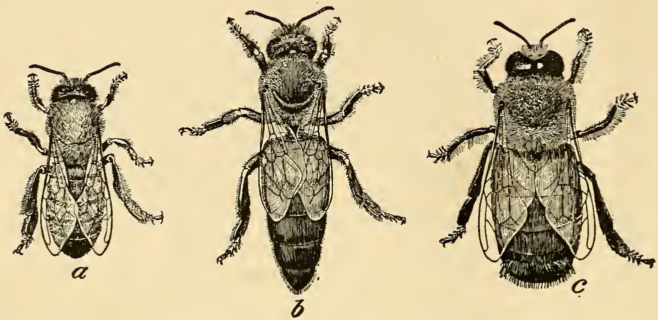


FIG. 34. — The honeybee: *a*, worker; *b*, queen; *c*, drone. Slightly enlarged.

new queen has been reared), (2) thousands of workers (Fig. 34, *a*) or sexually undeveloped females which normally lay no eggs but do all the other work and (3) many drones (Fig. 34, *c*) or males, often removed or restricted in numbers by the beekeeper, whose only function is to mate with young queens. These three types of adult individuals are easily recognizable even by a novice by differences in the size of the various parts of the body. In addition to the adult bees, there are normally found during the active season all stages of developing bees (Fig. 35).

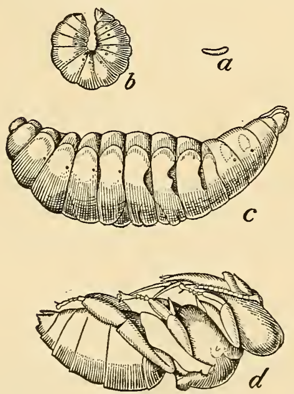


FIG. 35. — The honeybee: *a*, egg; *b*, young larva; *c*, old larva; *d*, pupa. Enlarged.

Queen.

There is normally but one queen, the largest individual in the colony. She has for her sole duty the laying of eggs and all the individuals normally develop from eggs laid by her. They are deposited at the bases of cells of the comb in that portion of the nest devoted to the rearing of brood, the brood nest. The eggs are fastened to the cell base by the posterior (future caudal end of the larva) end by means of a secretion of the queen. The number of eggs laid by the queen [1] varies from a few daily in early spring and late fall in the northern regions to about 1500–2000 a day at the height of the egg-laying season. Under special conditions, usually artificially produced by the beekeeper, she may lay as many as 4500 to 5000 eggs a day and maintain this rate for several days. The weight of the maximum number that can be laid in a day is equal to about twice the weight of the queen at any time during the period, indicating a marvelous rapidity in metabolism.

The queen is not, as her name would indicate, the ruler of the colony. It has for ages been known that there is one large individual in the colony and the ancients gave the name "king" to this supposed ruler. When it was learned that the supposed monarch laid eggs it became necessary to change the name. It is now known that the queen is men-

[1] In 1903, the author had occasion to study the egg-laying of normal queens. Queens were introduced to a small colony in an observatory hive on an empty comb. These queens usually deposited about four or sometimes six eggs a minute, passing quickly from one cell to another. The abdomen is inserted in the cell, the legs are braced firmly on the edges of adjacent cells and the wings are placed flat against the edges of cells to the rear. During egg-laying, the queen is often surrounded by a circle of worker bees with their heads toward her, rubbing her with their antennæ. Frequently this rapid egg-laying is continued without interruption for 20 to 25 minutes and at times for a longer period. There then is usually a resting period, often of about five minutes, during which time the queen is fed by the workers. Whenever the queen comes to rest, she is surrounded by a circle of workers and, as she walks over the comb, each bee turns toward her when she gets within half an inch. This is probably a response to the stimulus of odor.

Some curious traditions have arisen about this circle around the queen, one of the most interesting being the claim that there are always twelve, the number being associated with the twelve apostles. The turning toward the queen is often ascribed to the affection of the workers for her, but this is probably as well grounded as the tradition of there being always twelve.

tally less highly developed than the workers and that, to some degree, the workers determine the number of eggs to be laid and otherwise determine the queen's activities.

The ovaries of the queen (Fig. 92) are highly developed, as is necessary for her specialized function, and because of this development the abdomen is greatly elongated. Her legs (Fig. 81) are not specially modified as are those of the workers and the ovipositor is curved and smooth and has attached to it a poison sac [1] and functions as a sting. Whether it also assists in egg-laying is not determined. The eyes (Fig. 69) are much like those of the workers, the mandibles are notched and proportionately large, the head is not so elongated as that of the worker and is somewhat smaller. The antennæ have twelve segments, like those of the worker.

Mating normally takes place but once when the queen is from five to eight days old, the time differing slightly in different races and being influenced also by conditions of the weather. There is reason to think that some queens mate more than once, but always before laying eggs. Mating never occurs in the hive but on the wing and the queen receives a supply of spermatozoa (male sex cells), millions in number, which are stored in her spermatheca (Fig. 92) and remain functional during the life of the queen or until they are exhausted. Egg-laying commonly begins two days after mating. The queen often lives three or four years but a few exceptional cases are recorded of queens living seven years. The life of the queen seems to depend somewhat on the number of eggs which she lays. The queen, when she fails in egg-laying, is superseded by a young queen reared by the workers.

[1] On one occasion the author was stung by a virgin queen. While it was doubtless his own fault, this is an experience that comes to but few beekeepers. This was in the early days of his beekeeping experience and that there was a poison sac at the other end of the sting was attested by a goodly swelling. The queen was seemingly uninjured. This occurred in the apiary of the A. I. Root Co., Medina, Ohio and, by a strange coincidence, E. R. Root received a letter the same day from a western beekeeper who had a similar experience and who considered it rare enough to be worthy of publication.

While there is usually but one queen in the colony, it sometimes happens that two are found, usually mother and daughter at the time of supersedure. Records of this kind are not infrequent but usually each observer thinks that his observation is unique. v. Buttel-Reepen[1] claims that there are usually two brood-nests. He records one case in which this was not true and several American beekeepers have recorded the same thing. The specialization which normally permits but one egg-producing female is not well understood nor do we know why a queen usually attempts to kill any rivals (except under swarming conditions). Recently, Alexander[2] has advocated the use of two queens for rapid upbuilding of the colony in the spring and he brought this about by a special method of introduction. He records that usually but one remains in the fall.

Workers.

The larger number of bees in the colony are females whose sexual organs are undeveloped and which are structurally modified in other ways. These are justly called worker bees. These bees feed the growing larvæ, clean, guard and ventilate the hive, build comb, gather nectar, pollen, water and propolis and, in fact, do all the work of the hive, except that normally they lay no eggs (p. 187).

The ovaries are small and there is no spermatheca. The mandibles (Fig. 70) are not notched as in the queen, the legs (Fig. 81) are variously modified, the third pair being modified for the carrying of pollen. The ventral plates of the last four visible segments of the abdomen are modified on the anterior edge to form wax glands (Fig. 53) from which the wax used in comb building is secreted. The sting (Fig. 83) is straight and barbed. The antennæ have 12 segments. The tongue is longer than in the queen or drones. The

[1] v. Buttel-Reepen, H., 1900. Sind die Bienen Reflex-maschinen? (Eng. trans., p. 10.)

[2] Alexander, E. W., 1907. A plurality of queens in a colony, without perforated zinc. Gleanings in Bee Culture, XXXV, pp. 1136–1138. See also p. 1496 and Vol. XXXVI, p. 1135.

honey stomach (Fig. 60) is well developed. The workers never mate with the drones and lay eggs only under abnormal circumstances, which are discussed under Chapter VIII.

Speaking in general terms, the length of life of worker bees is measured not so much by days or weeks as by the amount of work which they do. During the period when nectar is being gathered abundantly, they literally work themselves to death and the population of the colony is appreciably decreased unless brood is being reared heavily. During such a period, the average length of life of worker bees is barely six weeks, while in periods when less work is necessary the life is lengthened. Those bees which emerge in the early autumn are the ones which live until the following spring. During the active season, the majority of worker bees die outside the hive, failing to return with the last load. Small wonder that in addition to their other burdens they must sometimes serve as examples of industry!

Drones.

The males of the bee are known by this name. The use of the word drone, meaning a lazy person, arose from the name of the male bee, and it may be re-applied to them as fitting. They are not a useful part of the colony organization in the routine, for they do none of the work of the hive nor do they assist in gathering. The only function of a drone is that of mating with a young (virgin) queen and in this act it dies. Drones are heavy consumers of stores and are not in favor among beekeepers, so that their numbers are greatly reduced in the modern apiary. This is done either by restricting the number of cells in which they may be reared or by trapping them after they emerge as adults.

The drone is a large individual, exceeding even the queen in girth of thorax.[1] The compound eyes (Fig. 69) are so

[1] This fact enables the beekeeper to trap out drones by means of the Alley traps (Fig. 30), which have openings $\frac{163}{1000}$ of an inch wide, through which workers can pass but which are not large enough for most drones and queens because of their larger thoraces.

large that they meet on top of the head, forcing the ocelli (simple eyes, O, Fig. 69) down on the front nearer the bases of the antennæ. The legs (Fig. 81) have no pollen baskets. The wax glands are missing, and there is no sting (this being a strictly female organ, a modified ovipositor). There is one more segment visible in the abdomen than in the female and the abdomen is larger and blunt at the end. A row of prominent hairs is present on the dorsal side of the abdomen.

In the early spring when brood-rearing begins, the first eggs laid by the queen ordinarily develop into workers and, as the colony becomes more populous and the weather moderates, drones rapidly appear. They may be fairly abundant, if the beekeeper does not reduce their number, up to the close of the honey-flow, but at that time the workers drive them from the colony. The first indication of this exodus is to see them in numbers on the bottom board and soon workers will be seen leaving the entrance carrying the heavy drones, with the base of a wing grasped by the mandibles. They are dropped a hundred feet or more from the hive and usually fail to return. If they do return the process is repeated.[1] There is reason to believe that the drones are first starved and then carried out when they become weak. They are rarely stung to death. This slaughter of the drones is best seen in localities where the honey-flow stops abruptly. In queenless colonies, drones are not removed and cases are reported of such colonies retaining them until well into winter. Drones usually do not fly until over a week old but they are probably functionally developed earlier, for the spermatozoa are developed in the pupa.

The drones are seemingly not so fundamentally members of a single colony as are females. They may be placed in any colony without being molested and appear to enter anywhere without challenge until the time of the slaughter.

[1] It is not so usually recognized that old workers are sometimes treated in the same manner.

Brood.

The developmental stages of bees (Fig. 35) are discussed in a later chapter (p. 93) and, for our present purpose, it is necessary only to present a general statement concerning the numbers of individuals in these developmental stages in the colony. In the earliest stages of brood-rearing (in late winter in the North), the queen lays only a few eggs a day and the number increases to 1500 or more a day in an average colony. In exceptional cases, however, this may be exceeded until there are in the combs at one time as many as 40,000 developing bees in all stages, and possibly of all three kinds of bees. Incidentally, this gives some basis for an estimate of the death rate of the adult bees of the colony. If bees emerge from the comb at the rate of 1500 a day during a honey-flow, the population of the colony is not noticably increased, indicating that 1500 or more bees from that colony are dying daily. In the spring when the bees are working less in gathering nectar, the population increases rapidly, indicating a much lower death rate. Truly, bees are creatures of a day.

NATURAL NEST

In a wild state, the bee colony lives in a hollow tree or cavity in the rocks, although they thrive in the artificial hive provided by the beekeeper. An examination of a wild colony will assist in the understanding of various manipulations and hive arrangements. The combs which form their abode are composed of wax secreted by the workers (p. 108). The horizontal, hexagonal cells of the two vertical layers constituting each comb have interplaced ends on a common septum (Fig. 36). In the cells of these combs are reared the developing workers and drones, honey and pollen also being stored in such cells. These combs hang from the top of the cavity and are frequently also attached to the sides. They are rarely built upward from a lower support.

The cells built naturally are not all of the same size. The ones in which worker bees are reared (worker cells) are about one-fifth of an inch across and those used for rearing drones (drone cells) are about one-fourth of an inch in diameter.

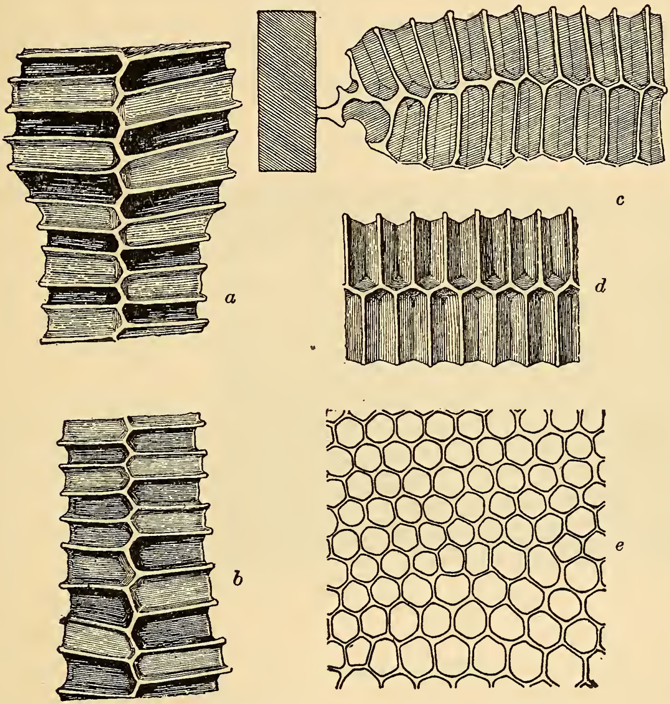


FIG. 36. — Structure of comb: *a*, vertical section at top of comb; *b*, vertical section showing transition from worker to drone cells; *c*, horizontal section at side of comb showing end-bar of frame; *d*, horizontal section of worker brood cells; *e*, diagram showing transition cells. Slightly reduced.

The cells used in storing honey are usually of the larger size while pollen is ordinarily stored in worker cells. The storage cells are less regular and as a rule slope upward at the outer end. The side walls are not all at right angles to the midrib (the common septum) but on all the edges of the comb there may often be noticed a sloping of the outer ends of the cell walls toward the edge of the comb (Fig. 36, *c*). Where drone and worker cells join, the bees overcome the lack of conformity by building transition cells (Fig. 36, *b* and *e*, Fig. 37) of irregular shape. Such cells usually cannot be used for brood-rearing. Attention should perhaps be drawn to the difference between vertical and horizontal sections of comb (Fig. 36, *a*, *b* and *d*). An examination of a comb will show these illustrations to be correct, although many authors of books on bees persist in labeling drawings like Fig. 36, *d* as vertical sections. In addition to the irregular transition cells, the cells at the junction of the comb to its support are quite irregular.

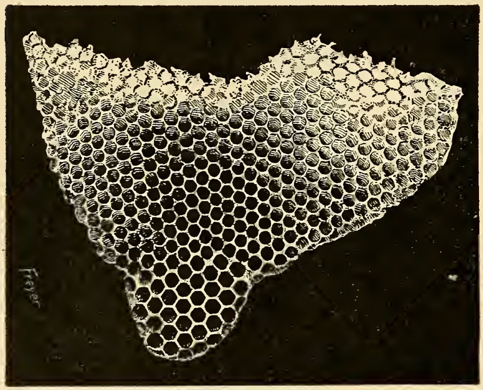


Fig. 37. — Piece of new comb showing transition cells.

The combs of the natural nest are often not straight but are bent and curved in various ways. The several combs may be parallel or, if this is not the case, the irregular spaces may be filled with short combs. Notwithstanding the irregularity of the whole comb, individual cells of the comb are commonly quite uniform. This regularity has been greatly overestimated, however. Reaumur went so far as to advise that the width of a cell be adopted as a legal unit of measure, but even a cursory examination of naturally built comb will show how impractical this would have been. There are also in bee-lore traditions of the marvelous accuracy with which bees form the angles of the side walls and those of the side walls with the base. It has been stated that the comb is built with such accuracy that the maximum capacity and strength are obtained with the minimum expenditure of wax. Miraldi and Koenig vied with each other in the supposed accuracy of their measurements of the various angles and in their calculations of the greatest economy of wax. While it would be a marvelous accomplishment if bees were able to build so accurately, it is perhaps more marvelous that they can adapt their cells to their needs. It need scarcely be said that the formerly supposed accuracy is not actual.[1]

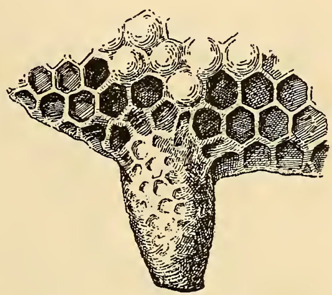


Fig. 38. — Queen cell. Natural size.

In addition to the horizontally placed hexagonal cells, there are found on the combs at certain times cells of a different type. These hang vertically from the combs and are used for rearing queens (Fig. 38). They are circular rather than hexagonal, are larger than the other cells and the outer surface is rough and pitted, somewhat resembling a peanut.

Contents of the cells.

As previously stated, the cells of the comb are used for the rearing of brood and for the storage of honey and pollen, each use being in a sense more or less restricted to cells in definite locations. As the larvæ (p. 100) reach the age when food is no longer taken, they are sealed over with a characteristic capping (Fig. 39), and when a cell is filled with ripened honey it too is sealed, but with a different capping

[1] Under manipulation, the size and regularity of the cells are controlled by the use of comb-foundation, sheets of pure beeswax on which the midrib is impressed (p. 28). Even when this is used, a sloping of the side walls of the cells toward the outer margin of the combs may often be observed.

(Fig. 40). The cells containing pollen are usually not entirely filled and, unless they are also used for the storage of honey, as is sometimes the case, the pollen is not covered.

While the usual conception of the use of the combs includes only the uses just mentioned, the cells actually have an important use as places for adult bees. In winter the bees normally form their cluster over cells containing no honey and adult bees crawl into the empty cells, filling every one within the space occupied by the cluster. They are thus able to form a much more compact mass, the outside of the cluster being essentially a solid wall of bees. During the active season, bees often crawl into the empty cells, but their function during this time is not clear, except that by this means cells are prepared to receive eggs. It has been suggested that many of these bees are "sleeping," but how one may determine this has not been explained.

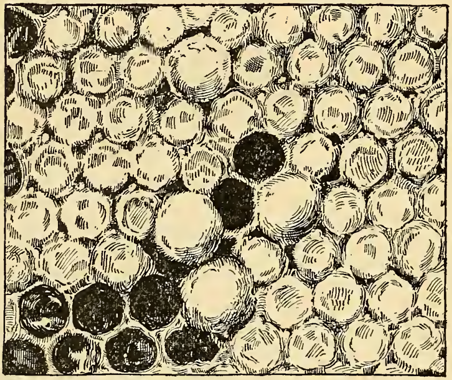


Fig. 39. — Cappings of brood; the larger cappings are over drone pupæ. Natural size.

Arrangement of the nest.

There is to be observed in a natural colony a definite and virtually constant arrangement of the contents of the combs. During the active season, the brood occupies an approximately spherical space involving several combs at the lower part of the center of the comb mass. This space may be shifted or restricted by excessive stores of honey. Around this, on the sides and above, are cells of pollen and beyond

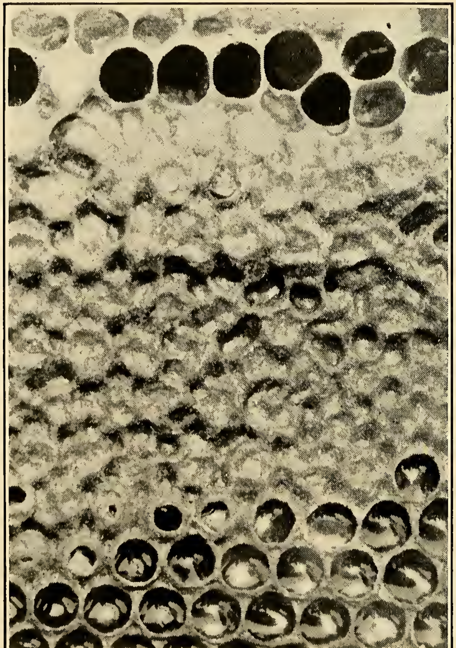


Fig. 40. — Capping of honey. Natural size.

Fig. 41. — Colony in the open air.

these are the honey stores, chiefly to the back of the nest. Drone cells are most often found in the lower corners of combs. This typical plan may be variously modified if the nest is of peculiar shape.

In natural comb-building, bees build for the immediate present, with no evidence of a plan for the needs of the future. When comb-building begins, worker cells are built so long as the queen continues promptly to lay eggs in the new cells. A queenless colony builds storage cells (drone-cell size). If the colony is rather weak and can care for only a little brood, the bees soon begin to build storage cells and this also occurs if the queen is a poor layer. In a nucleus, however, only worker cells are built. If nectar is coming in abundantly they construct storage cells. It may thus happen that some of the combs near the center of the brood nest contain a superabundance of cells suitable only for the rearing of drones or for the storage of honey, and this condition remains in future years, regardless of the best interests of the colony.

Color of the combs.

When first built, combs are light yellow or almost white in color,[1] but after brood is reared in the cells the comb is darkened by the "cocoons" left by the brood. These so-called cocoons consist of larval skins and excreta, with the possible addition of a portion of the delicate silken cocoon (p. 101). These deposits increase with successive rearings of brood until the bases of the cells are appreciably thickened while the outer parts of the side walls remain practically unmodified in size. If an old comb is soaked in water the layers of deposits may be readily separated. The combs are also darkened by deposits of propolis on the cappings of honey cells and the tops of combs are often strengthened by deposits of this substance, especially when the combs are attached to rough wood, as in a hollow log.

[1] The color varies with the sources of honey and pollen at the time the comb is being built. This fact is not yet satisfactorily explained. It is also known that waxes vary similarly in certain physical properties.

Protection of the nest.

Since the nest of a colony is usually built in a cavity, it is thereby protected, at least partially, from extremes of weather and from depredations. In addition to the protection afforded by the shelter, the worker bees cover the inside of the cavity (if it is rough) with propolis (bee glue). This serves to protect the colony from external moisture, often strengthens the wood in a rotten tree and covers irregularities in the surface. Certain races (p. 196) are especially active in reducing the size of the entrance with the same material (Fig. 94), sometimes adding wax to it. An examination of a cavity in a tree which has been occupied by a colony for a considerable time will prove interesting in showing the ways in which bees have improved their abode.

While swarms usually seek protection in a cavity, it sometimes happens that they fail to do this but build their combs in the open. Bouvier [1] has described in detail the comb architecture of such a colony which survived the winter in Paris but died in March. Similar cases are reported frequently in the United States but such a colony fails to survive cold winters. On one occasion, an open-air colony was discovered near Washington and was moved to the apiary of the Department of Agriculture, then located at College Park, Maryland (Fig. 41). The colony defended itself from robbers and wasps during a period when robbing was severe and wasps were unusually abundant, and lived until nearly midwinter, when it succumbed during a blizzard. In general, the combs of such colonies are bent so that the wind cannot blow directly through the nest, and the edges of combs are sometimes united with comb projections or propolis. This ability to live in the open suggests a similarity with the giant bees of India and the Philippines which normally build unprotected combs, the latter bees however usually building only a single large comb.

[1] Bouvier, E. L., 1905. Sur la nidification d'une colonie d'abeilles a l'air libre. Bul. société philomatique de Paris, Neuv. sér., VII, pp. 186–206.

Comparison with stingless bees.

The arrangement and protection of the natural nest of the honeybee may be compared with the arrangement found in the stingless bees, to which they are closely related. These bees do not build double rows of cells in their combs but the brood is reared in cylindrical cells fused together in single layers. The pollen and honey are stored in large spherical cells of wax. Several years ago, the author had opportunity to examine the nest of a colony of these bees minutely. In this particular species, the spherical cells for pollen and nectar are about one inch in diameter. The entrance is contracted and projects as a funnel almost two inches outward. This funnel is evidently composed of propolis and wax to which pellets of earth are added. Inside the entrance are the storage cells for pollen surrounding the outer half of the group of brood cells. Back of the brood cells and partially encircling them are the cells of honey, the honey in this particular case being well ripened and of superb flavor. The contracted entrance suggests a resemblance to the work of certain races of honeybees (*e.g.* Caucasian, p. 196) in closing the entrance in the autumn, while the general arrangement of the nest follows the usual plan for the honeybee closely, except that the pollen cells are between the entrance and the brood.

CHAPTER IV

THE CYCLE OF THE YEAR

To describe the various activities observed in the bee colony in its response to changes in the environment, there is perhaps no better arrangement of the facts than to follow such a colony through the year, assuming that it is normal and unmolested by man. For convenience, the cycle is begun at the close of winter. It must of course be understood that any such arrangement is arbitrary, since the cycle varies in different regions with differences in climate and in the sources of nectar.

In discussing the round of action, it is customary among American writers chiefly to discuss the phenomena observed in the white clover region, and they often fail to make clear that elsewhere the course of events may be materially modified. The long winter of the North is a striking feature of the year and greatly influences the activities of the bees. In this region, too, all of the seasonal influences which go to make up the year are intensified and the proper control of bees is more difficult. In the discussion which follows, the events typical of the North must be made rather prominent in order to follow the plan of arranging the facts to the yearly cycle, but an effort is made to include the differences which, in beekeeping literature, are often attributed to the abused term "locality." From the strong contrasts in seasons and in bee activities observed near the northern limits of the region where bees may be kept, there is a gradual fading of the boundaries of the seasons and a corresponding reduction in the extremes of bee activity until we reach the tropics, where every day to the bees is as the day before, except for

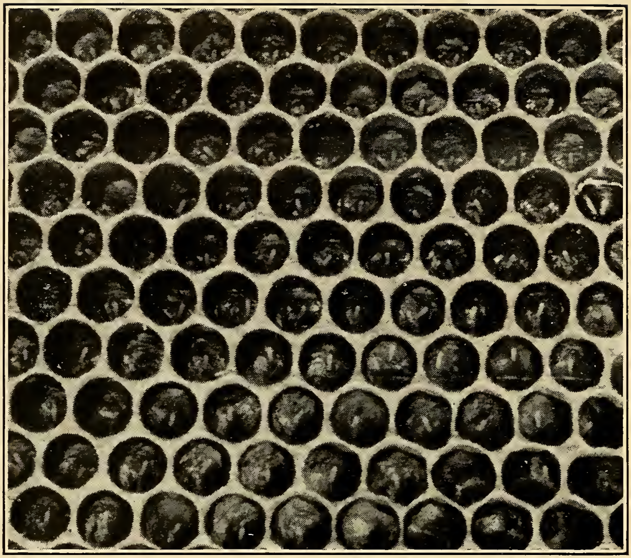


FIG. 42. — Eggs in cells of the comb. Slightly enlarged.

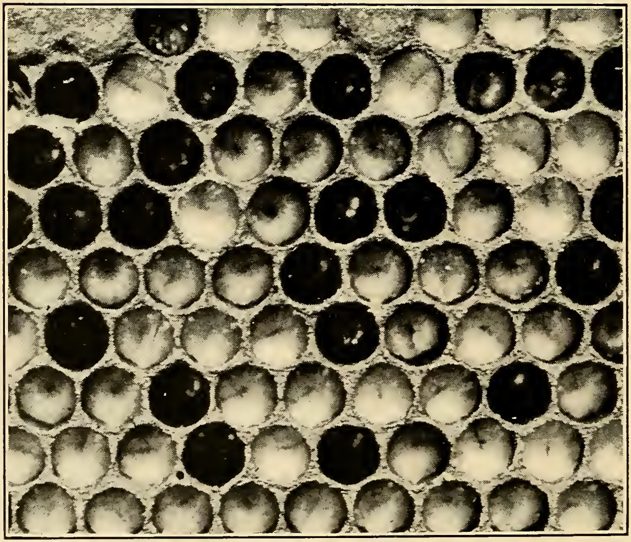


FIG. 43. — Larvæ in cells of the comb, almost full grown. Slightly enlarged.

the indistinctly circumscribed honey-flows and for temporary disturbances in weather conditions.

BROOD-REARING

A normal colony of bees in good condition just previous to the beginning of the season's activity may be assumed to be broodless and to consist of a mated queen and perhaps 10,000 or more worker bees. The combs contain an adequate supply of honey and stored pollen. The workers fly from the hive whenever the days are warm enough, especially after a period of confinement, and with the opening of the earliest spring flowers they replenish their stores of honey and pollen. Previous to the stimulus of incoming nectar, however, the rearing of brood is begun. This usually commences, in colonies wintered out of doors, in the coldest period of the winter, in February or even in January in the North, and this fact indicates strongly that the beginning of brood-rearing is usually not due to a rise in the outside temperature or to the procuring of nectar or pollen, as is usually assumed. It certainly is not due to any instinctive knowledge of the coming of spring.

The first eggs (Fig. 42) are laid in the center of the winter cluster, before it is loosened. They are usually deposited in circular areas of cells on adjacent combs and, if the queen can pass around the combs without leaving the cluster, such circles of eggs will be found opposite each other on the comb. As breeding continues, eggs are placed in concentric rings, not only on the middle comb but on contiguous combs, so that the form of the brood nest becomes approximately spherical. The development of the brood (Fig. 35) will be discussed in greater detail in a later chapter (p. 93) and it will suffice here to state that after approximately three days there hatches from the egg a small worm-like larva, pearly-white [1] in color. This is fed great quantities of food by the

[1] In the comb the larva appears white but, if one is removed from the cell and placed on white paper, a slight yellow or brown color is evident.

workers so that it grows nearly to fill the cell (Fig. 43) in a few days. It is then capped over (Fig. 39) and undergoes metamorphosis into an adult, this transition stage being known as the pupa. If about two weeks after brood-rearing has begun, the central comb is removed, we find the inner circle of the brood sealed, surrounding this concentric circles of larvæ, the smaller toward the outside, and in the outermost circle are recently laid eggs. Similarly as other combs are examined, the same succession of brood is found as we go to the outer lateral boundaries of the sphere of brood. As the brood continues to develop, the innermost cells are first emptied by the emergence [1] of the young adult bees and the queen then returns to the center of the sphere to deposit eggs. The emergence of the brood increases the size of the colony and consequently the amount of brood that can be fed and protected is greater, especially since the young bees normally do most of the work of caring for the brood. Furthermore, as the temperature of the outside air rises, the cluster is expanded and more brood can be included in it. Bees often attempt to rear more brood than they can cover in the event of unusually cold weather, and if the weather turns cold they may contract the cluster and leave brood exposed to die of starvation and cold. The concentric arrangement of the brood may often be observed throughout the breeding season (Fig. 44) but usually after a time the symmetrical arrangement of early spring is less conspicuous, due to irregularities in the combs or to external conditions modifying the extent of brood-rearing from day to day. In general, however, the brood consists of concentric spherical layers of various ages.[2] The concentric arrangement of the

The content of the intestine is often dark and this may frequently be seen through the transparent tissues as a narrow band on the convex side.

[1] Beekeepers frequently refer to the emergence of young adult bees as "hatching." This, however, is incorrect and the word should be applied only to the issuing of the young larvæ from the eggs.

[2] In a hive as shallow as the Langstroth the sphere is usually flattened, as in Fig. 44.

pollen and honey about the brood has been previously described (p. 50).

The first eggs laid develop into worker bees, but as the season advances eggs are laid in the larger cells of the comb, from which drones develop. The number of drones and the time when they first appear depend largely on the kind of cells in the comb. If there are drone cells near the place where the cluster is formed, they are soon included within the limits of the brood nest, as it expands, and drones appear earlier than if the drone cells were at one side of the hive.

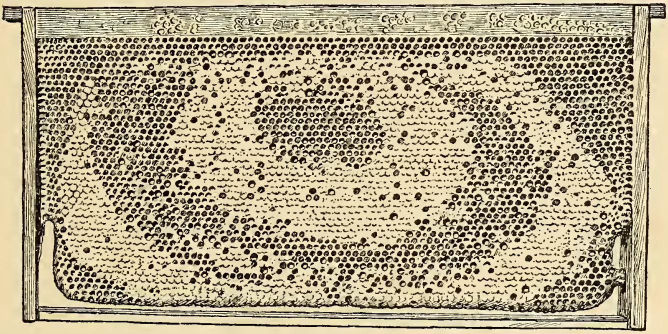


FIG. 44. — Concentric arrangement of the brood.

Brood-rearing during the season.

The cycle of brood-rearing has been studied by Dufour[1] for the conditions prevailing in Fontainebleau, France, from 1897 to 1900. This was done by measuring the extent of the brood nest every 21 days (worker brood requiring that time to develop) and by estimating accurately the number of eggs laid since the previous measurements. The hives (Layens) used contained 20 frames,[2] each 37 cm. (14.67 in.) by

[1] Dufour, Leon, 1901. Recherches sur la ponte de la reine. Ann. de la fèd. des soc. d'apiculture (France). Lille: Le Bigot Frères (with L'Apiculteur, 1902).

[2] These hives are comparable to the hives sometimes used in America, to which the name "long idea" is given. All 20 frames are in one hive body.

31 cm. (12.3 in.). To show the course of egg-laying during the season, the accompanying table is copied from this paper. These observations were made during 1900 on a colony in which the queen was reared in 1899, egg-laying of this queen having begun about June 17, 1899. During the year a total of about 150,000 eggs were laid. The maximum egg-laying occurred during the period of the chief honey-flow, which that year was from June 1 to 12. The colony did not swarm.

Table I. Egg-laying during an Entire Season — Dufour

Date	Period	Average Laying
Feb. 26	Feb. 5–Feb. 26	135
March 20	Feb. 27–March 20	220
April 12	March 22–April 12	309
May 3	April 12–May 3	1008
May 23	May 2–May 23	1454
June 14	May 24–June 14	1538
July 5	June 14–July 5	1081
July 26	July 5–July 26	668
Aug. 16	July 26–Aug. 16	348
Sept. 6	Aug. 16–Sept. 6	450
Sept. 27	Sept. 6–Sept. 27	83

In brief, the results of Dufour's work are as follows: For that locality and under the conditions prevailing, the largest average observed was 1627 eggs a day (June 10–July 1, 1898). The maximum occurs during a heavy honey-flow or immediately after. A queen about to be superseded may lay about 400 eggs daily, while a young queen may begin by laying 900 eggs daily (these figures probably vary with the time of year). Artificial swarming is said greatly to diminish egg-laying. It must be remembered that variation in climatic conditions and in honey-flows influence egg-laying and the results of such work would not be the same everywhere. Work of this character should be carried out elsewhere.

THE TEMPERATURE OF THE HIVE

In a study of the activities of a colony of bees, the question of temperature must be carefully considered. Bees are cold-blooded (poikilothermous) animals, that is, the temperature of the body of an individual bee is variable and is the same or almost the same as that of the air immediately surrounding the body. All cold-blooded animals usually have a temperature slightly above that of the surrounding medium, except in the case of animals having a moist skin and surrounded by air, in which evaporation on the surface of the body may cause the temperature of the body to fall a little below that of the air. The heat which raises the temperature of the individual bee, and collectively of the bee colony, above that of the surrounding air is generated chiefly by muscular activity. The individual bee can continue muscular movements only so long as the temperature of the body does not fall below 45° F., but at about this temperature it loses its power of movement. The highest temperature at which bees can live has not been accurately determined but it must be over 130° F.

While the individual bee does not possess the ability to maintain a nearly uniform body temperature, as do warm-blooded animals, the colony as a whole shows some remarkable temperature changes, different from any observed in individual bees or in other cold-blooded animals. Warm-blooded animals maintain a fairly constant temperature which may be either higher or lower than that of the surrounding air. While the colony of bees may maintain a temperature either warmer or colder than the surrounding air (colder than the air outside the hive), the temperature of the colony is not constant. In warm-blooded animals, most of the heat is generated by the processes of internal combustion in the assimilation of food, augmented by heat due to muscular activity. In the bee, the chief method of heat production is by muscular activity, with possibly some additional heat from other life processes, and the bee, unlike a warm-blooded animal, promptly cools if muscular activity ceases and the surrounding air is cool. The temperature changes of other colonial insects have not been studied, but it would seem probable from our present knowledge that the honeybee is the only insect which is able to generate heat sufficient to maintain active movements without hibernation throughout the winter in the North.

The most interesting and important phases of the temperature of the bee colony are to be observed in the winter season and this will be discussed at the close of this chapter. While many observations have been made on the temperature of the bee colony during the period of brood-rearing, the work has not been done with sufficient detail so that we have little information concerning heat generation during this season. The foregoing statement perhaps demands some explanation. If a colony of bees is disturbed,[1] its temperature promptly changes and consequently the insertion of a mercurial thermometer into the brood nest, or even an approach to the hive to read a thermometer already inserted, may at times produce abnormal temperature conditions. Furthermore, most of the thermometers used are of doubtful accuracy and the slow action of a mercury thermometer is an additional cause of inaccuracy. It is usually stated that during brood-rearing a temperature of approximately human blood heat is maintained within the cluster and that this temperature is practically uniform. The uniformity of the temperature has been greatly overestimated, at least in certain parts of the season, and it may vary over several degrees. It rarely exceeds 97° F. However, if the temperature of the outside air exceeds the maximum hive temperature, the bees reduce the temperature of the cluster by fanning, causing a drop in the temperature inside the hive by evaporation.

In the case of other insects, the length of the developmental stages varies greatly, according to temperature. Since the bee colony virtually creates its own temperature environ-

[1] This is specially true in winter when a definite cluster is formed.

ment within the brood nest during brood-rearing, the developmental stages are practically uniform in length of time. This is a great benefit to the beekeeper, especially in timing swarming and similar phenomena where queen cells are concerned. It has been found that if brood is removed and kept at a temperature lower than is usual in the brood-chamber, development continues but, as with other insects, it is retarded.

One other point regarding the hive temperature is important. The temperature is not uniform throughout the hive but may vary over many degrees in cold weather. This will be explained in greater detail under a discussion of bees during winter. In any weather, however, the efforts of the bees in heat generation are confined to the brood nest or, in the absence of brood, to the cluster, except when wax is being secreted, when a high temperature is also maintained at the point of building. Away from the centers of activity, however, the temperature is not raised except by chance muscular movements or by convection currents, but may be cooled if it is too hot. This perhaps explains the seemingly unreconcilable records of hive temperatures during the summer.

SWARMING

Continued and increased breeding, previously described as occurring in early summer, would result in enormous colonies if the queen were able to lay eggs with sufficient rapidity to meet the demands of such a case. It would not, however, result in any increase in the number of colonies. Obviously, it frequently happens that an entire colony of bees is destroyed, in Nature as well as in the hands of the beekeeper, and the very existence of the species depends on another method of reproduction. The colony life of the bee is so completely developed that it is permissible to think of the individuals as merely "winged organs of the colony," as Maeterlinck has expressed it. We now come to the breeding of colonies or swarming. This process of reproduction may be likened to the simple fission or division observed in the protozoa, by which they increase in number.

Preparation for swarming.

As the colony increases in strength, the rearing of brood is no longer confined to the worker and drone cells but special queen cells are built (Fig. 45), in which female larvæ are fed a specially prepared food, royal jelly, and in which the course of their development is so modified that there result queens with their special organs instead of worker bees. The rearing of queens also occurs if a colony becomes queenless by the death or removal of the queen, provided eggs or young larvæ are present, or when a queen is about to be superseded by a young queen because she fails in egg-laying. Queen cells may be built in advance of the laying of eggs in them (pre-constructed cells), as is usually the case in swarming, or the cells may be built around small female larvæ which would otherwise become workers (post-constructed cells), as is necessary in queenless colonies. The eggs from which queens and workers develop are identical, the only known cause of the difference in the course of their development being the special cells and the food provided for the developing queen.

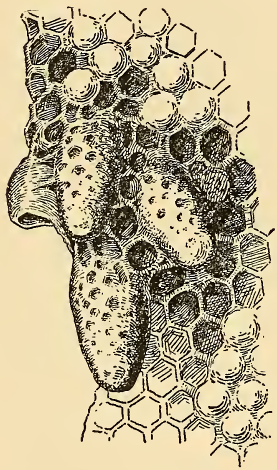


Fig. 45. — Group of queen cells. Natural size.

Issuing of the swarm.

When the larvæ in the queen cells are fully fed, they are sealed over as are other larvæ. At about the time of this sealing, the first (prime) swarm usually issues, although it may be delayed by inclement weather.[1] Swarming consists of the departure of the old queen with part [2] of the workers from the hive, leaving behind the brood, including the queen cells, some adult bees and the stores, except such honey as the workers are able to carry in their honey stomachs. Before leaving, the bees gorge themselves until the abdomens are distended and are thus provided with food for a few days, in case the weather is inclement. The queen usually lays fewer eggs just before swarming than is usual for that season and her abdomen often becomes smaller, enabling her to fly more easily. Frequently for a time before the issuing of the swarm, the work of the colony in gathering is decreased and many of the field bees remain at home, thereby crowding the hive. The swarm usually issues on a bright day about mid-day [3] and most of the workers in the hive at that time leave with the swarm. Those in the field at the time of swarming return to the hive and do not follow the swarm.

Stimulus to leave the hive.

The stimulus to the act of swarming is not understood, but it has been observed in hives with glass sides that bees in various parts of the hive show signs of excitement, which gradually spreads throughout the hive. Sometimes the queen leaves among the first but she usually remains inside until a considerable number have left the hive. Since a swarm sometimes issues without a queen, she can scarcely be considered the leader. This is also shown by the fact that when the queen is caged, as a means of swarm prevention, the bees sometimes swarm, leaving the queen in the cage. When a queen is disabled so that she cannot fly or is detained

[1] Races of bees differ somewhat in the time of swarming. Italians tend to swarm with the queen cells in an earlier stage of development than other races.

[2] Why some go and others remain is not known. They are not separated according to age nor duties.

[3] Swarms usually issue between 10 A.M. and 2 P.M. but in warm sultry weather may come out earlier, or quite late in the afternoon.

by a queen trap (Fig. 30), the bees may make several attempts to swarm and often finally destroy the old queen, sometimes swarming with a virgin raised at this time.

As soon as the bees leave the entrance there is a striking tendency to move upward. Some go upward within the hive and if it is opened they pour out at the top and if, as sometimes happens, the queen goes up inside instead of outside, the swarm soon returns to the hive. In an analysis of swarming this upward movement is to be reckoned with.

In seeking an explanation of the stimulus to leave the hive, there are some manipulations which produce similar results and which are of value for purposes of comparison. (1) In transferring colonies (p. 245) from a box-hive, an empty box is sometimes placed over the inverted box-hive, which is then pounded. This drumming causes the bees to fill their honey stomachs, after which they gradually move upward until practically the entire colony is clustered in the upper box in the shape of a swarm. (2) In making artificial swarms (p. 283) or in the use of the swarm box (p. 422) for starting artificial queen cells, the bees gorge themselves and later cluster like a swarm. (3) If bees are smoked excessively, they gorge themselves and begin to run (especially true of black bees), usually in an upward direction. In these three examples the bees are "demoralized"; the colony is disorganized. The bees usually do not sting and most of them do not attempt to fly so long as they can proceed in the desired direction on foot. They can be moved to a new location after these operations, in which event practically none of them return to the old location.

The same peculiar manner of leaving the hive may be induced by placing bees in a box with a small opening. If a substance with a repelling odor is now placed in the box, the bees shoot out the opening as in swarming. This manner of exit may be merely incidental to rapidity of movement and may not be specially characteristic. The fact that movements can be duplicated does not necessarily imply similar causes.

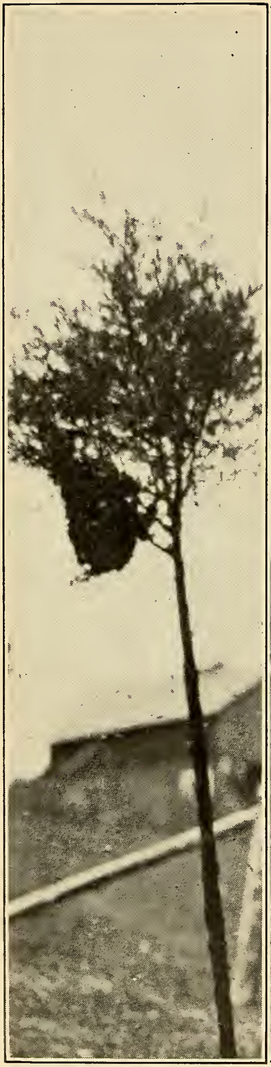


Fig. 46. — A swarm cluster.

Fig. 48. — Capturing a swarm.

Behavior of the issuing swarm.

The issuing of a swarm is one of the most exciting and interesting incidents in the apiary. The bees rush from the hive, giving the observer the impression that they are pursued or "possessed of the devil." They appear intoxicated with the "swarm dizziness" and whirl in "bacchanal delight," as if drunk with joy. Even the beekeeper becomes excited. The bees circle in the air and the whirling swarm may drift about the apiary for a time. There is an excitement in the "swarm tone" which is infectious.

It is especially to be noted that swarming bees rarely sting, and it is commonly stated that they cannot sting because their abdomens are distended with the load of honey in the honey stomach. This latter statement is incorrect, if taken literally, but even the hardened beekeeper finds enjoyment in walking into the midst of the circling swarm, in spite of the fact that he has probably tried to prevent swarming, and he needs no veil under such circumstances.

Clustering.

The swarm after a time begins to settle on the limb of a tree or some such support (Fig. 46) and the excitement is past. Like the issuing of the swarm from the hive, the incentive to cluster is not understood. The queen may be the first to alight, and this seems quite natural since she is heavy and a poor flyer compared with the workers, but she is just as likely to join the cluster after it is partly formed. However, the cluster is usually not formed if the queen has not accompanied the swarm. One feature is noticeable in the forming cluster, however, which perhaps throws some light on the subject. It is well known that when bees are thrown in front of a hive the abdomen is raised and the wings are fanned vigorously. At such a time the dorsal scent organ (p. 172), located on the intersegmental membrane between the sixth and seventh terga of the abdomen, is exposed by the bending ventrally of the last visible abdominal segment. During clustering, the bees on the outside of the mass expose this gland and the wings are moved rapidly so that it seems probable that the odor which is emitted and dispersed attracts the flying bees to the cluster.

If the cluster has been formed in an inaccessible place, the beekeeper often finds it desirable to have the bees move to another support. The cluster will gradually move (more readily upward) into the dark interior of a box placed nearby, this movement being more rapid if a piece of comb, or better, comb with brood, is placed inside the box (Fig. 47). If the queen has failed to fly or has been prevented in some way, the swarm usually does not cluster but returns to the hive, and if a cluster does form it usually breaks up in a few minutes.

In a large apiary when swarms are issuing frequently, many swarms will settle on one particular support. The only plausible explanation for this peculiar action is that the support retains an odor acquired from contact with the swarm which acts as an attraction to other bees in the act of swarming. This lends considerable weight to the theory that clustering is a response to an odor stimulus. Beekeepers sometimes take advantage of this phenomenon and provide an easily accessible and readily handled support for the clusters. The swarm catcher (Fig. 47) is readily adapted to this purpose. In Langstroth-Dadant [1] (p. 218) is the statement that swarming bees cluster on any dark object that resembles a swarm in shape, especially if that object affords adequate support. This presupposes that bees are attracted to the clustering place through sight, for which supposition there is little evidence. In this discussion an old comb is mentioned as a favorite support, but in this case it cannot be claimed that sight is the only means of perception.

Supposed aids to clustering.

An old practice at the time of swarming was to beat tin pans, ring bells or otherwise to create a din, in the belief

[1] Langstroth-Dadant, 1907. Langstroth on the hive and honey bee, revised by Dadant. Hamilton, Ill., 575 pp.

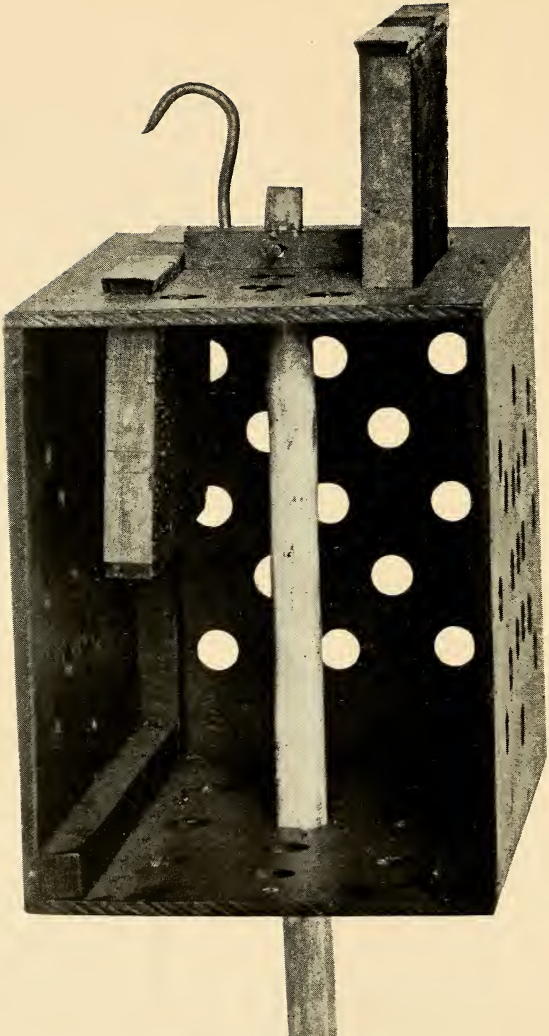


Fig. 47. — Swarm catcher.

that the distracting noise would cause the bees to settle. Modern beekeepers have abandoned this relic of antiquity, since it has no effect whatsoever on the clustering. The origin of this ancient practice has been variously explained, one plausible theory being that it arose from the practice of notifying neighbors of the issuing of a swarm, so that ownership could be claimed. Nowadays a bell is not a part of the apiary equipment and no evil seems to have come from neglecting this rite. Flashing lights on the swarm by means of a mirror is another theoretical impediment to long flights in which the modern beekeeper places no confidence.

Scouts.

Under natural conditions, when the queen is present, the swarm will hang on the support from fifteen minutes to a day or more. The cluster is usually then broken and the swarm flies away (often for a considerable distance) to establish itself in a hollow tree or cave. That scouts locate the future abode has been claimed, probably correctly. Baron v. Berlepsch, the celebrated German beekeeper, records [1] an instance of scouts working for several days in advance of swarming to prepare a place. Usually it cannot be so well demonstrated that scouts have been sent out, but the accuracy with which swarms often fly to a cavity without delay indicates that they are in some manner led to the place. How this is done is not known. Similar instances of bees being led to certain places are discussed in a later chapter (p. 120).

After the swarm has been removed (Fig. 48) a few bees will often be seen around the former location of the cluster, either at rest or on the wing. These bees are evidently attracted or held by the odor which adheres to the support. That these are scouts which return after the cluster is hived

[1] v. Berlepsch, 1852. Eichstädt Bienenzeitung, VII, Nr. 7. Reprinted in v. Buttel-Reepen, 1906. Are bees reflex machines? (Eng. trans.)

has been suggested. At any rate, the modern practice is to hive a swarm away from the clustering place for fear returning scouts may draw away the colony.

Entering the new home.

When a swarm enters a new abode, the first bees to locate the entrance stand with their legs extended and the abdomen raised to an angle of about 45°, while their dorsal scent glands (pp. 65 and 172) are exposed. They fan vigorously and the odor given off is sufficiently strong to be perceived if the nose is placed within an inch or two of the fanning bees. Bees to the rear take up the same position until finally the whole mass is fanning and moving toward the entrance [1] (Fig. 49). This may be observed also if bees are thrown in front of the hive.

When a swarm enters a cavity, the bees promptly clean it of loose pieces and dirt, the large pieces and irregularities of the cavity being ultimately covered with propolis. Large numbers of bees, especially the younger ones, now hang on one another in curtains while the secretion of wax takes place for the building of combs. The supply of honey carried in the honey stomachs is adequate to nourish the colony for a time if no nectar can be brought to the hive. As soon as there are cells available the queen begins egg-laying, the field bees gather the available nectar and pollen and these activities increase as the comb is supplied by the comb builders. The swarm is equipped as a normal colony in a surprisingly short time, if the nectar supply is adequate.

[1] If by chance the first bees are headed in the wrong direction or if the hive is moved after the fanning has begun, the whole mass may march away in the wrong direction. In shaking bees in front of the hive it is therefore advisable to toss some of them in the entrance. v. Buttel-Reepen attributes this action to the sound given off in fanning, but there is little to support this belief. In this marching, any slight obstacle interferes greatly with the progress of the mass of bees, which would scarcely be the case if sound were the attracting stimulus. Even the smallest amount of smoke interferes for the moment with the entrance of a swarm and smoking should be avoided at this time.

FIG. 49. — Swarm entering a hive.

Parent colony.

This name is usually given to that part of the original colony which remains in the hive after the swarm issues. It is misleading in that the actual parent of the individual bees, the queen, departs with the first swarm but, as ordinarily used, the term indicates merely the colony from which the swarm issues and is not misunderstood. The course of events in this colony will now be given, it being assumed that, in the present instance, another swarm will not be cast. In a few days (often about eight days) after the departure of the swarm, the first young queen emerges from her cell by gnawing her way out, often with the help of the workers.[1] She may destroy the other queens by gnawing into their cells, so that she is without a rival in the colony, and she may be assisted in this destruction by the workers.

Mating flight.

When a few days old, the time depending somewhat on the weather and the race of bees, the virgin queen flies from the hive for the first time. Her early flights, often several in number, resemble the first flights of worker bees for she circles about the entrance, gradually venturing farther away, apparently taking note of the location of the hive. At last when from five to eight days old, she flies quickly from the hive without preliminary circling and flies upward in larger and larger circles, often until she is lost to vision.[2]

[1] Before the queen emerges, the bees frequently gnaw away part of the capping of the queen cell, making it thinner and smooth. As the virgin queen cuts her way out she may be fed by worker bees. In cutting the queen cell, it frequently happens that a circular cut is made and at one place the capping is left intact, forming a kind of flap. After the queen emerges this flap may spring back into place, confusing the beekeeper who sometimes does not recognize the cell as an empty one.

[2] In the summer of 1903, the author and an equally ardent co-worker made a series of observations on the flight of virgin queens in the vivarium of the Zoological Department of the University of Pennsylvania. Small nuclei were placed about the room, which is covered with a glass roof, and a full colony was so arranged that the workers could fly freely to the outside but the drones could leave only to the inside. The drones used had never

On such a trip she meets the drone and after mating [1] takes place she returns to the hive. She may be followed back by a considerable number of drones which sometimes remain about the front of the hive for several hours. The mating flight may last only a few minutes or may be protracted to over a half-hour, probably depending on the number of drones in flight near by. The male genital organs which are torn off in mating may often be seen protruding from the queen's vagina and this is useful to the beekeeper as evidence of mating. These parts shrivel in a short time and are removed by the workers. In about two days after

flown outdoors, it being found that drones which had experienced flight in the open air soon wore themselves out on the glass in their efforts to escape. Virgin queens were introduced to the nuclei and their flights were observed from the rafters above. The first flights were circles of small diameter and while on these flights the queens were never seen to be followed by drones. If the virgins did not fly frequently enough to satisfy the observers they would sometimes be removed and tossed into the air, when they behaved normally. Finally the virgin would dart from the entrance and swiftly circle upward, often followed by several drones. She would soon strike the glass roof and alight and the drones would at once disperse, there apparently being no attraction in a queen at rest. It has long been the dream of beekeepers to induce mating in an inclosure, so that mating can be controlled for purposes of selection and the observations here mentioned were instigated by this desire. No queens mated in the room. The virgin queens usually returned to the nuclei unassisted, unless the flight occurred late in the afternoon.

During the summers of 1903 and 1904, several unsuccessful attempts were made to produce drone-laying queens (p. 187) by confining virgin queens to prevent mating flights. During the morning the small nuclei showed no special signs of excitement but in the early afternoon the queens would attempt to eave the hive and would be prevented by the perforated zinc over the entrances. They would sometimes continue these efforts until dark. While this was going on, the workers would crowd around the entrance both inside and out and rush about "as if offering assistance." These efforts were not observed during the first few days after emergence of the queens from the cell and finally the queens were no longer seen at the entrances. Within a month they had all died. Whether this was due to over-exertion or to the inability to mate or whether they were killed by the workers could not be determined. Keeping virgin queens in cages was equally unsuccessful.

[1] The act of mating is rarely seen, but a few beekeepers have reported instances in which this was observed. Apparently after the union the queen and drone fall to the ground and the queen turns around and around until she tears the copulatory organs from the dead drone.

mating, the queen begins to lay eggs and from that time on the routine of egg-laying is her portion. The so-called parent colony is now normal, with a laying queen, comb, stores and brood.

After-swarms.

If the colony which cast the first swarm is populous, there may be left in the parent colony enough bees to cause the issuing of other swarms. These are called second-swarms, third-swarms or, collectively, after-swarms. When the first virgin queen emerges she often does not destroy the other queen cells but, instead, flies from the hive with another swarm. This may be repeated several times as other queens emerge, the swarms usually becoming successively smaller. The queens departing with after-swarms are virgins and consequently must mate before they are able to fulfill their duties normally. Good beekeepers make every effort to prevent after-swarms as they are usually too weak to be of value and they deplete the parent colony, making the gathering of surplus honey impossible. When virgin queens fly out to mate, they may be accompanied by a little "swarm," which affords some evidence that the swarm is led out by the queen. Nuclei used for mating queens are often almost depopulated in this way.

If the old queen in a colony is prevented from flying or is unable to fly (as by having the wings clipped), the bees may make several efforts to swarm without her. They often finally kill the old queen and depart with a virgin. Such a swarm may be the first to issue from a colony in the season, but it is virtually an after-swarm in its composition and behavior. Swarms of this kind often cause the beekeeper trouble if he is unaware that the old queen has been superseded, and consequently if the old queen was clipped he thinks that the swarm is without a queen and will return.

After-swarms are the plague of the beekeeper's life, for they seem to break all the laws of the bee colony. They often cluster without a queen, they are fleet on the wing, they may fly directly to the woods without clustering and they cannot be accurately foretold, as can a first swarm, when the queen cells are of value as a forewarning.

Activity of swarms.

It is often maintained that the bees in a swarm work with greater vigor than those which have not swarmed. While this cannot be accepted without qualification, there are certain activities which are more in evidence at this time. Wax secretion is apparently carried on more readily than under other conditions, and if nectar is available the bees may be so manipulated that a large amount of surplus honey is obtained. To take advantage of the supposedly increased activity of the swarm, the same conditions are partially induced artificially in various manipulations. The effect of swarming on egg-laying has been mentioned. It is probable that the supposed vigor of swarms is due not so much to the accomplishment of more work as to the diverting of the labor of the colony into lines which are more conspicuous to the beekeeper. It will be shown later that colonies which swarm produce less honey than those which make no effort to swarm.

Swarming conditions induced artificially.

While so-called artificial swarms are a part of the practical manipulations to be discussed in later chapters, it may be of interest to record some attempts at producing swarming conditions which throw some light on the natural phenomenon. During the summers of 1912 and 1913, the author was interested in the taking of motion pictures of bee activities. In the first season, Fortune favored the project by permitting the use of a natural swarm, which was, however, artificially delayed until the camera was adjusted. In all cases the clustering was produced artificially. In the first case, a swarm issued on a Thursday morning and the queen was caught, caged and placed in the second story of the hive, thus causing the bees to return. At eight o'clock the following Saturday morning the queen was liberated and about nine o'clock the camera was focused on the entrance and front of the hive. In not more than fifteen minutes after everything was ready and as the waiting group was in attendance seated on adjoining hives, the swarm came out and the camera was put in action. When the (clipped) queen left the hive, the camera was stopped and she was put into a queen cage which was then tied to the limb of a tree, so situated that a swarm hanging on it would show against the sky. When the bees returned to the hive they were shaken into a box and thrown unceremoniously into the branches of the tree around the caged queen. Those that returned to the hive were again brought out. In a short time the fanning observed in a natural cluster was set up and the bees gradually formed a shapely cluster. To get pictures of the settling of the swarm, the branch was now shaken, at first gently and then more and more vigorously, and the bees returned to the same branch in the exact manner of the clustering of a natural swarm. Here again the camera man was busy. The further treatment of the bees was exactly as with a natural swarm.

Since the first pictures were not satisfactory, the performance was repeated twice the next year but without the aid of a natural swarm. The bees were shaken into an empty hive on the old stand with the entrance closed by a stick. The clustered bees were then loosened from the inside of the hive cover by pounding, and as the stick was removed the camera was started. The rushing out of the bees could not be distinguished from that of a natural swarm. The bees were then shaken into a box and placed on a branch about the caged queen. These unusual procedures suggest that the clustering is brought about by the attraction of the odor from the dorsal scent gland and that the bees may be induced to abandon their old hive by the shaking incident to this manipulation. It is also suggested that the queen plays an important part in clustering.

Peculiarities of bees in swarming.

A bee normally returns from the field to its own hive and, while it may make mistakes, it "knows" its own location. This is accomplished by the exercise of a memory of location (p. 179). When the swarm issues, the memory of the old location is abandoned (not destroyed), but if the queen is lost or removed this memory is again called into action and the bees return to the old hive. If the queen goes with the swarm, it may be placed in a new hive, even right beside the old one if desired, and the bees no longer return to the old hive. On the return from future trips to the field they go directly to the new home. The memory of the old location is no longer called into action and is finally lost. This is accomplished also in artificial swarming but perhaps not to so marked a degree.

When a swarm issues and the air is filled with the circling bees, it sometimes happens that other colonies which are preparing to swarm will send out swarms prematurely and the various swarms will mingle in the air and in the cluster. Even if this does not happen, drones from various colonies join the swarm. These facts indicate that swarming bees have an attractive influence toward other bees. This has been attributed to the noise made by flying bees, which is so well known to beekeepers and which is sometimes called the "swarm tone." Since it is not surely determined that bees hear, it may be that this attraction is not one of sound but may be one of smell.

The issuing of premature swarms and of numerous afterswarms may become so common as to demoralize the apiary and swarms may issue several at a time, without queens, when no queen cells have been built or when the colony has recently swarmed. Several swarms may unite in one cluster. The impulse to swarm is known among beekeepers as the "swarming fever" and the exaggerated conditions just described are often discussed as if this "fever" were infectious. Under such conditions, the usual rules for swarming laid down by the beekeeper are seemingly disregarded, which may be construed as evidence that, after all, the beekeeper knows little about swarming.

Since swarming bees influence other bees to swarm prematurely, it is evident that these conditions may become worse in large commercial apiaries than would be the case if colonies were scattered as wild bees are or where only a few colonies are kept together. This abnormal condition is largely the result of modern beekeeping, not only in the maintenance of large apiaries but more especially in the manipulations practiced in comb-honey production.

It is sometimes assumed that bees from colonies about to swarm get mixed in other colonies and serve to incite swarming in their new homes. There is no good evidence for this belief.

It should also be noted that when preparations for swarming are well under way, the various manipulations devised to prevent it are usually unsuccessful and the only way to get the colony back to normal (normal from the standpoint of the beekeeper) is either to allow it to swarm naturally, to make an artificial swarm, or to remove or cage the queen. This and numerous other facts observed in swarm control indicate that the condition of the bees which induces swarming is not one which comes into existence suddenly, but is the result of a gradual development. Whether this condition is physiological or psychological is undetermined. Whatever the condition may be, it is in a sense at odds with the gathering instinct, so that one of the most difficult problems of the northern comb-honey producer is to keep his colonies in the optimum condition for gathering, which is equivalent to swarm prevention.

Cause of swarming.

Perhaps no subject in bee behavior has been so much discussed as the cause of swarming. The simplest way to account for this phenomenon is to attribute it to "instinct" but naturally in doing this we are no nearer an explanation than we were before. Instinct is blamed for many things in bee literature, it being overlooked that instincts are called into action only by definite conditions in the environment. It is also a common error to assume that bees voluntarily call forth this instinct when "things look favorable," but this is similar to the giving of human motives to other actions and is unjustifiable here as elsewhere. This kind of error is mentioned again here because it appears so frequently in the discussion of swarming.

Overcrowding of the hive, lack of ventilation, heat, an abundance of drones and other conditions have been repeatedly given as causes or contributing conditions to swarming. Unfortunately for these speculations, the conditions named may be partially or entirely lacking at the time of swarming, although generally they are present in colonies about to swarm. To establish the cause of swarming, however, it is first necessary to find a condition or conditions which are invariably present. While this problem is as yet unsolved, an analysis of some of the facts observed may be helpful.

It should first of all be observed that swarming is particularly prevalent in the northern regions. Near the northern limits of the white clover belt, for example, there is a definite, relatively short period when swarming may be expected. This comes before and during the white clover honey-flow but when the nectar is coming in freely swarming may become rare. Beekeepers usually explain this by saying that the bees are too busy gathering nectar to swarm, but this explanation is unsatisfactory. Farther south, there is a less well marked swarming season and the percentage of colonies which swarm or which prepare to swarm decreases as a rule, until under average tropical conditions swarming becomes much less abundant, the swarming period being less definite and more prolonged. There are some exceptions to this general statement. Swarming may extend over six weeks or more in parts of Florida but is never as excessive as it sometimes is in the North.

It should further be noted that colonies headed by young queens are less likely to swarm than those with older queens. For example, if a young queen is introduced to a colony in August the probability of a swarm from that colony the following spring is less than if the queen were reared early the preceding spring.

Within the white clover region, some interesting differences may be noted. Geo. S. Demuth of the Bureau of Entomology reports the following interesting variations. In southern Indiana swarming has usually ceased before the beginning of the white clover honey-flow, while in the northern part of the State the swarming season extends into the honey-flow. This indicates that the stimulus of the heavy honey-flow is not the cause of swarming. In one season which came under Demuth's observation, white clover failed to secrete enough nectar to provide surplus honey in northern Indiana and colonies were unable to build up sufficiently to swarm. In August, however, there was a heavy yield from heartsease, the colonies built up rapidly and there was a well marked period of swarming. Demuth at one time practiced moving his bees in the fall to the Kankakee swamps for the Spanish needle honey-flow. While swarming was common in the spring during the white clover honey-flow, it was not so during the fall honey-flow. The same thing is observed when clover is followed by buckwheat. While, therefore, honey-flows influence swarming by providing stores whereby colonies may build up to swarming strength, they can scarcely be considered as primary causes of swarming.

The lack of adequate space for breeding is a common condition in colonies from which swarms issue and the contraction of the brood chamber in comb-honey production probably contributes to excessive swarming. However, if the contraction is excessive swarming is greatly reduced and if this is carried to the extreme we have artificial swarming, in which operation all the brood combs are removed.

There is a marked difference in the amount of swarming according to the type of honey produced. In the production of extracted-honey, in which the bees are provided with an abundance of empty combs, swarming is much less common than from the contracted and crowded hives considered necessary for the production of comb-honey. Similarly in the "non-swarming hive" devised by L. A. Aspinwall, Jackson, Michigan, an abundance of room is provided in the brood chamber by the insertion of slatted wooden separators between the brood combs. From this array of seemingly irreconcilable statements, one thing in common may be observed. So far as contraction is concerned, when swarming is less common there is room available for the young bees which have not yet begun their field duties.

In the preparation of his Farmers' Bulletin on Comb Honey,[1] Demuth makes a careful analysis of the various methods employed in the control of swarming, which is so important a problem in the production of comb-honey. The following quotation from this bulletin gives his conclusions: "Any manipulation for swarm control, whether applied after the colony has acquired the 'swarming fever' or applied to all colonies alike previous to the swarming season, is based upon a single principle — *a temporary disturbance in the continuity of the daily emergence of brood.* This disturbance should occur just previous to or during the swarming season." While the various methods of swarm control are reserved for a later chapter, the fundamental principle that there must be a temporary disturbance in the continuity of brood emergence, which Demuth was the first to point out, is of primary importance in a consideration of the cause of swarming. The methods described in Demuth's bulletin are those which have proved reliable in the hands of practical beekeepers throughout the United States and yet these methods do not have in common those things which are called for in considering overcrowding, overheating, lack of ventilation or the presence

[1] Demuth, Geo. S., 1912. Comb Honey. Farmers' Bulletin 503, U. S. Dept. of Agric. [see especially pp. 34–35].

of drones as causes of swarming. If these things are really causes of swarming it is somewhat remarkable that the application of remedies for these conditions are not more serviceable in controlling swarming.

The principle involved in swarm control and the differences in the amount and persistence of swarming observed in different regions and under different systems of manipulations indicate that swarming colonies have at least one condition in common. While this condition may not be the cause of swarming, it is at least interesting to study its application. Gerstung advances the theory that swarming is caused by the presence of too many young bees in the hive. These bees, as will be discussed in a chapter to follow, are those which feed the larvæ and the usual supposition is that there is too much larval food prepared and that the presence of this food in the nurse bees induces the building of queen cells and the rearing of queens. While this effort at explaining the results of the presence of an unusual number of young bees may be open to question, it may at least be pointed out that swarming is always accompanied by an unbalanced condition of the brood-chamber (not of the hive) in regard to the age of the bees found there. If the various preceding statements concerning swarming are re-examined, it is seen that when swarming occurs normally there is actually this unbalanced condition. In the northern regions breeding reaches its maximum in a shorter time than in the South and consequently as this brood emerges the colony suddenly acquires an unusual number of young adults. Where the season opens earlier this condition is reached earlier (*cf.* southern and northern Indiana), while in the South, where breeding increases more gradually, this condition becomes less marked. Finally in the tropics the preponderance of young bees does not occur unless breeding is decreased by a dearth and begun again by a rapid flow. Variation in seasons may cause either a more gradual breeding in the North or a greater rapidity farther south. This may explain the divergence in the experience of beekeepers from year to year in the number of colonies which prepare to swarm. If there is a dearth of nectar, swarming may be lacking and may accompany a later honey-flow (*cf.* example of heartsease honey-flow, p. 77), when the unbalanced condition likewise occurs. Where an abundance of room is provided (*e.g.* extracted-honey production), the younger bees are usually found in the upper portions of the hive away from the brood, and to this extent they are eliminated. In the Aspinwall hive, the space between the slats provides room for the young bees away from the brood. The distinction of having the young bees away from the brood is probably important and finds its application in the proper manipulation of comb-honey supers (p. 314). A queen is capable of maximum egg-laying only after some weeks of egg-production and this may serve to explain the lack of swarming in colonies headed by queens reared and introduced in August. Demuth's conclusion on the control of swarming exactly coincides with this theory as to cause.

This theory is not again brought forward as a satisfactory solution of the cause of swarming. It is desired at this time merely to point out that, of all the theories advanced, this most nearly satisfies the various and divergent conditions observed in connection with this peculiar phenomenon. The subject is one of great interest and of the utmost importance to the practical beekeeper. It is worthy of more serious investigation than it has so far received.

Swarming-out.

Bees sometimes abandon their nest and to this phenomenon is usually given the name "swarming-out." This is misleading since it indicates some relation between this and swarming and it is not definitely known that any such relation exists. Swarming-out may occur under a variety of conditions, the most common of which is in the early spring (or at other times) if the stores are exhausted. These are also known as "hunger swarms." Some of the published records of extraordinarily early swarms are doubtless instances of swarming-out rather than of swarming. Nuclei used in queen-rearing are frequently depopulated, but this may be a case of the bees accompanying the virgin queen on her mating flight. When American foul brood is present in a colony, swarming-out is of common occurrence, the bees abandoning the hive when in advanced stages of the disease. Whether this is due to the influence of the (to us) unpleasant odor is not clear.

Somewhat similar is the abandonment of the hive so frequent after hiving artificial or natural swarms or after treatment of a brood disease. After the artificial swarm is made, the bees may leave immediately or they may begin work and then desert the hive within twenty-four hours or even later. This is prevented if a comb containing unsealed larvæ is given the colony or, if a queen trap is placed over the entrance, the deserting bees will return to the imprisoned queen. When bees swarm-out they may cluster or they may fly away as after-swarms often do. After artificial swarming, a colony may repeatedly attempt to swarm-out, suggesting the intensified swarming sometimes observed in northern comb-honey apiaries. After sufficient comb is built and when larvæ have hatched, this trouble disappears. The swarming-out of colonies under adverse conditions suggests the reported action of giant bees (*Apis dorsata*), which are said to abandon their combs if attacked by the wax-moth, or to migrate with the change in seasons to districts where nectar is available.

GATHERING OF NECTAR AND STORING OF HONEY

At any time that nectar is available, if the weather is suitable for flight, the bees gather nectar to be converted into honey for use as food. Usually, as early in the spring as bees are able to leave the hive for extended flights, there is some nectar available but, under the adverse condition of spring, when the colonies are weak and when flying is difficult, no more honey can be obtained than bees need for their own use and usually they must draw on their old stores during this season. In almost every locality, there are later periods when no nectar is available or at least when there is less than enough to maintain the colony. That commercial beekeeping may be possible, there must be other periods when the amount of honey produced is in excess of the requirements of the bees until the next honey-flow. This surplus may become the beekeeper's.[1]

Periods of surplus depend solely on the plants of the region and consequently they vary with different localities, as do the plants. The problem confronting the beekeeper, therefore, is so to manipulate his bees that, when nectar is available near his apiary, the bees may be in condition to secure the maximum quantity. Varying conditions call for different systems of management. This fact is well known to practical beekeepers but, nevertheless, these differences lead to confusion. For example, a beekeeper in the white clover region works out a method by which he is able to control swarming and thereby to secure maximum returns. The system is published, whereupon it is perhaps tried by beekeepers in buckwheat, Spanish needle or alfalfa regions. The bee journals are probably then filled with articles by these men who perhaps report failure. There would be great good from this interchange of results did it not tend too often to create a belief that, for example, bees in Colorado behave peculiarly because they are in

[1] It may not be amiss to call attention to the incorrectness of the conception that bees and, in fact, all plants and animals were created or evolved for the use of man. It would scarcely be necessary to refer to this were it not that frequently such statements appear in the bee journals. Not until one realizes that every species of plant and animal is in a struggle for its own existence, without regard for the welfare of any other species, can one get a correct conception of the facts of Nature. The honeybee was evolved from less specialized insects because the changes fitted it better to its environment; they store honey because the instinct to do so fits them better to their environment. The fact that man can take some of this honey should not cause him to think that all this course of evolution was for his benefit.

Colorado. In other words, the difference in "locality" is too often considered as a matter of geography. Obviously, political boundaries are nothing to bees and they behave similarly everywhere under similar conditions. The differences lie in a failure to observe and to record the peculiar conditions of the "locality," to appreciate the underlying causes of the behavior of the bees and to explain why the manipulation is a success or a failure, as the case may be, in the light of local conditions. If these distinctions were better understood, it would save much loss of effort and many failures. Obviously, a beekeeper should know not only what to do and when to do it, but why. It frequently happens that a beekeeper going from one place to another attempts to follow his former practices in the new place and usually this leads to failure.

The flows of nectar which are of value for surplus are those which come after the colonies are strong, but earlier honey-flows are of great value in providing stores and in furnishing a stimulus to breeding. For each situation, it is therefore most desirable that the plants which furnish nectar be known and that the usual time of blossoming be learned. With this information, the beekeeper can so manipulate his colonies as to obtain maximum results. The study of the periods of blossoming is especially necessary in the more northern regions where the honey-flows are sharply circumscribed. In the South, the honey-flows more usually run together and there is less difficulty in having colonies strong for the surplus honey-flows. Honey plants do not bloom in the same relative times in different localities. For example, in some places white clover has usually ceased to secrete nectar before the basswood honey-flow begins while in others they are mixed. Following the clover honey-flow there is often a dearth until the fall flowers begin to secrete, but in some northern localities white clover may be delayed and the fall flow advanced until they leave practically no interval.

A current fallacy should perhaps be denied. Bees do not cease to store honey in the tropics. Just where a contrary statement originated is difficult to learn, but the supposed fact is sometimes used as a demonstration of the wonderful wisdom of bees in learning that nectar is always obtainable. It has also been used as an evidence of adaptation. The great crops of surplus honey obtained in tropical countries are sufficient denial.

The gathering of nectar and the storage of honey is a pure instinct, in that it is done without previous experience, for a definite purpose and with no knowledge of the end to be accomplished. As will be explained in the following chapter, this is normally the work of the older bees in the colony. The nectar is carried to the hive in the honey stomach (Fig. 60) where it is regurgitated into cells of the combs. Here it is "ripened" into honey. This ripening consists in the removal of the surplus moisture, the water in honey usually being about twenty per cent of the total, while nectar is often over sixty per cent water. The chemical composition of nectars has not been sufficiently studied and, indeed, this is a hard problem, because of the difficulty of obtaining sufficient quantities without modification. Enough is known, however, to allow the assumption that the ripening process also includes the changing of sucrose (cane sugar) into invert sugars (dextrose and levulose).

In the laboratory inversion is accomplished by the addition of an acid to the cane sugar solution and there is a small amount of acid in honey. What this acid is has not been determined, it being usually calculated in analyses "as formic acid," which must not be misinterpreted as indicating that the acid actually is formic acid. It indicates merely that in the analysis the acidity is calculated as if the acid were formic acid. It was formerly believed that the poison of the bee sting is formic acid and various fanciful theories have been advanced to explain the origin of the formic acid supposed to be present in honey. The worst of these explanations is that just before sealing the honey, a worker bee puts a drop of poison from the sting into the honey to preserve it. No such action has been observed. Possibly these speculations are the basis for the calculation of the acidity of honey by the chemist "as formic."

The conversion of sucrose to invert sugars may also be accomplished by the action of enzymes and the bee produces these, although what part of the bee's body is the origin of the enzymes is not yet fully established. Honey, as stored in cells, contains some suspended pollen grains which are a probable additional source of enzymes. Inversion doubtless continues after the honey is sealed.

The instinct to gather nectar and to store honey is not universally predominant in the activities of a colony, even though nectar is available. When a colony is preparing to swarm it does not store as actively as at other times and one of the serious problems of the northern beekeeper, especially the comb-honey producer, is to keep his bees in proper condition for storing. Since swarming and storing are both instinctive activities, the substitution of one for the other assuredly does not imply knowledge of future needs, as is sometimes claimed. After swarming is over, the storing instinct appears as prominently as usual.

Collection of other materials.

The gathering of pollen and propolis and the collection of water are likewise activities of the colony. It is sometimes stated that pollen is gathered only when needed but this is not true, for queenless colonies gather large quantities. The advice is occasionally given to watch the entrances of colonies in the spring to determine whether pollen is coming in, it being stated that queenless colonies may be detected by a lack of pollen gathering. This is not a safe criterion. Propolis is collected most abundantly in the late summer and autumn and usually only when there is no heavy nectar-flow. Water is needed at practically all times during the breeding season, perhaps more especially in hot weather. The bringing of water to the hive is most noticeable in the early spring.

KILLING OF THE DRONES

At the close of the honey-flow and after the swarming season, the drones are driven from the hive. They are not stung to death as is commonly reported. The first indication of the exodus of the drones is that numbers of them are seen on the bottom board or around the entrance. There is some evidence that before removal the drones are starved, they normally being fed by the workers and not taking food directly from the stores. Then the worker bees drag them out one by one and fly away, dropping them some distance from the hive. This driving out of the drones is more marked in the northern regions where the main honey-flow usually ceases abruptly. If a colony is queenless the drones may be retained, some of them often living into the winter and, even in normal colonies, a few drones are sometimes retained for a time. The cause of the driving out of the drones in most cases and their retention under some conditions is so far not satisfactorily explained.

THE END OF BROOD-REARING

Where winter occurs brood-rearing ceases in the autumn, while in the tropics brood is reared constantly, unless it is discontinued by a dearth. Cessation of brood-rearing is therefore not a necessary occurrence in the annual cycle. It was shown earlier that the reduction in egg-laying begins with the cutting off of the nectar-flow. When the days become cold, brood is no longer reared and finally the last of the brood emerges leaving the colony without brood for most of the winter, provided it remains normal. The last eggs laid may be removed by the workers before they hatch, or larvæ and pupæ may be carried out.

In seeking an explanation of the stoppage in brood-rearing, one becomes involved in some difficulties. In the first place, various races of bees differ in regard to the amount and continuance of brood-rearing in the autumn. Italian bees decrease the amount of brood when the honey-flow stops while Carniolan and Caucasian bees rear more brood "out of season," or after the honey-flow. But all races rear some brood "out of season," so that the final discontinuance of brood-rearing cannot be considered as due to lack of incoming nectar or pollen. Even among colonies of the same race there is considerable variation in a single apiary. Of course, no colony can rear brood without food for the young larvæ. The stoppage of brood-rearing is sometimes attributed to low outside temperature but, as stated earlier, brood is sometimes reared in the coldest months, in fact it is usually begun then in colonies wintered out of doors. As will appear later, the cold outside during January is the cause of a higher temperature within the cluster than is usual in the autumn and, combined with the effects of the accumulation of feces, is the cause of higher cluster temperature than occurs with the same intensity of cold in December. Furthermore, when a colony begins brood-rearing in the winter, the presence of brood seems to induce the production of sufficient heat to care for it, the resulting temperature being sufficient to induce more egg-laying, so that brood-rearing once begun continues through the remainder of the winter. Since a moderately low outer temperature may cause more active heat production in a small colony than in a strong one, this may explain some of the variation observed in the time that brood-rearing ceases. A small colony may have a higher cluster temperature than a strong colony, the greater activity in the center of the cluster being necessary to produce the required temperature in the shell of the cluster, which is a less efficient insulator in a weak colony. The structure of the cluster is described in the following section. If an explanation for the cessation of brood-rearing is sought, the paradoxical conclusion is reached that in the fall (1) the outside temperature is not high enough for brood-rearing without artificial heat production and (2) it is not low enough to cause the bees to produce sufficient cluster heat for brood-rearing. Egg-laying and brood-rearing may seemingly be stimulated either by a high or very low outside temperature.

THE WINTER CLUSTER

There are three possible ways by which an animal can survive a protracted period of adversity like a northern winter, when food is not available in the field and when it could not get food even if it were present, because of the cold. The first method is hibernation, in which the only storage of food is within the animal, and at low temperatures the vital functions apparently cease. This is the universal mode of wintering among solitary insects and, even among the social species, in bumblebees and wasps, the majority of the colony die off while the fertile queens hibernate like solitary insects. Ants hibernate in a mass during extreme cold weather. Another method is migration, but this is not open to most insects because of their size and inability to fly long distances, as do birds. If a cold-blooded animal cannot hibernate, as the honeybee apparently cannot, nor migrate, there is but one course open to it. This is to lay up a store of heat-producing food and, when the surrounding temperature falls below that at which the animal can live, to generate heat, virtually to create a thermal environment of its own. This remarkable procedure, in which the honeybee is unique among insects, is the one encountered in a study of bees in winter. Beekeepers have long known that the winter cluster is warm but they have perhaps failed to comprehend the marvel of an insect which can use this method of overcoming adverse conditions.

The hoarding instinct, the instinct to store food in great excess of the immediate needs, now becomes of vital importance to the continuance of the species, but it would serve no useful purpose in the winter season if the bees in a colony did not also have the ability to generate and conserve heat. As will be seen later, the generation of heat is by a method common to all insects and other cold-blooded animals while the conservation of heat depends chiefly on the structure of the winter cluster.

When the last brood has emerged, the colony and its nest are then in condition to pass the winter. In cold weather the bees form a single compact cluster and leave the hive only on occasional warm days for cleansing flights. Bees do not discharge their feces in the hive so long as they are in normal, healthy condition but, after even a short confinement, will venture out for this purpose as soon as the outside temperature permits.[1]

Movements in winter.

The cluster is first normally formed where the last brood emerged; here the bees find empty cells into which to crawl, so that they form themselves into a compact mass, separated only by thin walls of wax. They do not form the winter cluster where the combs are filled with honey and it would probably be impossible for them to conserve the heat of the cluster if sheets of honey separated the bees in adjacent spaces. As the contiguous stores are consumed and additional cells are emptied, the cluster is shifted so that the bees are always near stores. This shifting is, however, apparently impossible in extreme cold weather, when colonies sometimes die in a way that can be explained only as due to starvation through inability to reach stores just a few inches distant. The early fall cluster is usually low on the combs, near the entrance, if there is considerable honey stored and the movement of the cluster is usually upward and toward the rear of the hive as winter progresses, and as stores are consumed. If a colony is in a two-story hive, the cluster is often in the upper story in the spring.

Responses to outside temperature.

The cluster varies in size with the outside temperature. After the emergence of the last brood in the fall, if the

[1] Bees often remain in the hive at a temperature of 70° F. if a flight is not necessary, but will often fly when the temperature is about 50° F. if they have been confined for a time.

temperature is about 60° F., the bees do not cluster compactly and do not fly from the hive, even on bright days, but remain inactive on the combs. In this condition they are less active than at any other time in the cycle of the colony and approach most nearly to a condition of hibernation. During the warmer days there is no need of a tight cluster, for the function of the cluster is the conservation of the heat generated within. When the temperature is sufficiently high the bees generate no heat but, whenever the temperature of the air immediately surrounding the bees drops below 57° F. (the lowest temperature which normal bees ever experience in the hive), they form a definite cluster. As the outside temperature continues to fall, the cluster becomes more and more compact and the temperature of the inside of the cluster increases rapidly. After the generation of heat is begun, the temperature within the cluster soon reaches a point higher than that reached before heat generation was necessary. Within certain limits, the temperature of the cluster increases as the outside temperature drops and, as the outer temperature again rises, heat generation is reduced or discontinued while the temperature of the cluster drifts to meet the rising outside temperature. Heat generation is renewed if the outer temperature again drops, even though the temperature of the cluster and that of the outer air have not yet been equalized. This produces a peculiar inverse relationship between the outer and cluster temperatures. It is of particular practical importance that, within certain definite limits, the bees are not compelled to produce heat.

Conservation of heat.

The cluster consists of a hollow sphere of bees several layers thick, those between the combs with their thoraces in contact and abdomens extending outward. The cells within the cluster are also filled with bees. The hair on the thorax assists in making this living shell an excellent non-conductor of heat, so effective in fact that a point inside the cluster may sometimes be 100° F. warmer than a point a few inches away but outside the cluster. The number of inactive bees varies with the outer temperature, being larger at warmer temperatures when less heat production is required and smaller when more bees are engaged in activities involved in heat production.

Source of heat.

Within the hollow sphere are bees which move about freely, these being the ones most concerned in heat generation. They produce heat by muscular activity, such as movements of the legs and abdomen, but perhaps most effectually by vigorous fanning. The bees which form the shell constantly shift their positions and exchange places with bees from within. A bee from the center forces its way head first through the shell, then turns around and remains for a time on the outside layer. The shifting seems to be more rapid in cold weather than in mild.

Effect of accumulation of feces.

During the winter, the bees consume the honey stored during the summer. The undigested portion, which forms excreta, is retained in the rectal ampulla (hind-intestine) until the bees have opportunity for flight, for normally no feces are deposited by the workers within the hive. During the cold winters of the North there are times when bees cannot fly for several weeks and the generation of heat during such a period of cold weather requires increased consumption of food and causes an increase in the amount of feces. The presence of feces, on the other hand, causes the bees to become restless, to generate still more heat (see Fig. 145) and to accumulate still more feces. Apparently a colony in winter confinement is in the confines of a vicious circle and the successful wintering depends preëminently on good food. If, however, the colony is so placed that little or no heat must be produced, the situation is relieved and this the beekeeper accomplishes by placing colonies in the cellar, provided conditions within the cellar are correct.

Bees wintering in the open fly out whenever the outside temperature will permit, and after a considerable period of confinement many will fly out when it is so cold that they are unable to return. On these winter flights the feces are voided, consequently they are of the highest value to a colony wintered out of doors.

While numerous other points concerning the activities of bees in winter are left to be discussed in the chapter on wintering, it is evident from what has been said that bees are highly sensitive to changes in temperature, and that they have a wonderful ability to overcome the adverse conditions of winter by the generation of heat. It is to be noticed especially that they usually do not warm the whole hive or cavity but confine heat production to the cluster. It might therefore be concluded that a hive is actually little protection for them in winter but it should be remembered that this protects them from wind, rain and snow. They further seal the hive with propolis to make the top water- and even air-tight and some races contract the entrance with propolis. The practical bearing of these facts forms one of the most vital problems of the northern beekeeper and the discussion of this subject from the standpoint of practice forms a later chapter.

CHAPTER V

THE LIFE OF THE INDIVIDUAL IN RELATION TO THE COLONY

In the preceding chapter the activities of the colony are discussed, much as if the colony were an individual or unit. While this is a true picture of one side of the life of the species, it is not complete, for the individuals not only carry on their own life processes but pass through individual cycles. A knowledge of the interrelationships of the individuals within the colony is important for an understanding of the colony organization, for this complex society is based on a division of the labors of the hive, which is of the highest interest and of the greatest practical value to the beekeeper. While in this book there is no attempt at a complete discussion of the anatomy or development of the bee, it is necessary that these subjects receive some attention to outline correctly the little that is known concerning the physiology of the species. The discussion of physiology is reserved for another chapter.

DEVELOPMENTAL STAGES

This subject is one of mystery to the beekeeper. While the development of the bee in the egg has been investigated by several observers,[1] the papers on the subject are not

[1] Butschli, O., 1870. Zur Entwicklungsgeschichte der Biene. Zeit. f. wiss. Zool., XX.

Kowalevski, A., 1871. Embryologische Studien an Würmern und Arthropoden. Mèm. acad. impér. sci. St. Pétersbourg, (7) XVI, 12, pp. 1–70.

Grassi, Battista, 1882–84. Studi sugli artropodi. Intorno allo sviluppo readily accessible to beekeepers, and writers of books on beekeeping have not given to this subject as careful consideration as to the anatomy of the adult bee. The changes taking place during metamorphosis (pupa stage) are so wonderfully complex that an account of the transformation of the larva into an adult bee is almost unbelievable.[1] Because of the lack of attention given to the development of the bee in the literature on beekeeping, relatively more attention is here given it than to the anatomy of the adult bee.

Cellular structure of tissues.

To form a correct understanding of the development of the bee or of the structure of the adult, one must know something of the units of which the tissues are formed, called cells. This word, as used by the biologist, has a special significance, being applied to a type of structure which makes up the tissues of all plants and animals. This unit of structure is usually microscopic and a single organ of the bee may contain many thousands of them. The cell consists of a minute mass of protoplasm (living substance) containing a nucleus[2] (Fig. 50). Protoplasm is a complex organic substance characterized by life; the nucleus is a differenti-

dell Api nell' uovo. Atti dell' Acad. Gioenia di scienze nat. in Catania, Ser. 3, XVIII, pp. 145–222.

Dickel, O., 1904. Entwicklungsgeschichtliche Studien am Bienenei. Leipzig: Engelmann.

The work of Carrière u. Bürger (1898, Entwicklungsgeschichte der Mauerbiene. Abhdl. der kaiserl. Leop. Carol. Deutsch. Akad. der Naturf., LXIX, 2) on the mason bee, Calicodoma, is of value in a study of this subject. The recent work of Dr. Jas. A. Nelson of the Bureau of Entomology (1915, The embryology of the honeybee. Princeton University Press) is the most complete on this subject and is the most thorough work on the development of any insect. It is the only discussion of the embryology of the bee in English and should be consulted by any one interested in this phase of the life of the bee. The author is indebted to Doctor Nelson for help in the preparation of this section.

[1] The metamorphosis of the bee is described in detail by Anglas, J., 1900. Observations sur les métamorphoses internes de la guèpe et de l'abeille. 111 pp. Lille: Danel.

[2] This word, like "cell," is one of various meanings. It is used by the beekeeper to designate a small colony.

ated portion of the protoplasm which is especially active during the division of cells and carries the special organs (chromosomes), instrumental as the bearers of hereditary characters. The nucleus and surrounding protoplasm are closely united in their functions and are incapable of separate existence. The nucleus is, in its resting condition, usually rounded in form, while the remaining protoplasm is of various shapes according to the special functions of the cell. Protoplasm is characterized by ability to take in nourishment, to grow, to give off waste, to divide and to move in response to stimuli, but in each organ the cells become specialized to do some one thing especially well and they often lose some of the functions of primitive protoplasm. For example, a nerve cell loses its power of contractility but becomes specialized for transmitting nervous impulses, while a muscle cell has a marked power of contractility. A detailed discussion of the structure and function of the various parts of the cell in different tissues is, of course, impossible here,[1] but these few suggestions are sufficient to indicate the extreme complexity of the organization of each tissue that goes to make up any organism, such as the bee.

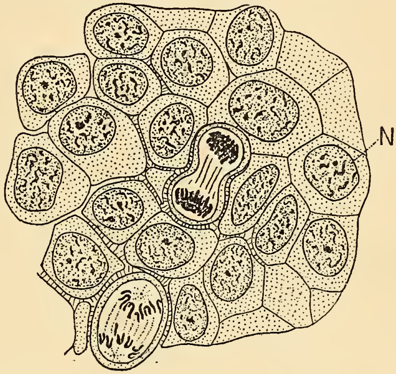


Fig. 50. — Group of tissue cells from skin of young salamander.

The egg.

The egg, as it leaves the ovaries of the queen where it is formed, is essentially a single cell. The eggs of most ani-

[1] The interested reader is referred to Wilson, E. B., The cell in development and inheritance. New York: Macmillan, and to other works on cytology.

mals known to the layman require fertilization (a union with one of the reproductive cells of the male) before they can develop, but there are many cases in which this is not necessary and the development of the drone bee is of this character. The eggs which develop into females are, however, fertilized. This difference has so important a bearing on practical beekeeping that a discussion of it is reserved for a future chapter.

The egg of the bee is a small white cylindrical object about $\frac{1}{16}$ of an inch long, somewhat larger at one end (future head end) and slightly curved. It is deposited on the base of the cell of the comb by the queen and is fastened in place by a secretion. The head end of the future larva is always formed away from the point of attachment. The egg is covered by chorion, a thin, tough membrane, the surface of which is ridged. These ridges are, however, quite minute and are not so conspicuous as most illustrations of bee eggs would indicate. In addition to the nucleus and surrounding protoplasm, the bee egg contains a relatively large amount of non-living stored food, yolk. The embryo is formed on the convex side of the curve of the egg, which becomes the ventral side of the larva. The fate of the various parts of the egg is therefore in a sense determined. Because of the presence of so much yolk, the early cells are not clearly marked off from one another.

Early embryonic development.

Development consists of the repeated division of the egg cell into numbers of united cells and of the rearrangement and differentiation of the resulting cells to form definite organs. As development proceeds, the cells become more and more specialized until the final adult condition is reached, and even in the adult, certain changes in some cells continue through the life of the individual. As cell division (or rather, in this case, nuclear division, for the protoplasm is continuous in the early stages) progresses, the nuclei move from the interior to the surface. During the second half of the second day, a thickening appears on the convex side, and, on the anterior end (larger end) of the egg, the first indications of the future appendages are soon visible (Fig. 51, *a* and *b*). These consist of the rudiments of the antennæ (*Ant*) and mouth parts (mandible, *Md* and maxillæ, *1Mx*, *2Mx*) on the head and of the three pairs of legs (*1L*, *2L*, *3L*) on the thorax. These rudiments are simply slightly rounded swellings which are at first smaller toward the posterior end of the egg, since development progresses from the anterior end. The embryo shows at first no division into

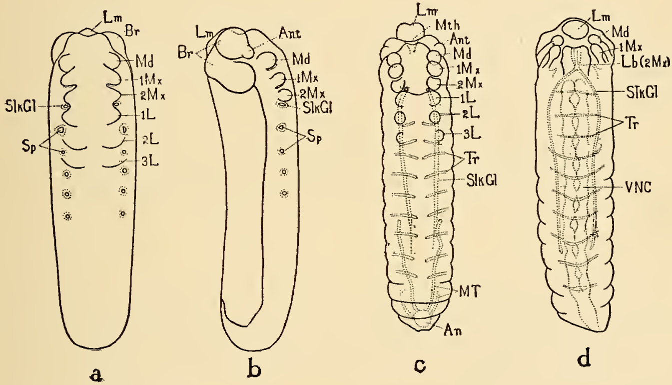


FIG. 51. — Three stages in the development of the embryo.

head, thorax and abdomen, but the fate of the various swellings must be determined by following them through. The rudiments of the stigmata (*Sp*, openings of the tracheal system) appear early and the first evidence of the silk glands (*SlkGl*) becomes visible about the same time just behind the second maxillæ. The first external indication of the nervous system is in two pairs of swellings (*Br*) on the upper side of the head. Even in this early stage, a number of important organs are already outlined.

Later embryonic development.

In a later stage (Fig. 51, *c*), the embryonic band on the ventral side of the egg has widened and in the next stage here illustrated (Fig. 51, *d*) the band completely envelops the egg. In the stage shown in Fig. 51, *c* the mouth (*Mth*) and anus (*An*) have appeared as pits. These continue to grow into the egg and ultimately join with certain cells on the interior to complete the alimentary canal. The portions formed by the two invaginations from the outside are the fore- and hind-intestine, while the part arising from the interior is the mid-intestine. The Malpighian tubes (*MT*), the excretory organs, arise as outgrowths from the anterior end of the hind-intestine. The pits (*Sp*) which are the rudiments of the spiracles, deepen and send branches forward, backward and downward to meet corresponding outgrowths from other pits, finally forming the tracheal trunks with their commissures and branches. The silk glands (*SlkGl*), which function only in the larva, project backward as long tubes.

Segmentation.

The most striking feature of the late embryo is the fact that it is constricted into a series of segments (metameres or somites) which are plainly recognized in the larva. These segments are characteristic of all insects and part of the metameres of the abdomen are still plainly marked off in the adult. From the fact that segmentation is recognizable in various parts of adult insects and is present in insect embryos, it is assumed that this form is characteristic of the primitive organism from which all insects have arisen. The typical appendages are arranged in pairs on the segments but in their later development these appendages are modified according to their fate. The stigmata and the ganglia of the nervous system are also arranged segmentally at first, but this primitive arrangement is later partially lost. The segmentation of various species studied does not wholly agree, but it is usually assumed that the first six or seven segments coalesce to form the adult head, the next three the typical insect thorax, and the remaining ones, usually twelve [1] in number, form the abdomen. The thorax of the adult bee is not typical, as will be explained later.

Fate of parts of the embryo.

Some of the head appendages of the embryo disappear early, being rudimentary organs. For example, the appendages of the second segment become the antennæ while those of the third disappear in insects, but in Crustacea (*e.g.* shrimps and lobsters) form the second antennæ. Several of the segments of the primitive insect head are not recognizable in the bee. In the adult insect, these segments fuse completely and by growth of various parts are so distorted that an examination of the adult head does not suggest segmentation and, without a study of the developmental stages, this segmental origin would be unsuspected.

The three thoracic segments are fused in the adult bee but, since the three pairs of legs arise from them, the segmental origin is suggested. The wings arise as secondary outgrowths or appendages, dorsal to the legs, from the two posterior thoracic segments and do not correspond with other appendages. In the adult bee, the first abdominal segment is also fused with the true thoracic segments to form the part known as the thorax, which therefore does not correspond exactly with the thorax of lower orders of insects. This fusion also occurs in most of the other Hymenoptera. The remaining posterior segments form the abdomen of the adult but not all of the segments remain visible to the outside. In the adult worker and queen bee, the five posterior segments are turned in to form a pocket around the sting and anus. In the drone, only four segments are so turned in.

The embryo, just before leaving the egg, shows no rudiments of antennæ or legs, these temporarily disappearing.

[1] Two of these segments are obscure and in later stages there appear to be present only ten.

The nervous system is now well organized, consisting of the brain and a chain of ganglia arranged segmentally. The second maxillæ fuse to form the lower lip (*Lb*).

Larval development.

At the end of about three days of embryonic development, the embryo breaks the chorion and becomes a young larva. During the larval period the most striking feature is the enormous growth of the animal. The illustration on page 40 (Fig. 35) shows an egg, a relatively young larva, a fully grown larva and a pupa drawn to the same scale and, when it is realized that the growth from the youngest larva to the fully grown larva takes place in a few days, the rapidity of growth is astonishing.

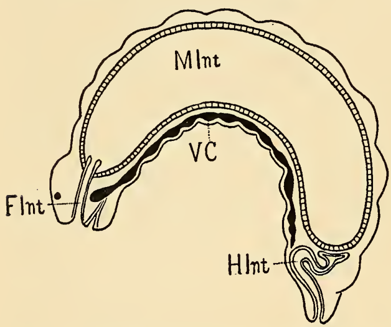


Fig. 52. — Diagram of a longitudinal median section of a bee larva.

It should be pointed out that the development of all insects is not similar. In the grasshopper, for example, a young insect hatches from the egg which resembles the adult in most respects. Such a development is known as incomplete metamorphosis. In the higher orders of insects, there hatches from the egg a larva unlike the adult and usually more or less worm-like, which when fully fed undergoes a complete and relatively sudden change into the adult. This type of development is known as complete metamorphosis.

The bee larva is an extremely simple organism, lacking legs, wings, antennæ and eyes, and is unprotected by hairs or thick chitin. A longitudinal section through the larva (Fig. 52) shows that the largest organ is the stomach, as is necessary for excessive growth. Being protected from enemies and from adverse environmental conditions in the cells of the comb, the bee larva needs no protective covering and, being fed by the worker bees,[1] it does not need organs which will enable it to seek or even to detect food or to masticate solid food. It is ideally adapted to the protected condition in which it is placed in the colony scheme and quickly perishes if removed and exposed to adverse conditions.

Metamorphosis.

After the excessive growth, the larva is sealed in the cell with a capping of wax (Fig. 39) and it then spins a delicate silken cocoon with the secretion of the silk glands (*SlkGl*) within the cell. Soon after this, all external motion ceases and the animal begins to undergo that wonderful series of changes known as metamorphosis. During the larval growth the mid-intestine and hind-intestine are not connected (Fig. 52) but this connection is made after sealing and the feces of the larva are then cast out.

The organs which served the larva are of course not suitable for the adult insect and the changes necessary to obtain suitable adult organs take place in the pupal stage. Anglas has described many of these changes but the metamorphosis of insects is so complex and so much disputed by various workers that it is to be hoped that the changes in the bee may be again investigated. The simple alimentary canal of the larva is discarded and a new one is formed in its place. The segmentally arranged muscles of the larva either disappear or are changed into those of the adult. The nervous system apparently loses some of the segmental ganglia by the fusion of various ganglion pairs. The antennæ, eyes, legs and wings develop from rudiments which have remained undeveloped in the larva. Not only do the internal organs change and new structures appear but the animal changes

[1] The larva of the honeybee is fed frequently during the period of rapid growth. In bumblebees (Bombus) and stingless bees (Melipona and Trigona), a cell is filled with a mixture of pollen and nectar, after which the queen lays an egg on the mass. The cell is then sealed and the larva is not fed further during the developmental stages.

its outward appearance. The small head of the larva grows to adult size, the thoracic segments and the first abdominal segment unite and undergo marked external changes to form the thorax of the adult. The abdomen changes least in external form but marked internal changes occur. This brief category of the vital modifications can give but a suggestion of the changes which the pupa undergoes. All of this occurs in an animal which externally seems lifeless, but the internal changes require such large expenditures of energy that the animal loses weight by the consumption of the food which the greedy larva stores up as fat in the fat body.

The external changes of the pupa are interesting, even though of minor importance. The compound eyes first change from white to pink by the deposition of a pigment around the rhabdomes of the eye (p. 167) and later this pink pigment is gradually covered by a darker external pigment so that the eyes appear brown and then black. The thorax shows coloration earlier than the abdomen. Toward the close of the pupal period, the outside of the animal becomes covered over with a layer of hard chitin for the protection of the adult and to serve as a skeleton for the insertion of the muscles. The legs and wings originate as hollow bud-like outgrowths on the thorax and after the last moult of the larva these invaginations are suddenly extended by blood pressure. The wings are at first small thin sacs which grow and finally take on the adult form, after which the two sides of the sac fuse and the blood in the sac returns to the body cavity, leaving the wings as dry membranes.

Length of developmental stages.

The length of the various stages of development varies among the different types in the hive. The preceding account applies especially to worker bees, which have been most frequently investigated, probably because of the ease of obtaining material. The stages are essentially similar in queens and drones. While the rapidity of development is slightly modified by changes in temperature of the hive, it is, in the main, quite uniform and it is therefore possible to give the time from egg-laying to emergence of the adult. It must be understood that these vary somewhat and it is rather remarkable that the variation is not more pronounced. On account of the variation the various tables given for the length of stages are not uniform. The following table (II) is a fair average:

TABLE II. DEVELOPMENTAL STAGES

STAGE	QUEEN	WORKER	DRONE
Egg	3	3	3
Larva	$5\frac{1}{2}$	6	$6\frac{1}{2}$
Pupa	$7\frac{1}{2}$	12	$14\frac{1}{2}$
Total	16	21	24

The figures given in this table for the pupal stage include all the time that the developing bee is sealed up in the cell. During part of this time, the larval stage is continued but no additional food is taken. This is followed by a semi-pupa stage, when the insect resembles a larva but has undergone a moult and the hind- and mid-intestine are connected. The true pupa stage follows this and the transition to the adult is gradual, the separation between the two stages being marked by the emergence of the insect from the cell. The number of moults in the larval stage are sometimes given as probably six (Cheshire). This should be more carefully studied.

The structure of the adult bee will be briefly discussed in conjunction with the functions of the various organs. When the young bee emerges from the cell it is structurally in the adult condition. It does not grow in size nor do any marked changes in most of the organs occur during adult life. This is true of all insects. While certain internal organs undergo change, these are not of a character to change the outside appearance. The food taken by the adult is not stored up within the body, as in the larva, but is taken for immediate use.

THE CYCLE OF DUTIES OF THE ADULT WORKER BEE

When the worker emerges from the cell, it is covered with a soft skin, the last pupal moult, which is quickly removed. For a day or two the young bee remains on the combs, frequently on the one from which it emerged, and moves about but little. Numbers of young bees are often seen in the upper part of the hive and especially in the supers. In a few days they begin the inside work [1] of the hive which

[1] An interesting opportunity for speculation is offered in attempting to determine the basis for the division of labor in worker bees according to age. In studying the structure of the compound eye, the author (Proc. Acad. Nat. Science, Philadelphia, Vol. LVII, pp. 123–157) was struck by the presence of enormous numbers of curved unbranched hairs which cover the eye of the young adult bee so completely that the facets are not visible. These hairs are broken off readily and in field bees most of the hairs have disappeared. It is probably impossible for the compound eyes to function while these hairs remain. These facts suggested the possibility that the young bees remain in the hive because they cannot see clearly enough to fly to the field and that when the hairs are lost the field work is begun. That the young bees are capable of flight is clearly shown by their ability to leave with a swarm. In this case, sight is probably not essential. In attempting to determine whether there is any ground for such a belief, numerous experiments were tried, by removing the hairs of young bees to see whether they were then more inclined to leave the hive. The hairs were scraped from some young workers and in other cases soft paraffin or beeswax and paraffin was applied to the eyes and then removed, the hairs breaking off with its removal. In every case the handling made the action of the bees abnormal, so that no conclusions of any value were obtained. That this is probably the correct interpretation of the function of these hairs still lingers in the mind of the author, in spite of inability to obtain proof through experiments.

It may be said in favor of this theory that it offers a structural basis for an instinct which is otherwise unexplained. The attribution of an action to "instinct" is a lazy way of explaining phenomena. Merely to classify an action and group it with others, to which a class name is given, does not throw any light on the behavior. When an action is attributed to "instinct" the study of the behavior often suffers a loss rather than gain, for the giving of a name, to some minds, constitutes an explanation. There is reason for the belief that instincts all have a physical basis, some consists of feeding and caring for the larvæ, feeding the queen and the drones, cleaning, ventilating, comb building when necessary, guarding the hive from intruders and other work inside the hive.[1]

When about a week old,[2] on bright days, the young bees take "play flights" in front of the hive. Suddenly, as if in response to a signal, the young bees fly out, circle about the hive, usually with their heads toward the entrance, and as a rule they do not at first venture more than a few feet away. In a short time this flight is over and the young bees return to the hive. This flight of young bees is often mistaken by beginners in beekeeping for the attack of robber bees but the action in the two cases is so different that close observation soon makes the dissimilarity clear. When robbers are numerous, they dart toward the hive and alight about every crack, while young bees circle about, rarely alighting on the hive. The flight of the young bees is also sometimes mistaken for the beginning of swarming.

Later flights are more extended, and when workers are from 14 to 21 days old (if during a honey-flow), they begin their field duties of gathering nectar, pollen, propolis and

peculiar physical structure which determines the action. This physical basis may be a specialization of some nervous element or of some other organ, but it probably always exists. In the case under discussion, it is not enough to state that the division of labor inside and outside the hive is instinctive and such a statement is largely an evasion of the problem which the facts observed present to us.

[1] In addition to the inside duties named, the young bees must sometimes serve as honey reservoirs during a heavy honey-flow. Especially in comb-honey production where the bees must be crowded to produce fancy honey, the comb built is often not sufficient to hold the nectar brought in and it is given to the young bees. They may be seen in the evening on the combs with abdomens distended, but usually before morning more comb is completed and the honey is deposited in cells. Possibly this may be part of the ripening process, which is poorly understood as yet. This function of young workers suggests the behavior of the honey ants, in which certain individuals serve as honey pots for the storage of honey until used. In this case the abdomen is abnormally distended.

[2] In giving age in days or weeks it must be understood that this is variable, depending on season and honey-flows. The determining factor in the aging of bees is work, not days (p. 126).

water. Normally, they now abandon the work inside the hive. It sometimes happens that a colony will contain relatively too many young bees or too many old ones, these conditions often arising in practical manipulations. If there is a lack of young bees, the old ones act in their stead, but they secrete wax slowly (p. 108) and do not produce larval food adequately. If a colony is made up artificially of young bees, some of them begin field work earlier than normally.

DIVISION OF LABOR

From the preceding chapter, it is evident that there is a definite division among the different members of a colony. In a colony composed of perhaps 60,000 individuals, the very existence of the bees depends on an orderly performance of the various duties, and the development of colonial life, therefore, rests on the evolution of some system for the division of labor. The organization of the colony, already described, shows one of the most marked cases of apportionment of work, for the egg-laying is normally performed by but one individual, the queen, while all the other females (workers) are so constituted that egg-laying is not normal and mating is impossible. The drones or males are so specialized in function that they are probably useful to the colony only in the mating of young queens. While the duty of egg-laying devolves on the queen, the care of the brood falls entirely to the workers. Since they must do work both inside and outside the hive, there arises the further necessity of a division [1] of these functions and this, as has been stated, is based on the age of the individuals.

[1] The division of labor is as highly developed among bees as in any insect community. Among certain species of ants, a greater diversity of structure accompanies the performance of certain duties. For example, there may be soldiers which serve only as protectors of the community and there may be two types of workers, differing structurally and in their duties. While structural differences do not occur in so marked a way, the members of the bee colony are fully as greatly specialized in their labor but the performance of specific duties is determined in some manner other than by structure.

Since it may not at first glance be clear how the age at which bees perform certain functions is determined, it may be well to explain the simple method by which this is accomplished. If the queen is removed from a colony of black (German) bees and a yellow (Italian) queen is at once introduced, for a period of twenty-one days after the removal of the old queen the young worker bees which emerge from the cells are black, since they are the progeny of the old queen. At the end of that time, however, the worker brood from the black queen has all emerged and yellow bees begin to appear. The time at which the yellow bees first perform certain functions may now be determined. This experiment may be variously modified, as by the removal of all the brood of the black queen at once or by the placing of a frame of brood from an Italian colony in a colony of black bees. The introduction of Italian bees into Germany and later into America has been an important factor in enabling investigators to learn many of the phenomena of the hive, for the use of bees of two colors [1] is often of the highest importance.

The labor within the hive.

When the workers first emerge from the cells they take no part in the work of the hive for a day or two, nor do they leave the hive. The first flight in front of the hive is usually when they are about a week old, if the weather is favorable, and these flights are continued on warm bright days until they are nearly three weeks old. Although they do not go far at first they may remain on the wing for a considerable period. That these early flights are necessary in enabling the young bees to void their feces is indicated by the fact that if confined they become restless.[2] The abdomens of young bees are frequently distended with feces.

[1] Another method of marking bees for observation is mentioned by Casteel, Cir. No. 161, Bureau of Entomology, p. 5. The method employed was to paint bees with different colors and also to number them.

[2] This was observed when colonies containing young bees were placed

Dönhoff [1] states that he offered a stick dipped in honey to young bees daily. Until they were fifteen days old they did not lick the honey eagerly. The younger bees never attempted to lick it, but as they grew older they paid more attention to it. He concludes that the "impulse for gathering honey" is not developed in young bees. Not until his experimental bees were seventeen days old did he find any on his outdoor feeders and not until they were nineteen days old did any fly to the field.

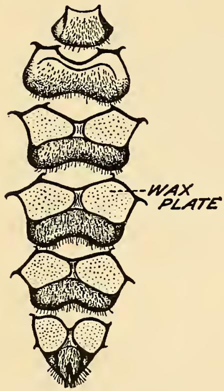


Fig. 53. —Ventral plates of the abdomen of a worker bee.

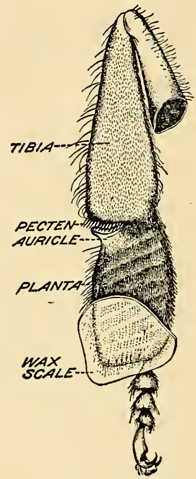


Fig. 54. — Inner surface of the left hind leg of a worker bee, showing a wax-scale.

Comb building.

If there is need for more combs, the workers form curtains by hanging on one another from the top of the hive or cavity. The temperature is raised and in a few hours wax-scales may be seen on the ventral sides of the abdomens of the hanging bees. Finally, some of these scales are removed and manipulated and the bees begin building new comb. The small pieces of wax are put approximately in the right place and are then sculptured and molded into

in a cellar for winter, in connection with work of Demuth and the author on winter activities. The entire colony became active and a high temperature was maintained. The condition was removed by taking the colonies from the cellar for a flight. Bees that emerged from brood combs were also kept in a warm room, away from older workers. These had distended abdomens and if one escaped from the hive it usually flew at once to the window, leaving a spot of feces on the pane.

[1] Dönhoff, 1855. Eichstädt Bienenzeitung, p. 163.

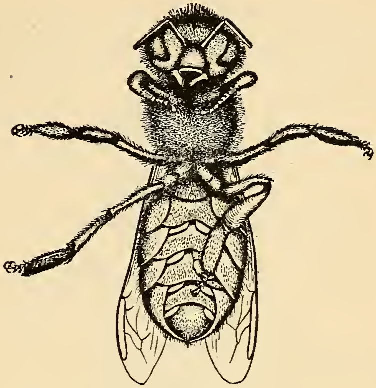


Fig. 55. — Ventral view of worker removing wax-scale. Enlarged.

their proper position and shape. In spite of the number of bees at work in building, the wax is quickly smoothed into its final form, becoming a part of the comb.

Dreyling[1] has shown that in just emerged worker bees the cells of the wax glands are not fully developed and that as the worker grows older the cells elongate. As the bee ages, however, these cells decrease and degenerate. These results fully support the observations of beekeepers that bees secrete wax best before they become field bees. If, however, a colony of old bees is required to build comb, the bees can still secrete some wax, but for some reason not understood they usually build irregularly.

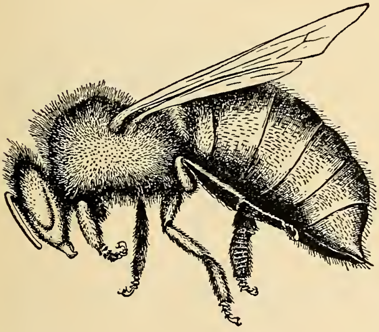


Fig. 56. — Side view of worker removing wax-scale. Enlarged.

Beeswax is secreted in pockets on the ventral side of the abdomen on the wax plates (Fig. 53) situated on the sternal plates of the last four visible segments of the abdomen. Each segment bears two of these plates, making eight in all.

[1] Dreyling, L., 1903. Ueber die wachsbereitenden Organe der Honigbiene. Zool. Anz., XXVI.

——, 1905. Die wachsbereitenden Organe bei den gesellig lebenden Bienen. Zool. Jahrbücher, Abth. Anat. u. Ont. d. Theire, XXII.

As the secreted wax comes in contact with the air, it hardens, forming the scales of wax.

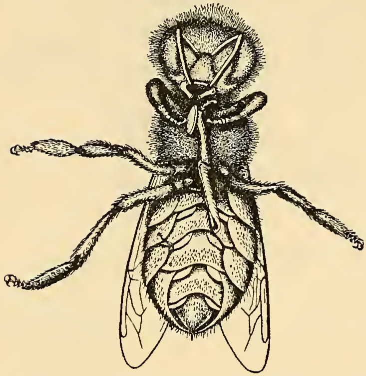


Fig. 57. — Ventral view of worker passing wax-scale forward. Enlarged.

The manipulation by the bees of the wax-scales has been carefully described by Casteel.[1] The scales are removed from the pockets by spines of the pollen comb (Fig. 54) on the first tarsal segment (planta) of the third pair of legs. The surface of the planta is passed over the ventral side of the abdomen (Figs. 55 and 56) and after the scale is loosened the third leg is bent forward (Figs. 57 and 58), thus passing the scale to the front pair of legs. It is then masticated by the mandibles, after which it is ready to put in place in the new comb. The various movements in manipulation are so well shown in Casteel's figures that further description is unnecessary. It is clearly shown that the so-called wax-shears, which are described by so many authors as being used to remove wax-scales, have in fact nothing to do with the wax manipulation. It is shown later that these are concerned in pollen gathering.

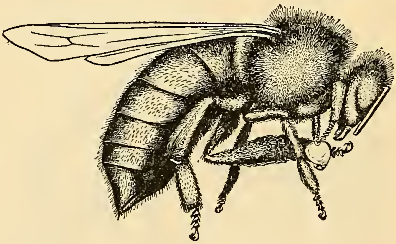


Fig. 58. — Side view of worker passing wax-scale forward. Enlarged.

[1] Casteel, D. B., 1912. The manipulation of the wax scales of the honey bee. Cir. No. 161, Bureau of Entomology, 13 pp.

Feeding of larvæ.

The feeding of the larvæ is one of the most ardently disputed questions in bee activity. The chief controversy arises over the source of the food, some authors claiming that it is a secretion of glands, while others maintain that it is regurgitated from the ventriculus. The heat of controversy seems to have hidden from view the fact that this can be determined only by investigation. An explanation of the two current views involves some study of the glands emptying into the alimentary canal and of the ventriculus.

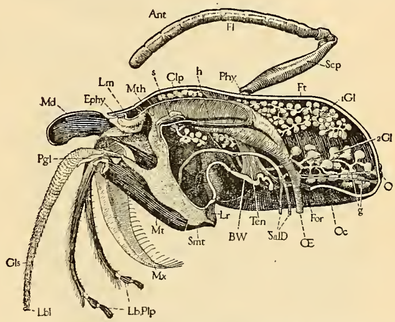


Fig. 59. — Median longitudinal section of head of worker, showing the glands (*1Gl* and *2Gl*).

There are in the head of the worker bee, two systems of glands (Fig. 59), the lateral pharyngeal (supracerebral of Bordas, System No. 1 of Cheshire) (*1Gl*) and the salivary glands of the head (postcerebral of Bordas, System No. 2 of Cheshire) (*2Gl*), and in the thorax are found the salivary glands of the thorax (thoracic salivary of Bordas, System No. 3 of Cheshire) (Fig. 60, *3Gl*). The ducts of the two systems of salivary glands unite into one median tube which enters the base of the labium and opens upon the upper surface of the ligula. These glands are homologous with the salivary glands of other insects and presumably their secretions assist in digestion although their exact function is unknown. They are found in queens, drones and workers. The lateral pharyngeal glands (*1Gl*) are absent in the drone and never more than rudimentary in the queen, and this leads to the conclusion that they function in some way which is especially useful to the worker. They are claimed by

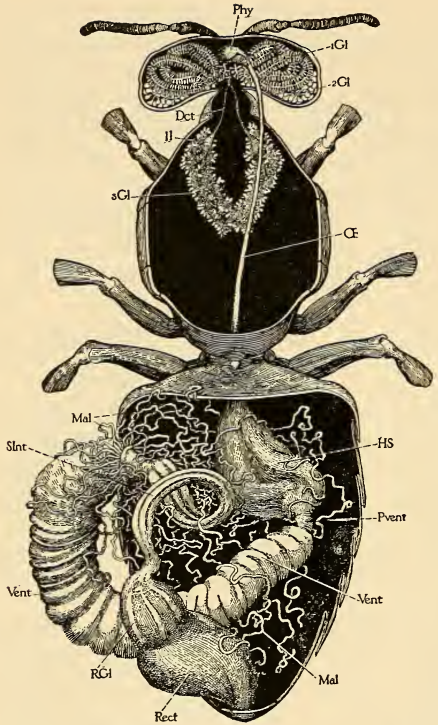


Fig. 60. — Alimentary canal of worker, showing glands, pharynx (*Phy*), œsophagus (*Œ*), honey-stomach (*HS*), proventriculus (*Pvent*), ventriculus (*Vent*), intestine (*SInt*), rectal ampulla (*Rect*) and Malpighian tubules (*Mal*).

Schiemenz,[1] and after him by Cheshire,[2] to be the source of food given by the workers to the larvæ of queens, drones and workers. It is claimed that the development of these glands is in proportion to the specialization of the species in the feeding of the larvæ; in bumblebees (Bombus) they are as well developed as in the honeybee. They are decreasingly smaller in Psithyrus, Andrena and Anthophora. Since the feeding of some of these species is entirely unlike that of the honeybee, this evolution perhaps proves too much for this theory.

Schonfeld,[3] on the contrary, holds that the larval food arises in the ventriculus and not in these

[1] Schiemenz, Paulus, 1883. Ueber des Herkommen des Futtersaftes und die Speicheldrüsen der Bienen, nebst einem Anhange über das Reichorgan. Zeit. f. wiss. Zool., XXXVIII, pp. 71–135.

[2] Cheshire, 1886. Bees and beekeeping. 2 vols., London: L. Upcott Gill.

[3] Schonfeld, 1886. Die physiologische Bedeutung des Magenmundes der Honigbiene. Arch. f. Anat. und Physiol. Abth., pp. 451–458.

glands. Cook [1] and Cowan [2] both adhere to this view. The alimentary canal of the worker (Fig. 60), posterior to the pharynx, narrows to a slender œsophagus (*Œ*) extending through the thorax. In the abdomen, this is enlarged into a thin-walled sac known in the honeybee as the honey-stomach (*HS*, crop of other insects), since it is used to carry nectar to the hive. At the posterior end this merges with the proventriculus, with heavy muscular walls, which contains a valvular apparatus (Fig. 61). Behind this is the stomach or ventriculus (*Vent*). Schonfeld claims that the brood food, especially that of the queen (royal jelly), is regurgitated from the ventriculus. The experiments of Schonfeld seem to show that the valve in the proventriculus opens and moves anteriorly even to the œsophagus when this is done, but Snodgrass [3] claims that this cannot be done without tearing the muscles of the proventriculus. Cowan and other authors figure this action in a diagram, but with no evidence from observation. Schonfeld and Cook fed charcoal in honey and found this in the brood food which would, in their estimation, be impossible if the food is of glandular origin, but they overlooked the fact that the charcoal might get into the brood food from the mouth of the worker. The charcoal could not pass through the walls of the ventriculus in

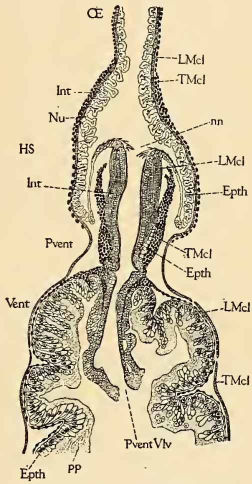


Fig. 61. — Longitudinal median section of base of œsophagus.

[1] Cook, A. J., 1904. The beekeeper's guide or manual of the apiary. 18th ed., Chicago.

[2] Cowan, T. W., 1904. The honey bee, 2d. ed., London.

[3] Snodgrass, R. L., 1910. The anatomy of the honey bee. Tech. Series, 18, Bureau of Entomology, pp. 162.

digestion. According to Petersen, the peritrophic membrane in the ventriculus is so formed as to make regurgitation from the ventriculus impossible.

While the work of Schiemenz and Schonfeld must be given due consideration, we must wait until some competent investigator takes up this problem. The various arguments are thus summarized by Snodgrass (p. 100):

"1. The brood food itself is a milky-white, finely granular, and gummy paste having a strong acid reaction said to be due to the presence of tartaric acid.

"2. The pharyngeal glands of the head are developed in proportion to the social specialization of the various species of bees; they are always largest in those individuals that feed the brood, and they reach their highest development in the workers of the honey bee. From this it would seem that they are accessory to some special function of the worker.

"3. The contents of the stomach in the workers consist of a dark brown, slimy, or mucilaginous substance in no way resembling the brood food, even when acidulated with tartaric acid. Pollen is present in varying quantity, mostly in the posterior end of the stomach, and shows little or no evidence of digestion. Since the brown food is highly nutritious, it must contain an abundance of nitrogenous food material, which is derived only from pollen in the bee's diet. Therefore it is not clear how the stomach contents can alone form brood food.

"4. The constituents of the food given to the different larvæ, at different stages in their growth, and to the adult queens and drones show a constant variation apparently regulated by the workers producing it. A variation of this sort cannot be explained if it is assumed that the brood food is produced by the glands alone.

"5. Powdered charcoal fed to a hive of bees appears after a short time in the brood food in the cells, and this has been urged as proof that the latter is regurgitated 'chyle.' But it is certainly entirely possible that the charcoal found in the food might have come only from the honey stomach or even from the œsophagus or mouth.

"6. We have Schonfeld's word for the statement that a regurgitation of the stomach contents may be artificially induced by irritation of the honey stomach and ventriculus in a freshly dissected bee, but all explanations offered to show how this is mechanically possible in spite of the proventricular valve are unsatisfactory when the actual anatomical structure is taken into consideration."

TABLE III. COMPOSITION OF LARVAL FOODS. — V. PLANTA

	Queen	Drones		Workers	
		Under 4 Days	Over 4 Days	Under 4 Days	Over 4 Days
Proteid . . .	45.15	55.91	31.67	53.38	27.87
Fat	13.55	11.90	4.74	8.38	3.69
Sugar	20.39	9.57	38.49	18.09	44.93

Composition of larval food.

The chemical composition of the larval food has been investigated by von Planta.[1] This larval food is obviously not merely a mixture of honey and pollen nor is the food given the various kinds of bees at different ages uniformly the same. The following is a brief summary of von Planta's conclusions: The three kinds of bees require different food and, in the drone and worker larvæ, the food changes after the third day, being mixed with half-digested pollen grains and honey in the case of the drone and honey only in the case of the workers.[2] On the other hand the queen larva receives the rich food supplied the young larvæ of other

[1] von Planta, Adolf, 1888. Ueber den Futtersaft der Bienen. Zeit. f. Phys. Chemie von Hoppe-Seyler, XII, pp. 327–354. 1889; *idem*, XIII, pp. 552–561.

[2] Pollen grains are found plentifully in the mid-intestine of the older worker larvæ, so that in this respect at least the results of v. Planta's work must be questioned.

castes throughout her entire larval period (called royal jelly) which is free from undigested pollen and completely predigested. The table (p. 115) gives the percentages of the various food constituents as determined by v. Planta.

Snodgrass (p. 93) reports finding undigested pollen grains in royal jelly, contrary to the statements of v. Planta. The larval food differs essentially in appearance from the contents of the ventriculus so that it is difficult to conceive of it being a regurgitated product to which is added merely an acid secretion of the glands. The beekeeping industry is under lasting obligation to v. Planta for his research in this and other subjects, but it is no disrespect to his work to express the belief that this subject should be thoroughly investigated by modern methods. The methods of analysis have been greatly improved since his work was done; they have, in fact, been so completely changed that v. Planta's results cannot be considered as conclusive in any respect.

Feeding of queens and drones.

In addition to the feeding of the various types and ages of larvæ, the workers feed the queen and seemingly the drones also during their presence in the colony. The excessive egg-laying of the queen (p. 57) obviously calls for nourishment in large quantities and during the season of heavy laying the queen usually stops for a few minutes about every half-hour and during this resting period she is almost constantly fed. While the feeding of the drones is less easily observed, there is reason to believe that the feeding is discontinued at the close of the honey-flow, at which time the drones are first driven to the lower parts of the hive and finally are easily carried out, because of their weakened condition. Both queens and drones are capable of taking honey from cells, but apparently do not take pollen themselves.

Other inside work.

Little remains to be said in detail of the inside work of the hive which is performed by the workers. They clean the hive, and in case they are unable to remove the débris, they may cover it with propolis. Lizards (Fig. 62), small snakes and other intruders to the hive, which are too large for the workers to remove, are sometimes found as "mummies" on the hive bottom, sealed in propolis. The ventilation of the hive is accomplished by fanning of the wings. The colony exhibits an astonishing degree of efficiency in its ability to protect itself and the brood from excessively high inside temperatures by rapid ventilation through a relatively small opening at the entrance.

Fig. 62. — Lizard incased in propolis.

The guarding of the colony from intruders is interesting and of great importance to the colony. This is done by bees which stand about the entrance and on the lower edges of the combs of the brood chamber. These bees usually do not remain long at this work for the guards are constantly changing. The hand may be placed right among them if the movement is slow, while a swift movement will cause them to dart out and will bring others to the entrance. The honeybee is capable of preventing the entrance of insects larger and more powerful than itself, such as wasps and bumblebees. During the summer of 1909, small yellow-jackets were especially abundant in the apiary of the Department of Agriculture, then at College Park, Maryland, and many dead ones were found daily in front of the hives. Numerous large wasps with hard chitinous covering are also killed by the bees. The bee-moth in some way often succeeds in entering the hive but usually the eggs or larvæ are removed before any harm is done. Their success probably depends upon their habit of flying by night.

Of all these labors which the workers perform within the hive, none of them monopolizes the time of certain individuals as completely as does comb building, in which the bees hang in curtains from the comb support. Casteel has shown that even in this the bees change their duties frequently. Bees are constantly changing from guards to feeders of the brood or from ventilators to cleaners, and yet the work of the hive is done well and, one is almost tempted to say, systematically.

The labor outside the hive.

While the division of the inside duties may be explained to a certain degree, the division of the outside work presents problems of far greater perplexity, chiefly because of difficulty of observation. That there is an order to this work is an inevitable conclusion, but how this order is brought about among the thousands of field workers is not easily determined. Bees go to the field to obtain nectar, pollen, water and propolis. If there were no "system," we should expect to find colonies lacking one or more of these substances in sufficient quantity or, perchance, a colony with the brood nest choked with pollen or a hive over-propolized. There are, in fact, variations in all these things, but there are no cases which can be considered abnormal. Furthermore, on the grounds of an apiary of 200 colonies may be found heads of white clover or other nectar-secreting flowers right at hand. The bees in any case are not falling over each other to reach a certain flower and leaving other flowers untouched, as would be the case sometimes if bees were guided to nectar merely by the chance sight of a flower. Or, assuming only that there is a system whereby the individual colony divides up the surrounding territory, there would be cases of conflict between bees from the various colonies in their attempts to reach the same flowers. If then we dare to assume a pre-arranged plan, it must include the entire apiary and even more, all the apiaries within the range of flight. While bees get nectar from the flowers right beside the hive, they are no more numerous on such flowers than on other flowers a quarter or half mile away.

On one occasion, the author watched a head of white clover within two feet of a hive entrance. This flower was without a visitor for so long that it was almost concluded that there must be no nectar in it. All this time hundreds of bees were flying to and from the hive, many of them passing within six inches of the flower. Finally, a bee flew from the entrance directly to this flower and worked for a considerable time, sucking nectar, and, evidently getting a sufficient quantity after a time, it returned to the hive. That there was considerable nectar present in this flower is shown by the fact that other visits were made to this flower within the next half-hour from the same hive. At no time, in an hour's observation, were two bees on the head at once.

Furthermore, when a bee flies from the hive, the flight is usually not uncertain but is directed toward a source of supply. It is usually stated that bees carry either nectar or pollen back to the hive but not both, but this is not correct. It may perhaps be stated that they usually gather from one species only on any given trip.[1] Some additional

[1] This feature is of the highest importance in a consideration of the value of the bee in the cross-pollination of plants. Since the trips are usually confined to one species, the beneficial results are increased many fold, for if they wandered promiscuously from one to the other species they would thereby scatter pollen where it would be ineffectual. That they fail to discriminate among various varieties may be considered as not a misfortune since certain varieties are pollinated better with pollen from another variety.

Bulman (1902, The constancy of the bee, Zoologist, Ser. 4, VI, pp. 220–222) quotes from various authors to the effect that bees keep to one species on a single trip from the hive, and even "as long as they can, before going to another species" (Darwin, Fertilization of Plants, p. 415). This constancy is considered most highly developed in the honeybee but is claimed for certain Diptera (Bennett, Proc. Linn. Soc. Zool. XVII, p. 184). Ord (1897, The constancy of the bee, Trans. nat. hist. soc. Glasgow, n. s., V, Pt. 1, pp. 85–88) undertook to examine this as "one of the great pillars of the Law of Natural Selection" and finds that "only about 30% have proved inconstant while they were under my eye. . . . In most cases when I was able to follow the bee for any considerable time, I found that, sooner or later, a change was made." He then records numerous observations which show inconstancy in a marked degree as from Leguminosæ to facts concerning the gathering of bees are of interest. If honey is exposed where it is accessible to bees, they go to it by the hundreds, if there is no nectar in the field, and under these circumstances they are on the lookout for openings in other hives so that they can rob. On the other hand, during a nectar-flow honey may sometimes be exposed in the apiary without a bee coming near it.[1] This leads sometimes to the conclusion that bees prefer nectar to honey. Even if honey is placed in a feeder inside the hive, it is often not touched during a heavy nectar-flow.

Division of labor in gathering.

There has been little done on the division of labor outside the hive but Bonnier [2] has written a paper of great interest on this subject. Whether his conclusions may be accepted must depend upon future experiments, but a resumé of his paper is of interest. The field bees are divided by him into two classes, searchers and collectors. Searchers fly to various plants, gathering some nectar and some pollen and lighting on many neighboring objects, and behave much as do wasps, which are generally searchers. A bee is transformed

Primulaceæ or Compositæ or from yellow flowers to pink, white or purple. He concludes that the majority of bees are constant, but if watched long enough they are by no means so, that "few bees appear to be able to withstand the temptation of a Garden," where a variety of plants present themselves, and that "the Hive-bee appeared to be fully as inconstant as the wild Humble-bees." Bulman gives records of 48 observations on honeybees in a garden which were inconstant. That bees go from white clover (*Trifolium repens*) to alsike clover (*T. hybridum*) or to two species of another genus which are perhaps less readily distinguishable to an untrained human eye should not excite wonder. All that can be claimed from the known facts concerning the so-called constancy of the honeybee is that if enough flowers of one kind are easily accessible, they seem to prefer those of one kind. They usually do not fly from dandelion to apple blossom, although Ord records one such case. No more than this is needed to make bees more beneficial to the fruit-grower than they would be if their visits were entirely promiscuous.

[1] Zander, Enoch, 1913. Das Geruchsvermögen der Bienen. Biol. Centralbl., XXXIII, pp. 711–716.

[2] Bonnier, Gaston, 1906. Sur la division du travail chez les abeilles. Comptes rendus hebdomadaires des seances de l'academie des sciences, CXLIII, pp. 941-946.

from a searcher to a collector when a suitable source of nectar or pollen is discovered, and other bees come to the same source. During a good honey-flow, searchers are sent out only in the early morning and soon all become collectors (which may account for the lack of robbing and the indifference to honey about the apiary at such times) but during a dearth of nectar, searchers are out all day. Bonnier further claims that bees "commanded" to collect either nectar, water, pollen or propolis do not leave their work and will not stop even to collect honey placed in front of them. This claim is supported by experiments. The following translation of a portion of the paper cannot well be summarized: —

". . . I shall cite the following which shows . . . how the division of labor among bees of the same hive is organized and so a sort of tacit understanding, which is manifested among bees of different hives. I detached six branches of flowers of Lycium, each having about the same number of open flowers. I put each branch in a bottle filled with water. On placing these bottles in the same place from which I had taken the branches, I saw that the workers continued to visit the flowers of the branches put in water just the same as those on branches not detached from the plant. This verified, I carried the six bottles containing the branches to the fruit garden, September first, away from all nectar-bearing plants, consequently to a new place for the bees. I remained constantly watching the six bottles containing Lycium branches. No bees came to visit the flowers on these branches. The next day I saw the first bee as a searcher, which discovered them. She inspected all the branches and took some nectar and pollen; I marked her on the back with talc colored red. In about three minutes she returned to the hive.

"Five minutes afterward the same first bee (which I call 'A'), as shown by the red mark, came back with another and the two bees as collectors undertook a methodic visit to the branches, one to collect nectar and the other pollen. I call the second bee 'B' and marked her white.

"Ten minutes after, there were three visiting bees. A new one 'C,' which I marked green, came to join the other two from the same hive, as I verified.

"Later the same three workers, A, B, C, A and C always collecting nectar, and B only pollen, came back regularly to the flowering branches and visited them in the same order. All the next day these same three bees, A, B, and C, visited the six branches.

"I then asked myself why other bees of the same hive or of other hives did not come to collect from these branches, as well as the three bees. Remaining under the branches, I observed attentively what took place on the second day. Early in the morning and several times in the forenoon, once in the afternoon, other searchers came to the branches of the flowers and each of these searching bees did the same thing as A. She observed the collectors with great care, their number, their manner of work, and, after two to four minutes of inspection, she flew away and did not come back. It seems that these bees, finding the place occupied, and the number of collectors sufficient for the small amount to be collected went elsewhere to search.

"The fact is that the day after, I saw more and the same bees, A, B, and C, continued to visit the six branches in the same manner, A and C always for nectar, and B for pollen.

"Then I replaced the six flowering branches of Lycium with twelve branches which appeared to me about the same; I saw two new recruits arrive, 'D' and 'E,' which I marked differently with colored powder; ten minutes after, two others, 'F' and 'G,' and A, C, D, E, [F in the text, evidently a typographical error] and G came for nectar, B and F for pollen. There were seven bees visiting in place of three. The number of flowering branches was double, the number of collectors was about double.[1]

[1] "Similar experiments have shown me that the number of bees visiting a definite number of flowers of the same species under similar environmental conditions is quite proportional to the number of flowers, except when

"The next day other searchers came. The seven marked bees continued their visits. I took some pollen from the stamens of Lycium and put it in a mass below the nectar of one flower. When bee 'C' arrived at that flower, she stretched out her proboscis as usual to suck up the sweet liquid but saw that it was not there and that something different was in the flower; she examined it carefully for more than a minute, did not collect the pollen but renounced it and went to pump nectar in the neighboring flowers. I made the inverse experiment and bathed the pollen of one flower in nectar; 'F,' after pollen, came to this flower, found the sweet liquid on the anthers, examined it, did not touch the anthers of that flower, but renounced it and went to continue her collecting on the neighboring flowers."

Bonnier further found that certain bees confined their visits to a certain limited portion of a row of plants which were all in bloom. He concludes as follows: "They thus accomplish on the whole, the collection of the most in the least possible time of the substances necessary to all colonies of bees in the same region."

If division of labor as described by Bonnier is even partially true, it may help us to understand why it happens that the flowers visited on a single trip are usually of one species. It is to be hoped that these interesting observations may be repeated by other investigators.

Pollen gathering.

Pollen is carried to the hive in the pollen baskets or corbiculæ (Fig. 63) situated on the outer surface of the tibiæ of the third pair of legs. The activities of the bees in collecting pollen have been admirably described by Casteel.[1] In collecting from a flower, the worker not only secures pollen on its mandibles and tongue but also on the hairs of the legs

the visit is disturbed by the arrival of wild Hymenoptera as numerous." — Bonnier.

[1] Casteel, D. B., 1912. The behavior of the honey bee in pollen collecting. Bul. No. 121, Bureau of Entomology, 36 pp.

and body, and this pollen must be transferred to the baskets and securely packed before returning to the hive. This is done either while resting on the flower or on the wing. The action of the pollen brushes on the legs is as follows: (1) those of the first pair of legs remove pollen grains from the

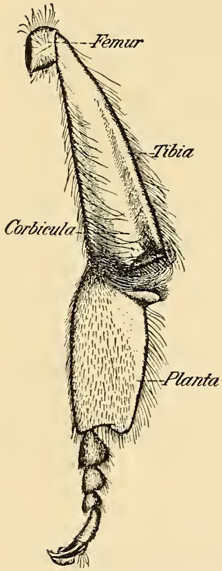


Fig. 63. — Outer surface of the left hind leg of a worker.

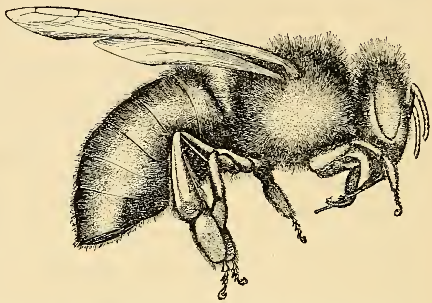


Fig. 64. — Flying bee, showing movements of legs in pollen collecting. Enlarged.

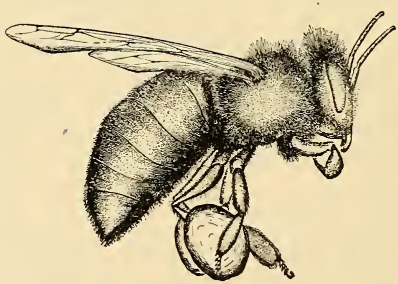


Fig. 65. — Flying bee patting pollen on the pollen baskets. Enlarged.

head and the region of the neck, and also take the moistened pollen from the mouth-parts (Fig. 64), (2) those of the second pair remove pollen from the thorax, especially from the ventral portion, and also receive the pollen collected by the front legs, (3) the third pair of legs collect pollen from the abdomen and also receive on the pollen combs (Fig. 64) the pollen collected by the second pair of legs. The pollen is moistened by the addition of fluid substances which come from the mouth and Casteel presents analyses (by Dunbar) showing that honey is used for this purpose.

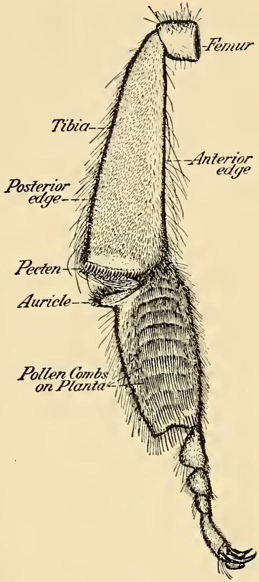


Fig. 66. — Inner surface of left hind leg of worker.

The method of loading pollen on the pollen baskets has been variously described, it usually being stated that it is put in place by the second pair of legs. This is not the usual method, however, although a little pollen is added to the mass while the bee pats down its load with the second pair of legs (Fig. 65). The loading is accomplished by the rubbing together of the inner surfaces of the hind legs (Figs. 66 and 67). It is removed from the pollen combs by the pecten combs, is pushed upward by pressure of the auricles and is forced against the distal ends of the tibiæ and on into the pollen baskets from below, being pushed upward against any pollen that may have been loaded previously. The long lateral hairs of the pollen baskets help to retain the pollen

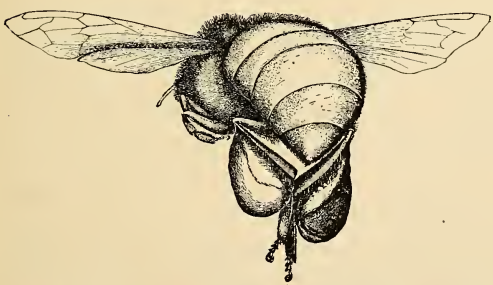


Fig. 67. — Flying bee loading the pollen baskets.

masses. It is thus clear that the so-called wax-shears, formed by the pecten and auricle, are part of the apparatus for pollen packing and, as shown earlier (p. 110), they have nothing to do with wax manipulation. Casteel shows also that in packing pollen in the cells of the combs additional moisture is probably used, for analyses show a higher percentage of sugar than in pollen from the legs.

Propolis collection.

The collection of propolis has not been so adequately described. This substance consists of gums collected from various trees and other materials of a similar consistency. The bees carry it to the hive on the pollen baskets, the load sometimes appearing smooth and shiny, at other times rough, depending upon the material collected. It is usually gathered most abundantly in late summer and autumn, and races of bees differ in the amount of propolis which they collect. Caucasian bees are troublesome because of the great quantities which they deposit in the hive (p. 197). Inside the hive, propolis is deposited on rough surfaces, in cracks and openings that are smaller than a bee-space (p. 26) and sometimes on the upper portions of the combs. The "travel-stain" frequently seen on comb-honey is propolis. Heddon showed some years ago that bees do not deposit it on smooth surfaces.

The collection of water is most commonly observed in early spring and during the hottest part of the summer, there probably being less need for water when the humidity within the hive is high. It is carried to the hive in the honey-stomach (Fig. 60), as is nectar.

DURATION OF LIFE

The length of life of the various members of the colony under different conditions presents a problem of great interest. The queen bee normally lives several years, while the workers, which develop from eggs identical with those from which queens develop, live from a few weeks in summer to possibly six months over winter in the North.[1] Drones usually live not to exceed four months, unless they are in queenless colonies, in which case they are sometimes reported to live over winter. Death comes suddenly to the drone at the time of mating, seemingly of shock. If a drone is caught on the wing during the time of mating and is slightly pressed, the male organs are ejected and the drone instantly dies. Obviously this death by shock does not concern us in a study of the normal term of life.[2]

The most interesting phases of this subject are the phenomena observed in worker bees. Those bees which emerge somewhat before the beginning of a heavy honey-flow, so that they begin their field duties when there is heavy work in gathering nectar, usually live only about six weeks, but if when the outside work begins there is no nectar available, the duration of life is much greater. Those workers which emerge at the end of the brood-rearing season are the ones which must live until the next spring if the colony is to survive. It is obvious, therefore, that the length of life of the workers is influenced to a marked degree by the conditions under which they live. Similarly, queens live longer if they are called on to lay eggs less abundantly, and it is observed that in the tropics and semi-tropics, queens do not live as long as in the North, where the brood-rearing season is relatively short.[3] Further evidence of a similar nature is afforded by various facts observed in practical beekeeping. Some honey-flows seem to deplete the colony more than

[1] The method of determining the length of life of bees is identical with that of determining the duties of bees at different ages.

[2] Bumblebee drones do not die at mating time, according to a quotation given by Weismann, without the reference.

[3] It is difficult to draw any conclusions from the length of life of queen bees since they are superseded by the workers when they fail in egg-laying. Death is often not natural with them. It is interesting to note that although they can continue to form new eggs in the ovaries (in contrast to some female insects which lay but one or two lots of eggs) they gradually fail in this respect.

others; if there is but little honey in the field the death rate often is greater than if there were no nectar available or than is the case when there is plenty of nectar. The work necessary to get the nectar costs more than the nectar is worth. Beekeepers often observe at the close of a severe winter what is known as "spring dwindling." This is, to the best of our knowledge, due to the fact that during cold weather the bees have had to work vigorously to generate heat and that, when the spring comes with its increased activities incident to brood-rearing, the bees are worn out and die rapidly.

Work determines length of life.

All of these facts and many others observed in the apiary indicate a peculiar condition found in bees which may be figuratively expressed in the following terms: a bee is born with a definite supply of energy and when this energy is exhausted the bee dies. It may be likened to a storage battery that continues to give out its stored energy until it is exhausted, but unlike the storage battery the bee seemingly cannot be "recharged." In our own experience, we find that after exhausting exercise, rest and food enable us to recover completely from the exhaustion, and we are probably better for the exercise. It must not be concluded from what has been said that bees have no recuperative power, but it is obvious from the various facts observed that in some fundamental way their term of life is limited by the amount of work they do.

Practical applications.

Success in practical beekeeping rests in a recognition of this phenomenon of the wearing out of bees, but nowhere is this more evident than in wintering. In order that the bees may live over winter and still have energy to do the work required of them, under the trying conditions of spring, the bees should be kept under conditions which will require of them the minimum exertion. This the northern beekeeper attempts to do by keeping the bees in the cellar or by packing the hives during the coldest months. As will be explained in the chapter on wintering, the character of the food is an important factor in the reduction of the necessary labor.

Possible determining factors.

The cause of the wearing out of bees is not fully understood, because there are so many phases of bee physiology about which we are ignorant. An old bee loses the hairs on the body and the wings often become frayed. These parts are not replaced, since in the adult they are non-living chitinous structures, but it can scarcely be believed that these factors are sufficient to cause the death of the insect. The fact that the larger number of bees die outside the hive during the active season perhaps lends weight to a belief that worn-out wings have failed to carry them back. However, if bees are confined in a cage and are constantly stimulated, they wear themselves out and die, when wings could be of no help to them. Koschevnikov [1] has described the fat body of the bee and records that in old age the fat cells become less vacuolated and the cells are filled with a granular plasma, while the cells become united into a syncytium, in which the cell boundaries are lost and the nuclei remain distinct. The œnocytes are rather mysterious cells, found in the fat bodies of insects. In the old bee, these become filled with yellow granules, which Koschevnikov thinks are excretory products which cannot be eliminated but are simply retained by the cells. These facts suggest the possibility that old age in a bee is due to lack of the excretory function of these cells, but far more evidence is necessary for adequate explanation.

Some comparisons with other insects help to make clear the difficulty of the problem which confronts us in the phenomenon of old age in the bee.[2] Worker ants have been

[1] Koschevnikov, G. A., 1900. Ueber den Fettkörper und die Œnocyten der Honigbiene (*Apis mellifera*, L.) Zool. Anz., XXIII, pp. 337–353.

[2] For an interesting discussion of the duration of life, the reader is re-

kept for several years in artificial nests and Lubbock[1] reports keeping a queen ant of *Formica fusca* for nearly fifteen years, "by far the oldest insect on record." Queen bees live several years and it may be that if worker bees were equally well cared for and fed they might live as long as the queen. We get no light on the potential length of life of bumblebees and wasps because the colony is not maintained over winter; possibly if they were protected as bees are or could hibernate like ants they might live for several years. It is perhaps not legitimate to compare the larval or pupal stages of insects which require several years for their development (*e.g.* Cicada, Lachnosterna). Among insects ants are perhaps the patriarchs, while most insects live but a few days, weeks or months. Many insects take little or no food as adults (*e.g.* females of Psychidæ, Phryganids, males of Phylloxera) and it is therefore not surprising that they do not live long. If, now, we compare ants and bees, we find them similarly constructed, similarly they live in colonies and their activities are in many ways almost identical. The marked differences are in the facts (1) that bees fly while ants do not and (2) that ants live on a mixed diet while bees in the adult stage live chiefly on sugars.

ferred to Weismann's essay "The Duration of Life" (Dauer des Lebens) in his Essays on Heredity (English translation, 1891, Oxford). Prof. Weismann considers death an adaptation, as secondarily acquired, produced by natural selection, not a primary necessity of living matter and that "unlimited existence of individuals would be a luxury without any corresponding advantage" to the species. Death is a "beneficial occurrence," whereby worn-out individuals which are harmful to the species are removed, leaving room for those which are sound. According to this view, duration of life is hereditary (for which there is much evidence) and therefore we should expect workers and queens to be potentially equal in duration of life (*l. c.*, p. 60), if the workers were as well protected as the queens. This is seemingly true for ants. However, it is difficult to comprehend the cause of an adaptation which leads to the use of food which fails to nourish the body and thereby shortens the term of life, since it is not evident in what way a shorter span of life for the workers is of benefit to the species. Beekeepers would probably be inclined to believe that if they could get worker bees which would live as long as do worker ants that it would be advantageous to the honey-producer, if not to the bees themselves.

[1] Lubbock, Sir John, Jr. Linn. Soc. (Zool.) XX, p. 133.

Probably bees consume more pollen than beekeepers usually believe but their main source of nourishment is honey. Carbohydrates do not furnish the nourishment suitable for the rebuilding of worn-out tissues and this may be at least a partial explanation of the differences in the term of life. The queen is, however, fed on predigested food all her life and it is usually assumed that this is comparable to royal jelly. If this assumption is correct, her food provides her with fats and proteids as well as sugars.

CHAPTER VI

THE LIFE PROCESSES OF THE INDIVIDUAL

THE discussion in previous chapters has had to do with the colony of bees and with the individual bees in their relation to the colony. To give a more complete account of the activities of the bees and to present a better conception of what manner of animal a bee is, it is necessary to discuss certain life processes of the adult individual. The entire form and structure of the body is so fundamentally different from that of man that it is difficult to form an adequate idea of the life activities. In this chapter mention of two important systems of organs is omitted, the nervous system with its sense organs and the reproductive organs, the structure and functions of these systems being so important that a separate chapter is devoted to each one.

To understand the life processes, it is obviously necessary to know the structure of the parts which function in the various activities. Fortunately the anatomy of the honeybee has been carefully studied and described by Snodgrass.[1] Previous to the appearance of this paper various books and papers on bee anatomy were published but unfortunately in many cases the descriptions were erroneous and the conclusions unjustified.

In presenting the subject in the present case, it seems desirable not to discuss anatomy separately but rather to treat the bee as a living animal and to describe the functions of the various systems of organs, giving only the anatomical

[1] Snodgrass, R. E., 1910. The anatomy of the honey bee. Tech. Ser. 18, Bureau of Entomology, U. S. Dept. of Agric., 162 pp., 57 ill.

data necessary to elucidate the points discussed. This point of view is to be preferred as being of greater interest to persons who are not specialists in morphology and, after all is said, our chief interest in any animal lies in the fact that it lives and moves rather than that it has legs or a stomach of a certain structure and form. This view is emphasized by Snodgrass who also shows in numerous places our woeful lack of knowledge of the details of the physiology of the bee. Since anatomy is not treated fully in this book, the reader may find certain points not described sufficiently to meet his needs. In the illustrations used in this chapter, all of which are from Snodgrass, parts are shown which are not here described and symbols are used which are not explained. Partially to remedy these necessary shortcomings, the symbols used by Snodgrass are given in the Appendix (pp. 439–448). For fuller descriptions the reader is referred to his admirable bulletin.

GENERAL PLAN OF THE BODY OF THE BEE

The plan of organization of the bee is quite unlike that of the human body. The structure of the body as a whole and of the various organs is different from that with which we are most familiar and it is imperative that we avoid forming conclusions as to the functions of various organs from supposed homologies. First of all, there is no internal skeleton for the attachment of muscles and to serve as a support for the organs of the body, but the chitinous covering serves as a skeleton. The body of the bee is divided into three portions, head, thorax and abdomen, the legs and wings being attached to the thorax.

The three portions of the body differ greatly in function. The head is the seat of the brain and carries the two kinds of eyes (three simple eyes and two large compound eyes), and the antennæ (feelers), which are covered with sense organs. It also carries the complex mouth parts. The thorax is chiefly concerned in locomotion, being almost entirely occupied by large muscles for the movement of the wings. The abdomen contains the greater part of the alimentary canal, the reproductive organs and large air sacs. It will of course be understood that the functions of these three main parts are not confined to those named. The tracheal sacs extend into the thorax and head, the nervous system extends along the central side of the thorax and abdomen.

Head.

On the head are located numerous sense organs, the discussion of which is reserved for a later chapter. Aside

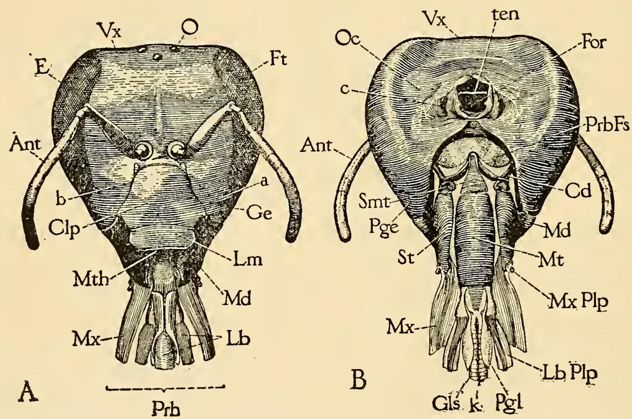


FIG. 68.—Front (*A*) and back (*B*) views of head of worker bee with the mouth parts cut off near their bases.

from these, the most interesting features are the complex mouth parts. The general appearance of the head of a worker bee (with all the hairs removed) is shown in the accompanying figure (Fig. 68, *A* and *B*). It is roughly triangular with the apex below, where the mouth parts are situated. The sides are rounded out by the compound eyes (*E*). From front to back, the head is flattened and is concave on the posterior surface to fit the rounded thorax. The three ocelli (*O*) in the worker are arranged in a triangle at the top of the head, the antennæ (*Ant*) arise from the center of the face. On the posterior surface is the foramen magnum (*For*) through which pass nerves, œsophagus, dorsal blood vessel and tracheal tubes connecting the head and thorax. Below the foramen magnum is the fossa (*PrbFs*) where the proboscis is attached.

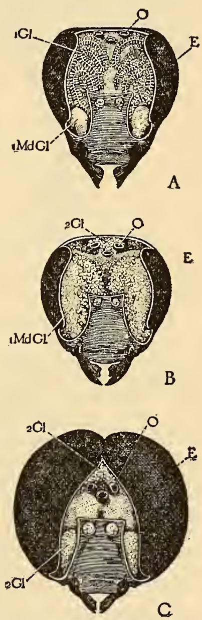


Fig. 69. — Anterior view of heads of worker (*A*), queen (*B*) and drone (*C*), with front, antennæ and proboscis removed from each.

The heads of the queen and the drone differ from that of the worker in size and shape (Fig. 69, *A*, *B* and *C*). The face of the queen (*B*) is more nearly round and is relatively wider. That of the drone (*C*) is larger and nearly circular, this being due to the unusual development of the compound eyes (*E*) which meet at the vertex of the head, crowding the ocelli (*O*) to the front near the bases of the antennæ. The head of the queen is smaller than that of the worker.

The mandibles (Fig. 68, *A*, *Md*) or jaws, which are of special interest to the beekeeper, are situated on the sides of the mouth anterior to the base of the proboscis, being attached to the clypeus (*Clp*) and the postgena (*Pge*) by two articulations, so constructed that they serve only to crush or bite food and not to grind it. The mandibles of insects, when present, work sidewise and not up and down in a median plane, as do our jaws. The mandibles of the three types of bees differ in shape and size. Those of the worker (Fig. 70, *A*) are hollowed out and have smooth and rounded edges, while those of the drone (Fig. 70, *B*) and of the queen (Fig. 69, *B*) are pointed and notched.

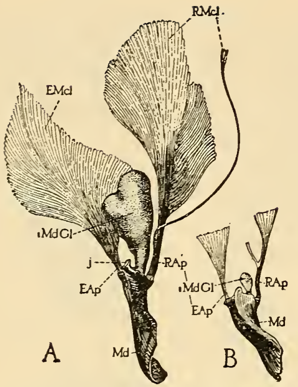


FIG. 70.—*A*, right mandible of worker with muscles and mandibular gland (*1MdGl*) attached; *B*, corresponding view of mandible of drone with muscles cut off.

The typical mandible of the Hymenoptera is like those of the queen and drone while the worker mandible is a specialized type. The fact that the worker mandible is smooth and rounded is often pointed out in connection with the fact that worker bees cannot puncture fruit. It need scarcely be said that queens and drones never injure fruit. The mandibles are moved by two sets of muscles (Fig. 70, *A*, *EMcl* and *RMcl*) with their origin in the head. On each mandible is the opening of a gland (*1MdGl*), located in the head (Fig. 69, *A*, *B*; Fig. 70, *A*, *B*), which is a large sac in the worker (Fig. 70, *A*) but is reduced in the drone (Fig. 70, *B*). In the queen (Fig. 69, *B*) it reaches its greatest size. It was originally described by Wolff [1] as a mucous gland which serves to keep the surface of the roof of the mouth moist, where he thought the olfactory organs are located. The function of this gland is not clear, but it is supposed by Arnhart [2] to function in softening wax. This theory rests on the assumption made by Cheshire and others

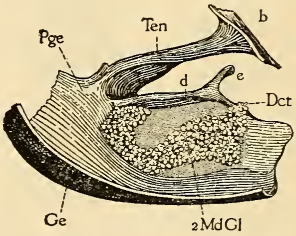


FIG. 71.—Internal mandibular gland (*2MdGl*) of worker.

[1] Wolff, O. J. B., 1875. Das Riechorgan der Biene. Nova Acta der Ksl. Leop.-Carol. Deutsch. Akad. der Naturf., XXXVIII, pp. 1–251.

[2] Arnhart, Ludwig, 1906. Anatomie und Physiologie der Honigbiene. In Alfonsus' "Allgemeines Lehrbuch der Bienenzucht," Wien. (99 pp., 4 pls., 53 figs.).

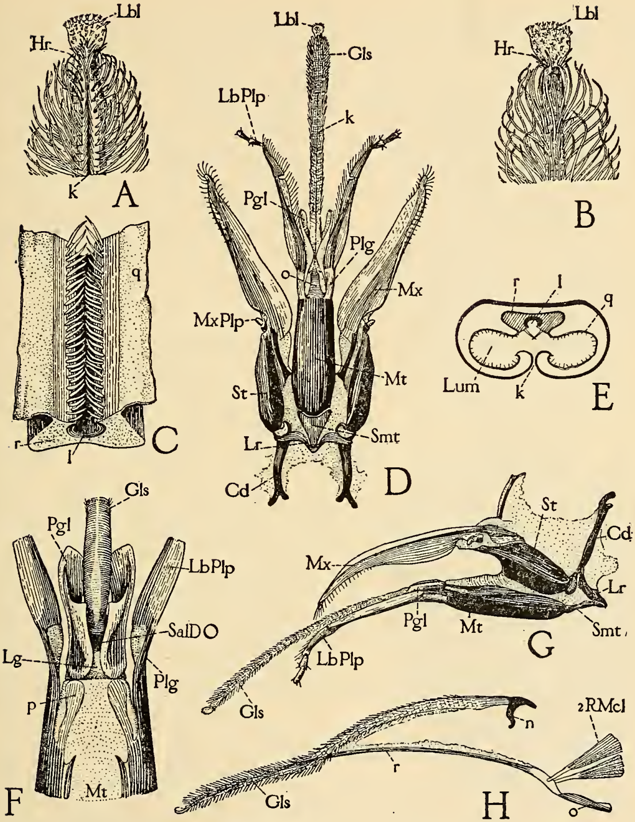


FIG. 72. — Mouth parts of the worker: *A*, tip of glossa; *B*, same from above; *C*, small piece of glossal rod; *D*, parts forming the proboscis, flattened out, ventral view; *E*, cross-section of glossa; *F*, end of mentum (*Mt*) and bases of ligula (*Lg*) and labial palpi (*LbPlp*); *G*, lateral view of proboscis, showing parts on left side; *H*, lateral view of glossa with its rod detached.

that the wax is changed chemically when it is manipulated by the mandibles. A second gland (Fig. 71, *2MdGl*) is found in workers only on the inner wall of the postgena (*Pge*) with an opening at the base of the mandibles.

The proboscis consists of the external mouth parts other than the mandibles (Fig. 68, *Prb*, Fig. 72, *A–H*). This group of organs serves in taking up liquid food. The name "tongue" is usually given to the slender median portion (*Gls*) but is loosely applied to the three median parts, the labrum. Snodgrass (*l.c.* pp. 44–45) explains the relation of these parts to the mouth parts of other insects and points out the true homologies, at the same time showing the errors into which various writers on bee anatomy have fallen. The accompanying illustration (Fig. 72, *A–H*) shows the structure of the organs of the proboscis. It will be seen (Fig. 72, *D*) that there are three terminal pieces, the central glossa (*Gls*) and two lateral labial palpi (*LbPlp*) arising from the mentum (*Mt*), a median basal sclerite, and two maxillæ, arising from separate basal pieces, the stipes (*St*). These in turn articulate with the lorum (*Lr*), a flexible band connecting with the cardines (*Cd*) which attach the whole proboscis to the head at the fossa of the proboscis (*PrbFs*, Fig. 68, *B*), on which it is suspended.

The maxillæ (*Mx*) are articulated by the cardines (*Cd*) to the maxillary suspensoria on the side walls of the fossa while the mentum (*Mt*) articulates with the submentum (*Smt*) which is held in the lorum (*Lr*). These parts are suspended in the membrane in the fossa floor, giving great freedom of movement.

The glossa (*Gls*) is covered with circles of hairs and the tip (labellum, *Lbl*) is spoon-shaped. The tip is protected by spiny hairs (*Hr*), formerly supposed to be taste organs, between which is the end of the ventral groove (*k*) of the glossa.

When the proboscis is not in use the labium and maxillæ are folded back against the mentum and stipes. When in use, these parts are unfolded and held together. In sucking liquid the base of the labium slides between the bases of the maxillæ. To acquire this motion, the submentum turns on the lorum and the mentum turns on its articulation with the submentum. This gives the mentum a forward and backward movement and the labium is pulled and pushed through the maxillæ. This motion doubtless effects a pumping action, bringing the liquid through the temporary tube formed by the curling of the glossa. It is probably sucked farther by the pharynx. The glossa is also retracted into the mentum and this with its own contractility gives it great flexibility of movement.

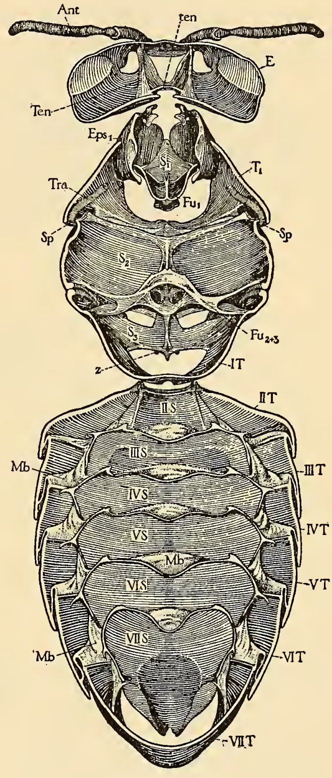


FIG. 73. — Dorsal view of ventral walls and internal skeleton of worker. Much enlarged.

Thorax.

As explained earlier (p. 99), the functional thorax of the bee (Figs. 73 and 74) consists of the three segments which form the thorax in other orders of insects and the segment which is the first abdominal segment of other orders. This modification is found in most other Hymenoptera[1] but the fact has seemingly escaped most writers on bees. The prothorax (1st thoracic segment) is reduced and the first pair of legs, arising from this segment, are loosely attached. The mesothorax (2d thoracic segment) is specially well developed to accommodate the large muscles which propel the fore wings, while the metathorax (3d thoracic segment) is reduced, consisting only of a narrow plate (*T3*), the metatergum, and two lateral plates on

[1] Snodgrass, R. E., 1909. Proc. U. S. Nat. Mus., XXXVI, pp. 511–595.

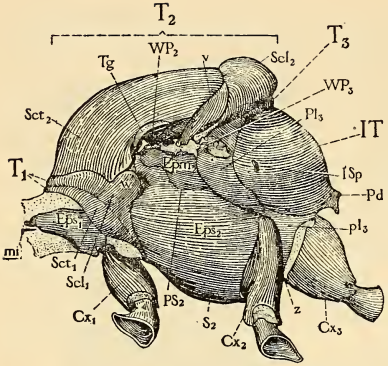


FIG. 74. — Thorax of worker, showing propodium or first abdominal segment (*IT*).

each side (pleural plates, *Pl3* and *pl3*). The tergum (dorsal plate) of the first abdominal segment (*IT*) is fixed to the metathorax. The posterior portion of this segment (propodium or median segment) forms the peduncle (*Pd*) to which the functional abdomen is attached. The legs and wings are discussed under organs of locomotion (p. 154).

Abdomen.

The abdomen of the female bees (queens and workers) appears to consist of six segments (Fig. 75) but to this number must be added the modified abdominal segment on the thorax (*IT*). In the drones, there are additional segments partially visible externally. Snodgrass has figured (Fig. 76) the tip of the abdomen of the worker, showing that the eighth abdominal segment is invaginated and the eighth abdominal spiracle opens within the invagination.

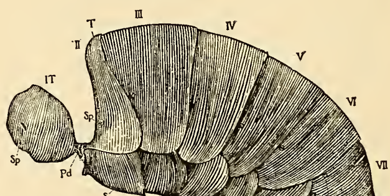


FIG. 75. — Lateral view of abdomen of worker.

Zander[1] further claims that the quadrate plate (*Qd*) is a part of the ninth tergum. The anal opening (*An*) is in a

[1] Zander, Enoch, 1899. Beiträge zur Morphologie des Stachelapparates der Hymenopteren. Zeit. fur wiss. Zoologie, LXVII, pp. 288–333.

tube (without chitin) which represents the tenth abdominal segment (*X*) so that the bee, like most other insects, has ten abdominal segments. In the drone, nine of these segments are partially visible. The plates of the abdomen are easily movable, being connected by membranes so that the abdomen may be distended by food, or in the queen by the growth of the ovaries. In the typical segments (II–VII), there is a tergum (*T*) covering the dorsal and lateral surfaces, overlapping a sternum (*S*) or ventral piece. The spiracles (see p. 151) (*Sp*) are on the terga (see Figs. 73 and 75).

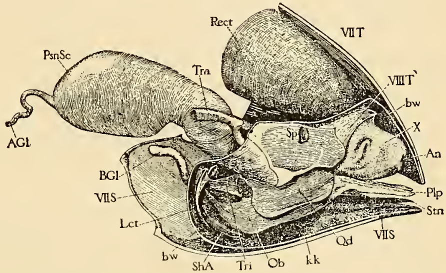


Fig. 76. — Tip of abdomen of worker with left side removed, showing normal position of sting and anus.

The eighth, ninth and tenth segments of the drone are not typical. The tergum of the eighth segment (Fig. 93, *D*, *VIIIT*) is partly covered by that of the seventh and carries the most posterior of the spiracles (*Sp*). The sternum of this segment (*VIIIS*) is likewise concealed on the ventral side. The dorsal portion of the ninth segment is chitinized to but a small extent but the ventral portion (*IXS*) is chitinized and carries two pairs of clasping organs, used during copulation (*1Clsp* and *2Clsp*). The penis is extruded during mating between the clasping organs.

DIGESTION

The workers take in food not only for their own nourishment but also that they may be able to provide food for the larvæ. The queen eats frequently, especially during the period of active egg-laying, and a rapid metabolism must take place to permit her to produce the large number of eggs which she lays in the height of her activities. The larvæ, as has been explained in the previous chapter, take enormous quantities of food, given them by the worker bees, permitting the rapid growth during the short period of larval development.

The food of the various members of the colony all comes from nectar and pollen. The workers eat honey and pollen for their own nourishment but modify the raw materials before feeding the larvæ. They also normally feed the queen and the drones, but the composition of the material furnished is not determined. That the raw materials may serve their purpose, they must be so modified that they may pass through the walls of the alimentary canal and then remain in a soluble condition in the blood until taken up by the tissues. To accomplish this, various digestive enzymes are needed. The source of these will be discussed later.

The digestive processes of the bee are not thoroughly understood. The usual discussions, which are abundantly numerous in spite of our lack of knowledge, are too often confined to the drawing of analogies with human digestion. No such analogies are permissible and it is, for example, entirely unwarranted to apply the name "chyle stomach" to the ventriculus, because of a supposed homology with human intestinal digestion. The whole structure of the insect alimentary canal is different from that of man and it is, in fact, better not to apply names to any of the parts which are drawn from human anatomy. It is perhaps permissible to use the terms mouth, œsophagus and anus for both insects and man, but to call the ventriculus the chyle stomach or the rectal ampulla the large intestine is misleading. These parts do not seem to have homologous functions in man and bees.

The structure of the alimentary canal has been well described by Snodgrass and by other workers and in so far as a knowledge of anatomy is helpful there is little room for criticism. There have been, however, very few investigations of the digestive processes. The digestion of insects is discussed by Biedermann,[1] and more recently Petersen[2] has published a discussion of the processes of digestion in the honeybee. This is the first good paper on this subject and the author is to be commended for taking a stand against the making of comparisons with human physiology.

The mouth parts have already been described (p. 135), and those glands (*1Gl*, Fig. 59) which are supposed to be concerned in the production of larval food have also been discussed (p. 111). Behind the mouth is an enlargement of the alimentary canal called the pharynx (*Phy*, Fig. 60), leading to a long narrow tube extending through the thorax, the œsophagus (*Œ*). Behind the constriction between the thorax and abdomen, the alimentary canal widens to form the honey-stomach (*HS*), homologous to the crop of other insects. This is a thin-walled, muscular organ used by the worker in carrying nectar to the hive. Behind the honey-stomach is a valvular structure, the proventriculus (*Pvent*, the anterior part being often called the stomach-mouth) which separates the honey-stomach from the ventriculus (often called the chyle stomach). The proventriculus is of special interest in the bee, since when closed it prevents the nectar from mixing with the contents of the ventriculus and makes it possible for the honey-stomach to function as a carrying vessel. It is claimed by Schönfeld that the anterior end of the proventricular valve (*nn*, Fig. 61) may be moved forward to touch the posterior end of the œsophagus, so that the contents of the ventriculus may be forced out as larval food. Snodgrass has shown that this cannot happen without tearing the muscles of the

[1] In Winterstein's Handbuch der vergleichenden Physiologie, vol. 2, Heft I.

[2] Petersen, Hans, 1912. Beiträge zur vergleichenden Physiologie der Verdauung. V. Die Verdauung der Honigbiene. Pflügers' Arch. fur die gesammte Phys. d. Menschen u. d. Tiere, XLV, pp. 121–151.

honey-stomach, and furthermore, as is shown later, the contents of the ventriculus could not escape were this contortion possible. Cheshire claims that the hooks (at *nn*, Fig. 61) of the proventriculus serve to separate the honey and pollen in the honey-stomach, but no proof is presented. The only known function of the proventriculus is that of opening to allow food to pass to the ventriculus. There is no evidence that it assists in the mastication of pollen.

Behind the proventriculus is the ventriculus (*Vent*), a thick-walled organ, ringed by numerous constrictions. It consists (Fig. 77) of longitudinal and transverse muscles surrounding a much folded epithelium, the cells of which are supposed to produce some of the digestive enzymes. The inner depressions of this epithelium are filled with a gelatinous mass (*pp*) which extends into the lumen. The food contents of the ventriculus are surrounded by layers of membrane (peritrophic layers, Fig. 77, *Pmb*), formed from the gelatinous mass in the enveloping epithelium. The peritrophic layers are often described as chitinous but this, according to Petersen, is an error. These membranes do not seem capable of allowing the passage of the food contained in them to the ventriculus wall and probably little or no absorption of food occurs here. Furthermore, pollen is usually found at the posterior end undigested and, according to Snodgrass, it is not prepared for absorption until it reaches the rectal ampulla. Snodgrass observed in certain parts of the ventriculus wall a sloughing off of the ends of the epithelial cells (*Enz*), presumably enzymes, which are seen in the gelatinous peritrophic mass. Petersen, in confirmation of this view, found that the peritrophic layers (which come from the peritrophic mass on the epithelium) are not chitinous but contain proteolytic ferments. The peritrophic layers and their attachment to the proventricular valve effectually prevent the regurgitation of the contents of the ventriculus into the honey-stomach. The contents of the ventriculus does not at all resemble larval food. It therefore appears clear that the theory that

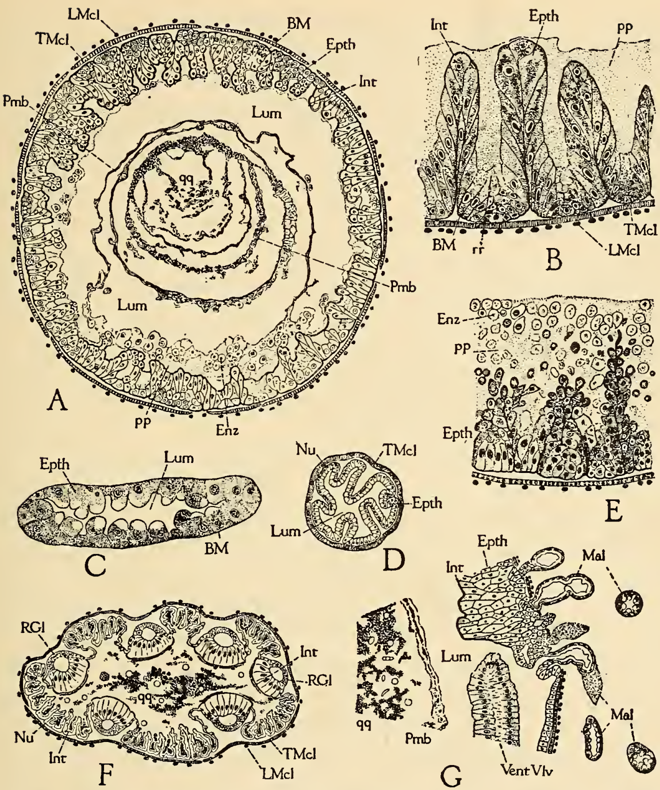


Fig. 77. — Histological details of alimentary canal of worker: *A*, cross-section of ventriculus; *B*, section of ventriculus wall; *C*, section of Malpighian tubule; *D*, cross-section of small intestine; *E*, section of ventriculus wall, showing formation of enzyme cells; *F*, section of anterior end of rectum, showing rectal glands (*RGl*); *G*, slightly oblique section of posterior end of ventriculus, showing openings of Malpighian tubules.

larval food is regurgitated can no longer be considered as at all tenable.

Behind the ventriculus, the alimentary canal narrows to form the small intestine (Fig. 60, *SInt*) and at the point where the ventriculus and small intestine join, the Malpighian tubes (*Mal*) empty into the alimentary canal. The small intestine is coiled and finally empties into the rectal ampulla (*Rect*, rectum or large intestine). The inner epithelium of the rectum is thrown into six longitudinal folds, the so-called rectal glands (Fig. 77, *RGl*) of unknown function. It is usually believed that they increase the absorbing surface but, since they are covered on the inner surface with chitin, this explanation seems improbable. The rectal ampulla is capable of considerable expansion and normally retains the feces when bees are confined to the hive, as in winter. It is supposed that most of the absorption of food takes place in the hind-intestine. Petersen advances the fantastic theory that the rectal glands are the source of the hive odor.

The food of bees which must be acted upon by the various digestive juices to be prepared for absorption have their origin in the nectar and pollen collected from flowers. The chief food is honey, which consists largely of invert sugar. This name is given to a mixture of two sugars, levulose and dextrose, which by various means can be made from sucrose (cane sugar). In the higher animals, these sugars are capable of absorption without further change, and this is presumably true of bees also. The sugar in nectar is probably sucrose with some invert sugar. The preparation of this material for absorption therefore begins with the ripening of nectar into honey. As explained earlier (p. 85), this is by the action of an enzyme and, according to Petersen, such an enzyme was extracted from the head of the bee by Erlenmeyer and by v. Planta, presumably from the salivary glands. The absorption of sugars probably occurs in the ventriculus and any water in the honey which is not needed is ejected. The process of such an ejection is not clear. It is also stated by Petersen that the bee produces a diastatic ferment by which the digestion of starch is possible, but he was never able to prove from experiments that starch is changed into dextrin, maltose or dextrose in the honey-stomach. However, pollen contains no starch so that the breaking down of starch plays a small part in the digestion of the bee.

The next important constituent of bee food is proteid, derived from pollen. Petersen shows the presence of proteolytic ferments in the salivary gland secretions and especially claims that the layers of peritrophic membrane consist largely of such ferments. He also makes the interesting observation that the bee is incapable of digesting the proteid from pollen unless the grains are broken before they enter the ventriculus, any ones remaining unbroken simply passing out in the feces. It would therefore seem probable that the pollen is surrounded in the ventriculus with the peritrophic layers containing the ferments and is then passed on to the small intestine without being broken up or absorbed. The use of pollen is more in evidence during brood-rearing and it is usually assumed that the workers predigest this, or perhaps more correctly, secrete a mixture rich in protein for the use of the larvæ. However, since the mid-intestine of the older larvæ contain considerable pollen, a large part of their proteid digestion is by their own proteolytic ferments.

Pollen contains considerable oil but Petersen failed to find that any of it is digested by the bee, at any rate most of it passes through without being broken up or absorbed.

The retention of feces by bees, so long as they stay in the hive, except when dysentery develops, is of importance in their management. The relation of this retention to the activities of bees in winter is discussed in a previous chapter (p. 91). Usually during the active season, when feces accumulate most rapidly, there are frequent opportunities for flight and the ejection of feces.

For bees living only on honey or perhaps on a syrup of cane sugar, digestion is reduced to a minimum. It remains to be proved whether under such conditions the bees are fully nourished. That bees can live over winter without pollen is of course not proof that they do not need it then.

While bees can convert sucrose (cane sugar) into levulose and dextrose and can digest maltose, they cannot digest certain other sugars. There is also considerable evidence that dextrine cannot be digested and that the presence in the food of unusual amounts of dextrine may produce the condition known as dysentery. It has also been found that certain proteids which have been used as substitutes for pollen cannot be digested. The alimentary canal of the bee, therefore, appears to be a highly specialized system, incapable of any considerable flexibility. Bees would evidently fail to be nourished by the mixed diets of many other species, which is additional argument against attempted homologies with human digestion.

CIRCULATION

When the products of digestion are absorbed and traverse the alimentary canal wall, they must be carried to the various tissues for assimilation. This is done by means of the blood. In the higher animals blood is normally confined in blood vessels which carry it throughout the body, but in the bee, as in other insects, the blood bathes the various organs, filling up the interstices between them. These spaces may, however, be so arranged that the blood flows in definite channels or sinuses. The blood is further confined to definite paths by membranes stretched across the dorsal and ventral walls of the abdomen (*DDph* and *VDph*, Fig. 78) which bound the chief sinuses. These diaphragms have a rhythmical motion and assist in the circulation of the blood. The heart (*Ht*) is located dorsal to the dorsal diaphragm, this sinus being therefore known as the pericardial chamber. The heart is a long muscular tube consisting of four chambers lying in the third, fourth, fifth and sixth segments of the abdomen. In each of these segments is a valvular opening (ostium, *Ost*) on each side for the admission of blood from the pericardial chamber, and there are also segmental valves to prevent a backward

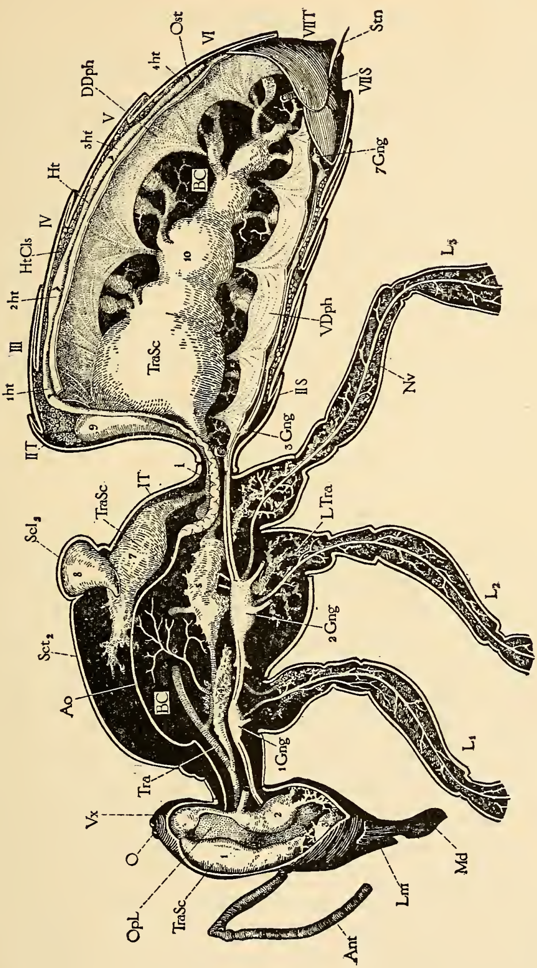


Fig. 78. — Longitudinal median vertical section of body of worker, showing nervous system, tracheal system, dorsal and ventral diaphragms and dorsal blood vessel.

flow of blood. The posterior end of the heart is closed but on the anterior end it is continued in a long tube (aorta, *Ao*) extending in various convolutions and arches through the thorax and opening by simple branches into the head cavity.

The blood of the bee is a colorless liquid containing certain corpuscles, but no red ones such as are found in mammals. The blood is forced through the heart and aorta to the head cavity. It then flows backward through the sinuses of the thorax into the ventral sinus of the abdomen. Pumped backward by the pulsation of the ventral diaphragm, it flows through various definite cavities between visceral organs in the abdomen and into the pericardial cavity, from which it again enters the heart through the ostia. In its passage through the sinuses about the viscera, the blood takes up the food which has passed through the walls of the alimentary canal. This nourishment is promptly carried to all parts of the body by the circulation.

METABOLISM

It is not proposed at this time to enter into a long discussion of the ways by which each organ is rebuilt as needed. In the general discussion of the cells which make up the various organs (p. 94), it was stated that each cell is capable of taking up nourishment and of building this into protoplasm. It also utilizes oxygen furnished by the respiratory processes. To this process the name anabolism is given. Not all cells require the same constituents of the food presented or the same amount of oxygen, but by some mysterious process each cell is enabled to choose those parts which it needs. Similarly, as the activities of the cells progress, protoplasm is broken down and waste products are formed: this we know as katabolism. The final products of katabolism are carbon dioxid and water, together with various more complex chemical compounds usually containing nitrogen, such as uric acid and urea. The elimination of the more complex waste products is discussed under excretion.

RESPIRATION

That an animal may live, it must have oxygen. The oxygen taken into the body in respiration does not go to form protoplasm in the various cells but it is used to combine with the products of katabolism to make simpler compounds which can be eliminated from the body. These products of the breaking down of the living substance are of such a character that they poison the cells unless they are promptly removed. The process is like ordinary combustion in that these products combine with oxygen to form carbon dioxid and water and to generate heat.

In man, the oxygen is taken into the lungs and the blood is pumped there to meet the oxygen. But the bee does not have a closed circulation which will effectually carry the blood to the oxygen. Furthermore, the higher animals have in their red blood corpuscles a substance, hæmoglobin, which is capable of absorbing abundant oxygen, but this is lacking in the colorless blood of insects. In the bee, instead of the blood being carried to the oxygen, the oxygen is carried to the blood by means of tracheal sacs and a multitude of tracheal branches which go to every organ and to every part of the bee's body. These tracheæ receive their air supply through openings in the outer wall, the spiracles, two pairs on the sides of the thorax and eight pairs on the abdomen. The tracheæ are composed of a delicate epithelium lined with a thin layer of chitin. To prevent the collapse of the tracheal trunks, some of them are further strengthened with spirally placed rings of chitin, which are thickenings of the chitin lining. The finer branches lack these chitin rings and there are few heavy trunks in the bee, the walls usually being delicate.

The oxygen is therefore carried to all parts of the bee's body, passes through the walls of the tracheal system, is absorbed by the blood and is carried to every cell. The products of katabolism are in turn carried by the blood, and the water vapor (at least most of it) and the carbon dioxid enter the tracheal branches and are expelled through the spiracles. The more complex compounds are eliminated in the process of excretion.

The tracheal system of the bee is shown sufficiently in the accompanying illustration (Fig. 79) so that a detailed description is unnecessary. The abdomen contains the unusually large tracheal sacs (*TraSc*) connected with each other by ventral commissures (*TraCom*). They are also connected with tracheal sacs of the thorax. From the most anterior spiracles of the thorax are heavy trunks to the air sacs of the head, above the brain. The tracheal system of the bee is more elaborate than that of most other insects and probably in no other species is there more free access of oxygen to all parts of the body.

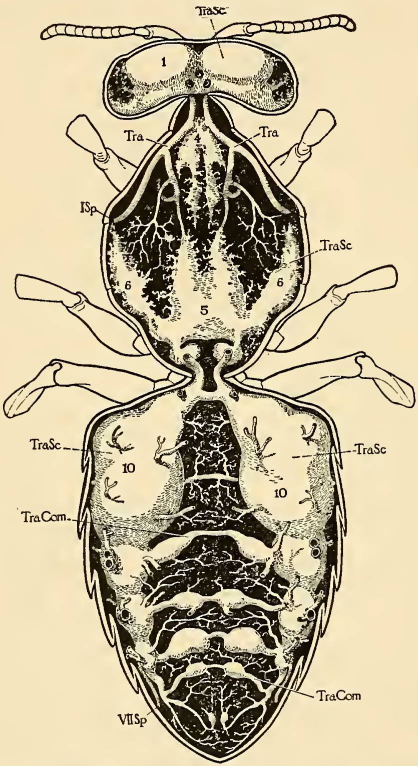


Fig. 79. — Tracheal system of worker with dorsal sacs and trunks removed, from above.

The pumping of the air through the body is accomplished by the respiratory movements of the abdomen, consisting of a lengthening and shortening of the abdomen and a slight dorso-ventral movement. The muscles of the abdomen which function in respiration have been described by Carlet,[1] who distinguishes seven sets. It is stated by Djathchenko[2] that in expiration the spiracles are momentarily closed, the contraction of the muscles thus forcing air to the minute branches. The spiracles are then opened and the air is expelled.

EXCRETION

The products of the breaking down of protoplasm consist, as previously stated, of carbon dioxid, water and various compounds containing nitrogen. Since the adult honeybee can live for long periods (especially in winter) on pure sugar, excretion must at times be reduced to a minimum. Sugar breaks down into carbon dioxid and water, both of which may pass off as gases through the tracheal system. It is only the other components of honey and the pollen which ultimately go to form nitrogenous compounds. The carbon dioxid is all expelled through the tracheæ and probably most of the water escapes as vapor by this course, although some may be ejected with the nitrogenous compounds. The excretory organs are the Malpighian tubules (Fig. 60, *Mal*), about 100 in number in the bee, which open into the alimentary canal at the junction of the ventriculus and the intestine. They are long delicate tubes which coil about the other viscera. These tubules are only one cell in thickness and the ends of these cells (*Epth*, Fig. 77, *C*) often bulge into the cavity of the tubule. The junction of the Malpighian tubules with the intestine is shown in Fig. 77, *G*. Minute crystals of urates have been found in the Malpighian tubules. The excreted products empty into the intestine and are expelled in the feces.

In the fat body (located in the body cavity) are found certain large cells of rather mysterious function, called

[1] Carlet, G., 1884. Sur les muscles de l'abdomen de l'abeille. Comptes rendues de l'Acad. des Sci. de Paris, XCVIII, pp. 758–759.

[2] Djathchenko, Sophie, 1906. Zur Frage der Athumsorgane der Biene. Ann. de l'Inst. agron. de Moscou, XII, pp. 1–14.

œnocytes. Koschevnikov [1] states that the œnocytes of the young adult bee have a uniform, slightly pigmented protoplasm, while in old bees yellow granules begin to appear in these cells. After the winter confinement, these granules are numerous and in old queens they are especially abundant. According to the view of this author, œnocytes are excreting cells which take up waste products of katabolism and, after modifying them, deliver them again to the blood to be carried to the Malpighian tubules. The changes of age may be interpreted as due to an accumulation of these products in cells which are no longer able to discharge them. This failure of the œnocytes should be investigated from the point of view of the term of life of the bee. In some of the primitive insects the fat body is supposed to function as a permanent storage for urates.

LOCOMOTION

Bees are able to go from place to place by means of two systems of locomotor organs, the wings and the legs. Both of these are attached to the thorax and the muscles of flight are so well developed that they occupy almost the entire space in the thorax.

The wings (Fig. 80) are membranous structures with a definite framework of veins attached to the sides of the thorax. As previously explained (p. 99) they are not primary embryonic appendages, but are secondary outgrowths from the second and third thoracic segments. The details of the venation of the wings need not be considered at length. This has been investigated in a careful manner by Comstock and Needham [2] and the designations used in Fig. 80 are those decided upon by these authors after a study of the comparative venation of the various orders of insects. The symbols are explained in the appendix. The

[1] Koschevnikov, G. A., 1900. Ueber den Fettkörper und die Œnocyten der Honigbiene (*Apis mellifera* L.). Zool. Anz., XXIII, pp. 337–353.

[2] Comstock, J. H., and Needham, J. G., 1898–99. The wings of insects. Am. Nat., XXXII and XXXIII: Reprinted, Ithaca, N. Y.

attachment of the bee's wings to the thorax has been investigated by Snodgrass (*l.c.* pp. 61–63).

The motion of the wings in flight is in four directions, up, down, forward and backward, and the combination of these movements causes the wing tips to describe the course of a figure 8, if the insect is held stationary. In flight, the 8 is of course modified. The hind wings are small and are attached by hooks on their anterior margins to thickenings on the margin of the front wings. They are not provided with large flight muscles of their own but are carried along by the action of the powerful muscles in the mesothorax which propel the fore wings.

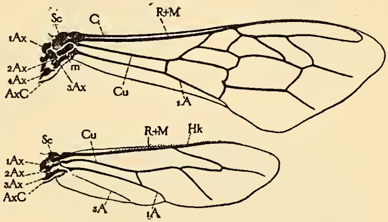


Fig. 80. — Fore and hind wings.

The muscles of flight are in four sets, corresponding to the four directions of wing movement. The chief muscles are not attached directly to the bases of the wings, as in dragonflies, but the wings are moved into the right position by muscles situated inside the pleura of the two thoracic segments. After the wings are in position for flight, the compression of the thorax by the vertical muscles lowers the dorsum and raises the wing while the contraction of the longitudinal muscles raises the dorsum and lowers the wing. The vertical muscles are therefore the elevators and the longitudinal muscles the depressors. The movements of the wings during flight is therefore produced mainly by changes in the shape of the thorax. The forward and backward movements are accomplished by the action of the muscles on the pleurum, acting directly on the bases of the wings.

Because of the enormous development of the two main sets of flight muscles, bees are capable of strong and rapid flight. They are also capable of arresting progress suddenly

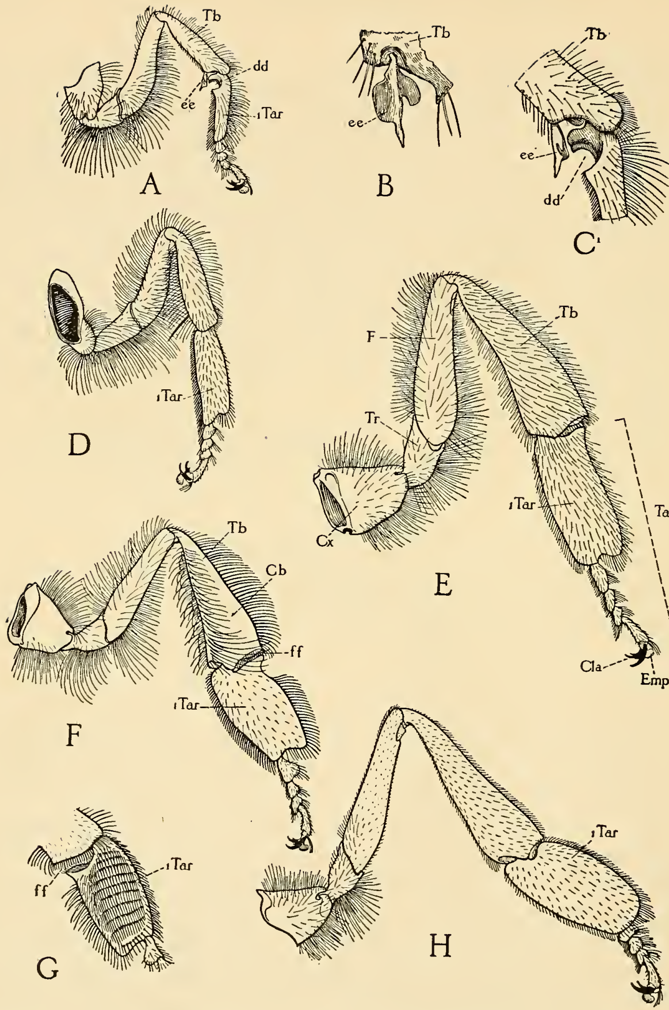


Fig. 81. — *A*, left front leg of worker, anterior view; *B*, spine of antenna cleaner; *C*, details of antenna cleaner; *D*, left middle leg of worker, anterior view; *E*, left hind leg of queen, anterior view; *F*, left hind leg of worker, anterior view; *G*, inner view of left hind leg of worker, showing pollen-combs; *H*, left hind leg of drone, anterior view.

or of getting under way rapidly. There is no reason to believe that flight is in any way dependent upon the amount of air in the tracheæ, as has been claimed, for filling the air sacs obviously does not reduce the weight of the bee. The maximum rate of flight is not clearly established, for the currents of air must be eliminated in making such determinations; the rapidity of movement depends largely upon the load being carried. Bees are able to fly at a considerable angle for some distance as is seen in apiaries in mountainous districts. The power of the wing muscles is shown by the ability of a worker to fly from the hive carrying a drone, which weighs more than the worker itself.

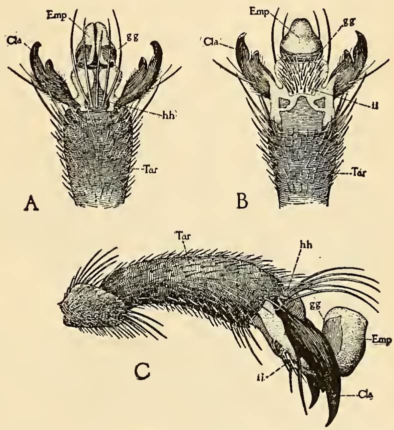


Fig. 82. — Dorsal (*A*), ventral (*B*) and lateral (*C*) views of last tarsal joint of first foot of worker.

In walking, bees use all six legs (Fig. 81). In addition to their function in locomotion, the legs constitute a rather complex set of tools for numerous other purposes, especially complex in the worker. On the front legs at the articulation of the tibia and first tarsal joint are the antennæ cleaners. The middle leg has a spur to which has been attributed the function of prying pollen from the hind legs in storing it. The hind legs of the worker bees are highly specialized, carrying pollen baskets or corbicula on the outer side of the flattened tibiæ and rows of spines on the inner side of the first tarsal joint. Between these two joints are the so-called wax-shears, which in fact have nothing to do with the wax, but function in pollen gathering (p. 123). Each leg is provided with a pollen brush for collecting pollen.

The muscles for moving the legs are located inside the joints and are inserted on the chitinous walls.

The last tarsal joint on each leg carries a pair of bilobed claws (Fig. 82, *Cla*), which differ among the three types of bees. Those of the drone are bent more nearly at right angles than those in the workers and queens and those of the queen are larger than the claws of the workers. Between the claws is a lobe (empodium, *Emp*) used when the bee walks on a smooth surface. On such a surface the claws are useless and the sticky empodium is lowered and flattened, providing a good foothold.

The motion of the legs in walking is typical of all insects. The legs move in two sets; the fore and hind legs on one side move in the same direction as the middle leg on the opposite side, thus giving a triangle for support at all times. In flight the legs hang freely and are forced somewhat backward, except when they are being used as in the manipulation of pollen (p. 123).

PROTECTIVE APPARATUS

Worker bees defend the colony by means of the sting, situated usually in a cavity at the tip of the abdomen (Fig. 76) but capable of marvelously rapid action when it is protruded. As was stated earlier (p. 140), this sting cavity is formed by the infolding of the eighth, ninth and tenth segments of the abdomen. The sting is homologous with the ovipositor of other insects (see Snodgrass, *l.c.* pp. 76–77) and is made up of parts considered by some embryologists as comparable with the legs and mouth parts of the more anterior segments of the bee. The sting of the worker bee is straight while that of the queen is longer, curved and less strongly barbed.

The sting (Fig. 83) and its accessory apparatus form a rather complex structure. The shaft consists of three parts, a dorsal sheath (*ShS*) along which move two barbed lancets (*Lct*). The sheath is enlarged at the anterior end into a bulb (*ShB*) and is further continued in two arms (*ShA*) which curve outward. The lancets slide on a grooved track the full length of the sheath, past the bulb and diverge along the two basal arms. The sheath and lancets combine to form a hollow tube (*PsnC*) through which the poison flows.

The arms of the sheath are attached at their anterior ends to oblong plates (*Ob*) which overlap the sides of the sting. To these plates are attached palpi (*StnPlp*), soft white projections provided with sense organs, by means of which the bee can tell when she is in contact with the object which is to be stung. The lancets are attached to triangular plates (*Tri*) which in turn articulate with the quadrate plates (*Qd*). By the movements of these plates on each other the lancets are slid along the sheath when the sting is used. It has been shown by Zander[1] that the triangular plate (*Tri*) is part of the eighth sternum, the quadrate plate (*Qd*) is part of the ninth tergum and the oblong plate (*Ob*) is the ninth sternum.

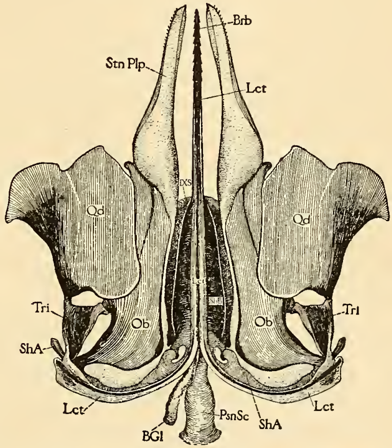


Fig. 83. — Ventral view of sting of worker and accessory parts, flattened out.

"In the accessory plates of the bee's sting we have a most excellent illustration of how parts of a segment may become modified to meet the requirements of a special function, and also an example of how nature is ever reluctant

[1] Zander, Enoch, 1899. Beiträge zur Morphologie des Stachelapparates der Hymenopteren. Zeit. f. wiss. Zool., LXVI, pp. 288–333.

to create any new organ, preferring rather to make over some already existing structure into something that will serve a new purpose." — Snodgrass, *l.c.* p. 78.

The poison of the sting arises from two sets of glands. The conspicuous poison sac (*PsnSc*) which opens into the bulb of the sting is usually seen attached to the sting when the sting is pulled from a bee. The contents of this gland have an acid reaction and it was formerly believed to be formic acid. This acid comes from two long coiled tubes (*AGlD*) on which are two small enlargements, supposed to be the secreting glands (*AGl*). The tubes (*AGlD*) also probably have gland cells in the walls. The other poison glands (*BGl*), known as the alkaline glands, also empty into the bulb of the sting. Their secretion is supposed to have an alkaline reaction. According to Carlet,[1] the secretions of these two sets of glands must be mixed to be fully effective. The secretions enter the bulb where they are mixed and are then forced down the canal (*PsnC*) formed by the sheath and lancets.

In most books on bees, certain lateral openings in the lancets are described as paths of the poison in the process of stinging. Snodgrass showed, however, that these do not connect with the poison canal and supposed them to be ducts of some kind of subcuticular glands. McIndoo has shown them to be olfactory pores (p. 170).

The sting, as every beekeeper knows, is an effective weapon of defense. When used, it usually cannot be withdrawn because of the barbs (*Brb*) on the lancets. The sting with the accessory plates and poison sac are therefore usually torn from the body of the bee, causing so severe an injury to the abdomen that the worker dies within a short time. The defender is thus sacrificed for the good of the colony. The parts torn away include the muscles which operate the accessory plates and indirectly slide the lancets on the sheath. The sting may therefore be driven

[1] Carlet, G., 1890. Mémoir sur le venin et l'aiguillon de l'abeille. Ann. des sci. nat., Zool., 7 ser., IX, pp. 1–17.

farther and farther into the wound if not promptly removed and the same reflex actions of the muscles serve to force more poison from the poison sac. In removing the sting, care should be exercised not to squeeze the poison sac thus emptying its contents into the wound.

CHAPTER VII

THE NERVOUS SYSTEM AND THE SENSES

In order that bees may respond to factors in the environment, obviously these influences must be perceived. The organs which receive the stimuli from without are the special organs of sense. The resulting nervous impulses are then transmitted through the nervous system, by means of which also the actions of the animal are coördinated and molded in response to the stimuli received. The nervous system and its various organs of special sense are therefore of the highest importance to the animal and the influence of the stimuli of the environment are so important in the behavior of these insects as to justify a separate chapter.

Nowhere in the entire discussion of bee activities is it more necessary to avoid comparisons with our own actions than here. Man is capable of conscious and volitional acts while evidence of such acts in bees is lacking. Furthermore, the structure of the nervous system and of the sense organs is so unlike analogous structures in man that attempts at homologies are entirely unwarranted.

NERVOUS SYSTEM

This system of organs consists of a series of nerve masses called ganglia (Fig. 84, *Gng*) situated on the mid-ventral line of the body, the ganglia being connected by a pair of longitudinal cords, called connectives. The nerve cells are located in the ganglia while the delicate processes from these nerve cells, the nerve fibers, form the connectives and also go to all parts of the body, some serving to transmit stimuli from the sense organs and some to carry stimuli from the nervous system to the various organs of the body. The nerve fibers therefore are often compared with wires used in conducting electric energy from place to place.

In an hypothetical generalized insect embryo we should doubtless find a ganglion for each segment of the body, probably twenty in all, but the ganglia of the bee larva are modified from the primitive condition and in the adult still further specialization is observed, by the fusion of various ganglia.

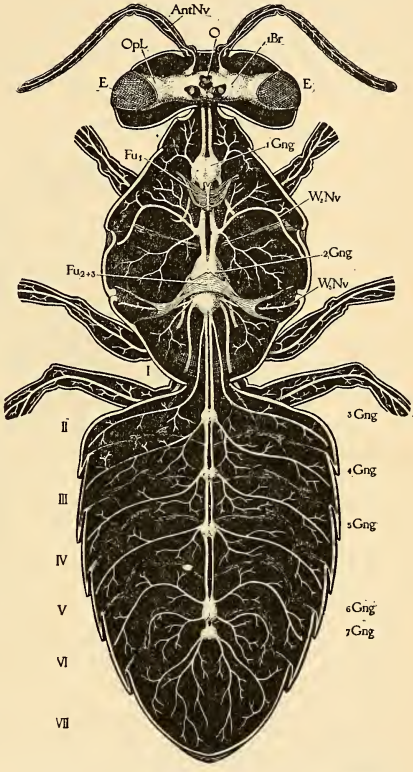


Fig. 84. — Nervous system of worker, dorsal view.

The brain (Fig. 85), situated above the œsophagus, consists of three consecutive ganglia, recognizable in the embryo, but completely fused and not readily recognizable in the adult. From the brain, two short connectives (circum-œsophageal) pass one on either side of the œsophagus to the subœsophageal ganglion (*SœGng*) also located in the head. Continuous with the brain are the optic lobes (*Opl*) forming the nervous connection with the large compound eyes (*E*), and from the brain are nerves to the antennæ (*AntNv*) and also to the frontal ganglion (*FtGng*), from which the stomatogastric system (sympathetic system) has its origin (*StgNv*). The subœsophageal ganglion gives off nerve branches to the mandibles (*MdNv*), maxillæ (*MxNv*) and labium (*LbNv*). For a study of the minute structure of the brain and the paths of the various nervous elements, the reader is referred to the works of Kenyon [1] and Jonescu.[2]

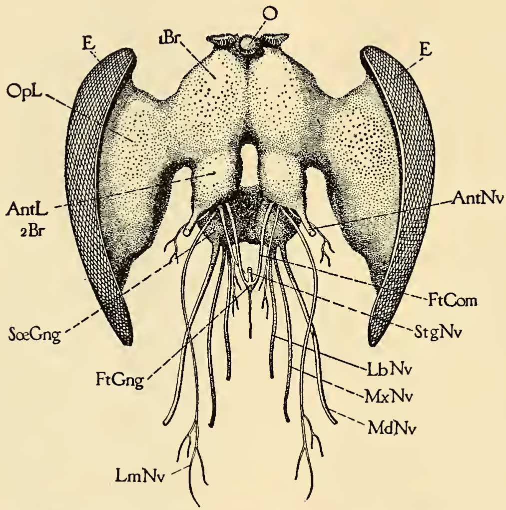


Fig. 85. — Brain and subœsophageal ganglion of worker, anterior view.

In the thorax the number of ganglia is reduced to two (Figs. 78 and 84, *1Gng* and *2Gng*). The first innervates the first pair of legs while the second is a combination of four ganglia, as shown by the fact that it innervates the meso-

[1] Kenyon, F. C., 1896. The brain of the bee. Jr. comp. neurol., VI, pp. 133-210.

——, 1897. The optic lobes of the bee's brain in the light of recent neurological methods. Am. nat., XXXI, pp. 369–376.

[2] Jonescu, C. N., 1909. Vergleichende Untersuchungen über das Gehirn der Honigbiene. Jenaischen Zeit. f. Naturwiss., XLV, N. F., XXXVIII.

and metathoracic segments (with the corresponding two pairs of legs and wings) and the first abdominal segment, which is fused with the thorax in the bee, as well as the first segment of the abdomen behind the constriction. It should be noted that nerves (*W2Nv* and *W3Nv*) run to the bases of the wings to innervate sense organs (p. 170).

In the abdomen are five ganglia (*3–7Gng*) which send nerve branches to the remaining abdominal segments. The third and fourth ganglia lie one segment in front of the segments which they innervate while the remaining ones are in their own segments, the last (*7Gng*) supplying the remaining posterior segments of the abdomen, it therefore being actually a fusion of four ganglia.

The action of the nervous elements remains a matter chiefly of conjecture. These cells have lost their contractility and probably never regenerate nor divide in the adult bee. Their function is obviously important, for if this system is injured the coördination of the body is destroyed. However, the cutting of the nerve cord does not cause death and even if the thorax and abdomen are entirely separated the parts may function independently. If the head is removed, the animal can still walk and if the abdomen is removed it can still take in food. These facts indicate that the nervous control of the body is not centralized in the brain as completely as in man and in many other animals. Proper correlation of movement cannot, however, take place unless the nervous connections are intact.

SENSE ORGANS

So little is known of the structure and function of the sense organs of bees that this subject must be discussed with caution. We know that the simple and compound eyes are the organs of sight and recently it has been found where the organs of smell are located. Beyond this is a vast field for investigation and a fertile field for speculation.

Sight.

The organs which receive light stimuli are the three simple eyes or ocelli (*O*) and the two large compound eyes (*E*), all situated on the head. The compound eyes are located on

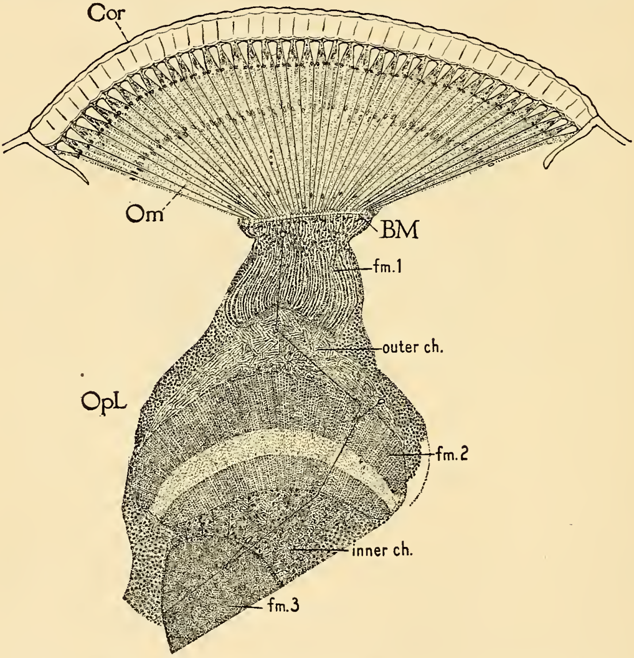


Fig. 86. — Section of compound eye and optic lobe of worker; *Om*, ommatidia.

the sides of the head, each eye consisting of many units. In drones, the number of these units is larger than in the two types of females and the compound eyes are so enlarged as to meet on the vertex of the head. The structure of the units of the compound eye was described some years ago.[1] On

[1] Phillips, E. F., 1905. Structure and development of the compound eye of the honey bee. Proc. acad. nat. sci. Phila., LVII, pp. 123–157.

the outer surface, these units (ommatidia) are indicated by hexagonal facets in the chitinous covering of the eye. If a section is cut through the entire eye of a worker bee (including the optic lobes), the structure is that shown in Fig. 86. Numerous ommatidia are shown in full length and beneath these are the optic lobes, which need not be described here. An examination of a single ommatidium (Fig. 87) shows the following details of structure: (1) an outer corneal lens of chitin (*CL*) continuous with the chitin of the head, (2) the crystalline cone (*CC*) and (3) the rhabdome (*rhb*) surrounded by eight or nine sense cells or retinulæ (*ret*). Surrounding the ommatidia are two types of pigment cells, (1) the corneal pigment cells (*c.-p.c.*), which in the pupal stage secreted the chitin of the corneal lens, and (2) the outer pigment cells (*o.-p.c.*). So far as can be determined, the functions of these parts are as follows: rays of light pass through the lens and crystalline cone cells and enter the transparent rhabdome where the stimulus is received. Any rays of light which enter obliquely or which strike the edge of the crystalline cone are absorbed by the surrounding pigment cells so that it seems probable that only those rays which strike the surface of the eye at a right angle ever reach the sense cells. There is no apparatus for changing the focus of the lens.

Fig. 87. — Section of entire ommatidium.

The type of image formed by the compound eye has been the subject of considerable speculation. The two theories on this subject are (1) that each facet forms a separate image[1] and (2) that the impressions of the individual facets form a mosaic image.[2] The latter theory has most to support it and is generally accepted. Forel [3] gives an admirable discussion of these theories and adds considerable evidence to support the latter theory.

As was stated earlier, it is probable that only the rays of light which strike the lens perpendicularly can reach the sensory cells. The image is probably not a distinct one. If an object in motion is within the range of vision of the bee, the image is transferred rapidly from one set of ommatidia to another, which probably accounts for the fact that bees perceive objects in motion more readily than they do still ones.

In addition to the compound eyes, there are three simple eyes or ocelli (*O*), which Grenacher [4] states are derived from the same primitive organ as the individual ommatidia of the compound eyes; in fact, as shown by him and by Forel, compound eyes in some species are replaced by ocelli.

The parts played by the ocelli and by the compound eyes in the vision of the bee are not clear. From a study of the angles of refraction, it has been inferred that the ocelli are for perceiving near-by objects, while the compound eyes are far-sighted. However, just the reverse has been claimed, and we have no reliable data on this subject.

It has been shown by numerous experiments and by the experience of beekeepers that bees perceive differences in

[1] Gottsche, C. M., 1852. Beitrag zur Anatomie u. Physiologie des Auges der Fliegen u. s. w. Müller's Archiv. f. Anat.

[2] Exner, Sigmund, 1875. Ueber das Sehen von Bewegungen und die Theorie des zusammengesetzten Auges. Sitzb. des K. Akad. der Wissensch., LXXII, Abth. III.

This theory goes back to the work of J. Müller, 1826. Zur vergleichenden Physiologie des Gesichtsinnes. Leipzig.

[3] Forel, Auguste, 1908. The senses of insects. Eng. trans. by Yearsley. London: Methuen and Co.

[4] Grenacher, H., 1874. Zur Morphologie und Physiologie des facettirten Arthropodenauges. Nachrichten v. d. K. Gesellsch. d. Wissensch. a. d. G. A. Univ. zu Göttingen, pp. 645–656.

——, 1877. Untersuchungen über das Arthropoden-Auge. Beilageheft zu d. klinischen Monatsblättern f. Augenheilkunde, XV. Rostock.

color. It is asserted that ants do not perceive red light and the same statement is made concerning bees, but this is incorrect for bees. It is also sometimes said that insects perceive some of the ultraviolet rays, beyond the range of human vision. The color preferences of bees have also been observed, it often being stated that they prefer blue.

It seems certain that bees do not see objects distinctly and their vision is clearly far less acute than that of wasps and some other insects. Perhaps they do not perceive the form of objects at all. The relative intensity of light is probably an important part of their vision. When it is recalled that the hairs (p. 104) cover many facets of the compound eye, especially in younger bees, and that the structure of the eyes does not suggest a high degree of efficiency in vision, it becomes a matter of wonder that bees are helped by vision as much as appears to be the case.

Smell.

It is commonly believed that bees possess an acute sense of smell, and this belief is borne out by experiments on this subject. With the exception of qualifying statements by Lubbock [1] and Forel, this is usually conceded. The location of the olfactory organs is a matter of much less unanimity of opinion. McIndoo [2] has recently performed a valuable service in gathering together the literature on the olfactory organs in insects and it is necessary only to give a list of the organs which are supposed to carry the olfactory organs to show the confusion which has existed. These sense organs have been located by various authors on the following structures: (1) the spiracles, (2) organs close to the spiracles, (3) glands of head and thorax, (4) œsophagus, (5) "internal superior surface," (6) folded skin beneath antennæ, (7) rhinarium, (8) plate between eyes and beneath antennæ,

[1] Lubbock, Sir John, 1899. The senses, instincts and intelligence of animals. Internat. Sc. Ser. London., vol. 65.

[2] McIndoo, N. E., 1914. The olfactory sense of insects. Smithsonian misc. col. LXIII, no. 9, 63 pp.

(9) mouth cavity, (10) epipharynx, (11) palpi, (12) antennæ, (13) various structures on the antennæ, (14) caudal styles, (15) organs on base of wings and on legs, and (16) on different organs for different orders of insects. Notwithstanding this assortment of theories, it is probably correct to state that until recently it was the consensus of opinion that the olfactory organs are located on the antennæ. However, McIndoo[1] shows that if the antennæ of the honeybee are removed, the insect still reacts to odor stimuli. It is impossible to go into the details of this work here, but, in brief, this author concludes that certain sense organs located at the bases of the wings, on the legs and on the stings of females are olfactory organs, named by him olfactory pores. His work covers not only a study of the structure and distribution of these organs but is supported by experimental evidence, which is usually omitted in other papers on this subject.

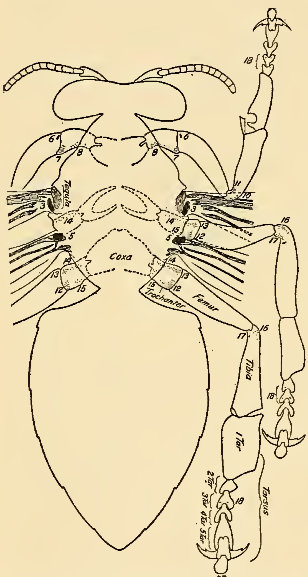


Fig. 88. — Diagram of dorsal view of worker, showing location of groups of olfactory pores.

The location of these organs is indicated on the diagrams from McIndoo's paper (Figs. 88 and 89), the organs being indicated by black areas and the different groups being numbered (21 groups in all, Nos. 19, 20, and 21 being on the sting and not shown in the diagrams). The structure of a typical olfactory pore is shown in Fig. 90. From the sense cell (*SC*), a nerve fiber (*SF*) extends to the surface of the body through the pore aperture (*PorAp*), this aperture being

[1] McIndoo, N. E., 1914. The olfactory sense of the honey bee. Jr. exp. zool., XVI, pp. 265–346.

within a flask (*PorW*) which lies in the chitinous body wall. These sense organs have protoplasm exposed to the outer air, not covered with chitin, while most of the other organs which have been supposed to have the olfactory function are covered with a chitinous layer. This is especially to be noted in the sense organs of the antennæ and it is difficult to see how odors may be supposed to penetrate such layers. The structure of the olfactory pores therefore fits them for their olfactory function and McIndoo has shown by experimental evidence that this is their office. He[1] has also found these olfactory organs in spiders and in other Hymenoptera.

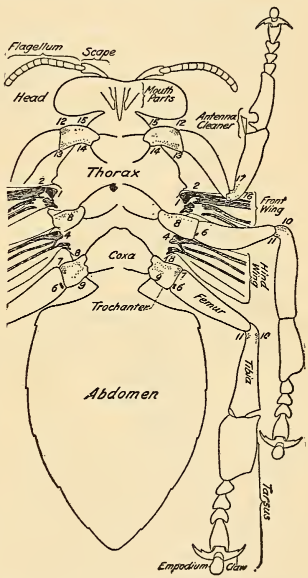


Fig. 89. — Diagram of ventral view of worker, showing location of groups of olfactory pores.

Admitting that these olfactory pores are the true organs of smell, we are still confronted with some difficulty in deciding what part responses to odor stimuli play in the behavior of bees. That bees are attracted by odor to honey during a dearth of nectar cannot be doubted. Similarly it is believed that the recognition of hive-mates, the discovery of enemies and the reactions toward the queen are due to responses to odors. A difficulty encountered in this field of investigation is that the human sense of smell is so inefficient that it is difficult to comprehend the responses observed,

[1] McIndoo, N. E., 1911. The lyriform organs and tactile hairs of araneads. Proc. acad. nat. sc. Phila., LXIII, pp. 375–418.

——, 1914. The olfactory sense of Hymenoptera. *Ibid.*, LXVI, pp. 294–341.

which is perhaps but another way of saying that we are too prone to put human interpretations on all such observations.

v. Buttel-Reepen,[1] from his wide experience with bees, concludes that there are seven normal odors in a colony of bees which influence behavior. These are (1) an individual odor, (2) an odor common to the offspring of one queen, (3) brood and larval-food odor, (4) drone odor, (5) wax odor, (6) honey odor and (7) the hive odor, which is a combination of all or part of the other odors. Whether there are other normal odors is a matter of conjecture but, in cases of dysentery or a brood disease, abnormal odors occur which influence the behavior of the bees.

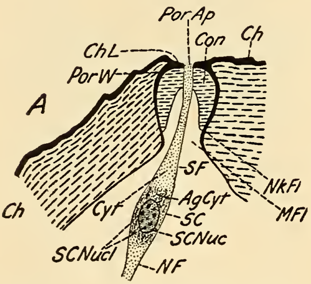


Fig. 90. — Cross-section of typical olfactory pore: *SC*, sense cell; *SF*, sense fiber; *PorAp* pore aperture.

On the dorsal side of the abdomen of the workers and queen on the articular membrane between the sixth and seventh terga (counting the propodium) is a transverse area which is the external portion of a scent-producing organ. This organ was described by Nassenoff,[2] later by Sladen[3] and more recently McIndoo[4] has described the structure of the glands on the interior as well as the external structure. This organ may perhaps be considered as the source of the individual odor of the females.

[1] v. Buttel-Reepen, H., 1900. Sind die Bienen Reflex-maschinen? Biol. Centralbl., XX; reprinted Leipzig: Georgi; Eng. trans. by Mary H. Geisler, Medina, O.: A. I. Root Co., 48 pp.

[2] Nassenoff, see Zoubareff, A., 1883. A propos d'un organe de l'abeille non encore decrit. Bul. d'apic. suisse rom., V, pp. 215–216. Trans. Brit. bee jr., No. 136. Nassenoff's paper is in Russian.

[3] Sladen, F. W. L., 1901. A scent-producing organ in the abdomen of the bee. Gleanings in bee culture, XXIX, pp. 639–640; also in Ent. month. mag., XXXVIII, pp. 208–211.

[4] McIndoo, N. E., 1914. The scent-producing organ of the honey bee. Proc. acad. nat. sc. Phila., LXVI, pp. 542–555.

If the queen is removed from a colony and a strange queen is placed among the bees in a cage, after a day or so she has, according to the current belief, acquired the hive odor and she will be accepted if released. If a strange bee attempts to enter a hive, it is usually recognized at once and repelled, this being considered as due to the possession of a different hive odor, but if a field bee returns to its own hive, it is admitted, because it has the hive odor. These responses may vary according to the honey-flow and other environmental factors. In these cases and many others, there is evidence of the importance of responses to odors in the behavior of bees, so that there is justification for believing that the sense of smell is of primary importance. It must be admitted that the belief in this importance is based chiefly on the accumulated experiences of beekeepers rather than on careful experiments, which are sorely needed in an examination of these data in order to eliminate complicating environmental factors. Additional evidences of odor influences are given in the discussion of swarming.

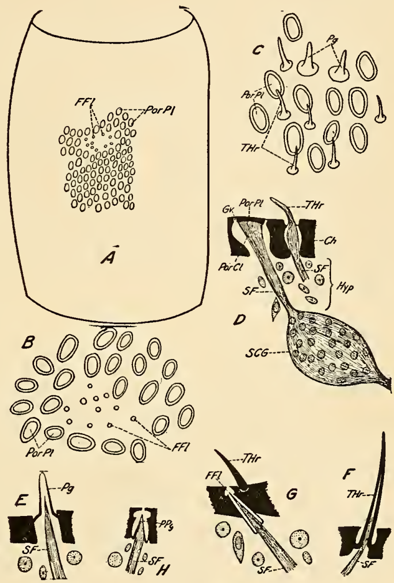


Fig. 91. — Antennal organs: *A*, antennal joint of drone, showing a few pore plates (*PorPl*) and a group of Forel's flasks (*FFl*); *B*, pore plates and Forel's flasks from drone's antenna; *C*, pore plates (*PorPl*), pegs (*Pg*) and tactile hairs (*THr*) from worker's antenna; *D*, structure of pore plate and tactile hair; *E*, structure of peg; *F*, structure of tactile hair; *G*, structure of Forel's flask; *H*, structure of pit peg.

Antennal sense organs.

Before the work on the olfactory pores, just described, it was supposed that some of the sense organs on the antennæ are olfactory organs. Just which of the organs serve in this way was not easy to decide. That these are sense organs can scarcely be doubted, but in view of the elimination of organs of smell from the antennæ of bees, the only course at present is to describe these organs and leave their function to be decided by later experimental work. The accompanying illustration (Fig. 91) shows the distribution and structure of these organs. These organs are known as (1) pore plates, (2) pegs, (3) Forel's flasks, (4) pit pegs and (5) tactile hairs. In all of them the sensory cells are covered with chitin.

Taste.

To what extent bees have this sense has not been made clear. In human experience, the senses of taste and smell are so closely related that to determine these separately in the bee will prove a somewhat difficult task. There are sensory cells on the epipharynx, in the mouth cavity, on the palpi and perhaps on other mouth parts, some of which may prove to be organs of taste. The evidence that bees distinguish tastes is meager. It is well known that bees show preferences in the material collected. They will for example abandon honey-dew if nectar becomes plentiful, but this action may not be due to a sense of taste.

Touch.

This sense is probably well developed, and it is safe to assume that some of the antennal sense organs function in this way. The use of the antennæ by the bees suggests this. Bees are remarkably sensitive to jars and respond promptly when touched on various parts of the body. Most of the hairs which cover the body are not sensory, however.

Hearing.

No organ has so far been described for bees which is surely an organ of hearing nor is it definitely established that bees can hear. In experimenting on this subject, it is of course necessary that vibrations through solids be eliminated and that the stimulus come to the bee only through vibrations of the air. It is commonly believed by beekeepers that bees hear, the belief being based chiefly on the fact that bees make noises which are interpreted as purposeful. Various investigators share this belief, among whom may be mentioned v. Buttel-Reepen[1] (*l.c.*). Since this author has (pp. 12–18 Eng. trans.) gathered together the evidence on this subject, it is necessary here only to mention the various phenomena which he details. (1) Queenlessness of a strong colony is noticed in from one hour to several hours. The bees no longer hum "contentedly," but this gives way to a "lamenting buzz." This change is said not to be due to the lack of the queen's odor, although the author admits that if a dead queen is placed in the colony the agitation ceases. (2) If a colony is made queenless and the caged queen is later placed in the upper part of the hive, the agitation ceases and v. Buttel-Reepen cannot believe that this is due to odor. (3) Bees disregard a queen in the open air a foot from the hive. From these observations, he believes that odor is not the only factor in "communication" of bees and he believes that bees communicate by sound. He further details some other evidence. (1) "It can hardly be doubted that sounds of some kind perhaps serve here [in swarming] for communication." (2) The "swarm tone" serves to draw out colonies scarcely ready to swarm. (3) The humming of bees is interpreted as leading the bees during the hiving of a swarm.

[1] On p. 2 (Eng. trans.), v. Buttel-Reepen says: "No zoologist who has done any experimental beekeeping can have the least doubt that bees have an excellent sense of hearing, since observations yield him hundreds of proofs. The man who is not familiar with biological facts might recognize nothing of the kind with certainty, for up to the present the organ of hearing has not been discovered."

(4) The queen makes at least two sounds, "teeting" and "quahking." (5) When a queen is "frightened" she emits a peculiar sound. This author concludes by claiming that the fact that bees do not respond to artificial sounds is no proof of a lack of hearing.

It need scarcely be pointed out that these statements are not conclusive evidence of a sense of hearing in bees; in fact most of the phenomena observed are as readily interpreted as evidence of a sense of smell. In earlier chapters it is mentioned that the phenomena in swarming and in the hiving of a swarm are most plausibly explained as brought about by reactions to odors. v. Buttel-Reepen's statement that "only the dead bee is quiet" may be answered by the statement that a totally deaf man often makes more noise in walking and frequently by articulate sounds than does a man with acute hearing. To sum up, we are justified in concluding (1) that no organ or organs of hearing are recognized, (2) that the existence of a sense of hearing is doubtful, and (3) that the investigations so far carried out are inconclusive.

Temperature sense.

In the discussion of the activities of bees in winter (p. 90), it is stated that at about 57° F. the bees form a cluster and, if the outer temperature drops below that point, they begin to generate heat. When no cluster is formed the bees are more active at temperatures above 69° F. than at temperatures below this. In a discussion of the temperature of the hive at other seasons (p. 60), it is shown that the temperature of the hive while occupied by the bees rarely exceeds 97° F. and that during brood-rearing the temperature of the brood chamber is quite constant. This brief summary of the facts of hive temperature indicates that in some manner bees perceive changes in temperature and it may almost be believed that they have a temperature sense superior to our own. The nerve endings or sense organs which function in this response to temperature stimuli are not determined and perhaps this is a function of some of the problematical organs on the antennæ.

Finding of the flowers.

In a previous chapter (p. 118), a discussion is given of the division of labor whereby bees are seemingly able to apportion the available forage to prevent duplication. In this connection the interesting question arises as to how the bees find the flowers. Considerable detailed and painstaking work has been done on this subject. Plateau[1] and his followers on the one hand believe that bees are guided to the nectar by odor, this being supported by experimental evidence as well as by an array of facts concerning the gathering of nectar from inconspicuous flowers. Forel[2] and other writers assert, on the contrary, that color is the important stimulus and that flowers are found through the sense of sight. Plateau's work is open to one important criticism, since he overlooks the possibility of the return of bees to his mutilated flowers through memory. Burton N. Gates, several years ago, showed that bees visit artificial flowers and also fly to natural flowers which have been sealed in glass tubes. The reaction to these unusual objects was entirely normal. These results point strongly to the belief that odor is of minor importance in the location of nectar-

[1] Plateau, Felix, 1895–97. Comment les fleurs attirent les insects. Bul. acad. roy. d. Belgique, 3 sér., XXX, n. 11, XXXII, n. 11, XXXIII, n. 1, XXXIV, n. 9, 10, 11. See also Plateau, 1888. Recherches expérimentales sur la vision chez les arthropodes, *ibid.*, part. 3–5 and other papers.

[2] Forel, Auguste, 1886–88. Recueil zoologiques Suisse, 1 sér., IV.

——, 1908. The senses of insects. Eng. trans. Yearsley. London: Methuen and Co., 324 pp.

See also: Andreæ, Eug., 1903. Inwiefern werden Insekten durch Fabre und Duft der Blumen angezogen. Beihefte z. Bot. Centralbl., XV.

Giltay, E., 1901. Ueber die Bedeutung der Krone bei den Blüten und über das Farbenunterscheidungs vermögen der Insekten, I. Pringh. Jahrb. f. wiss. Bot., XL.

Detto, Carl, 1905. Blutenbiologische Untersuchungen I u. II. Flora odor Allg. bot. Zeit., XCIV.

Kienitz-Gerloff, 1898 u. 1903. Proffessor Plateau und die Blumentheorie I u. II. Biol. Centralbl., XVIII u. XXIII.

secreting plants. That bees differentiate between flowers which are encountered in their flights is shown by the fact that they usually visit but one species on a trip (p. 119).

Finding of the hive.

It is well known that bees normally return to the right hive. The fact that strange bees are not usually admitted may be explained on the basis of difference in colony odors but this does not explain the method by which they find the right hive in the majority of cases. Bethe [1] asserts that the bees are led back to the hive by an "unknown force" but, as v. Buttel-Reepen points out in his discussion of memory of place in bees, this explanation is not satisfactory, and cannot be accepted until the known forces are eliminated. It will be recalled (p. 105) that young bees take "play flights" on warm days. If bees which have not taken such flights are taken out a few feet from the hive, they fail to return. Bees that have had some experience on the wing are able to return from short distances, and, finally, old bees are often able to return if taken away two miles or more. They evidently increase in efficiency with experience. It is also known that if the hive is moved a foot or more in any direction the returning bees seek the entrance to the hive in the old place. If the hive has been moved only a short distance they may soon find it by searching, but if it is moved several feet they may fail to find it.

If bees were attracted to the hive by odor, the field bees would probably have no difficulty in finding it if it were moved perhaps a mile. Under such circumstances a short distance would make no appreciable difference and yet the moving of the hive a foot often delays their entering it. Odor is therefore evidently not the guiding sense.

Bees in the field cannot always see their hive, and in all probability, they can see neither far nor distinctly. If

[1] Bethe, A., 1898. Dürfen wir Ameisen und Bienen Psychische Qualitäten zuschreiben? Arch. f. d. ges. Phys., LXX, also as separate, 1898. Bonn: Emil Strauss, with different paging.

sight is their guide, they must remember various objects over or about which they fly as they go out and must return by known paths. This is actually the case. If bees are accustomed to fly in only one direction to the forage and are carried off a short distance into unknown environment, they fail to return. It is evident that bees are guided back to their hives by a memory of the objects encountered, as perceived by sight. If a hive is moved, they then follow over the accustomed paths to the old location of the entrance, but having no experience over the road from the old location to the new one, they fail to make the trip unless they accidentally encounter the hive. No "unknown force" need be called in here to explain the phenomena. Evidently the play flights and the early trips to the field are the times during which bees acquire knowledge of their surroundings. If a colony is moved several miles, the bees must orient themselves anew, and in order that they may perceive the change and "recognize" the necessity for re-orientation, the beekeeper often places brush or grass about the entrance so that the change may be perceived when they first fly out.

That sight is the important sense in the location of the hive is appreciated by beekeepers who have learned that irregularities in the rows of hives, landmarks of trees or shrubs in the apiary or differences in color of the hives are beneficial in enabling the bees to find their hives quickly. These customs are well founded on the behavior of the bees.

Memory.

It would appear from the preceding discussion that bees are not entirely bundles of reflexes but that they actually have memory. The finding of the hive is good evidence of this fact and it is also asserted (v. Buttel-Reepen) that they remember the location of the feeder in the hive and that scouting bees remember the paths to the locations chosen by them.

The best evidence of memory is found in the fact that memory is sometimes lost. If bees are stupefied by tobacco smoke, by the smoke of the puff ball (an old practice) or by some anesthetic, they are unable to return to their old location and must re-orient themselves after they revive. When bees swarm they usually do not again return to the location of the old hive (except when hived on the old stand by the beekeeper) and may safely be placed in a new location perhaps only a few feet from the old hive. The memory of the old location is not lost immediately, however, for if within a day or two the bees desert the new quarters they often return to the old hive. Here the old memories are, as it were, reserved, but they are lost in a short time. Similarly in artificial swarms, after drumming or after certain manipulations in which the colony becomes "demoralized," the memory of the location is lost, either permanently or temporarily. If bees are confined for a few days they may be placed in any location and bees wintered in a cellar no longer remember their former locations. The loss of memory in these cases is not due to the formation of new associations. Bees obviously cannot lose what they do not possess and, if it is granted that memory is sometimes lost, the only conclusion is that they possess memory.

Nature of bee activities.

In the introduction to Chapter III, it was stated that bees are essentially creatures of instinct. While in the intervening discussions there are given evidences of the possession of memory, of limited powers of learning and association and of certain adaptations of the reactions of bees to circumstances, it should be clear that in the bee we have to do, not with human intellects and poetic passions, but with animals whose behavior is chiefly guided by mental capacities imprisoned in the chains of instinct, with animals most of whose activities are justly described as machine-like. If this discussion of the nervous responses of bees has destroyed some of the poetry of the hive, this can scarcely be considered as a serious loss, for it is not by such fancies that we can come to know the truth concerning the things about us.

CHAPTER VIII

THE REPRODUCTIVE PROCESSES AND PARTHENOGENESIS

THE organs of reproduction are those which produce the cells from which individuals of the next generation develop and they also include the accompanying organs which serve to permit the proper disposition of the sex cells. The continuance of the species is the function of these organs. In the larger number of species, new individuals arise from eggs which have been fertilized by sex cells of the male of the same species. In the honeybee, we are not only interested in the methods by which new individuals arise but certain peculiar phenomena play an important part in practical apiary manipulations. The development of the drones or males from unfertilized eggs must be considered, especially by the queen breeder.

Origin of the eggs.

The eggs from which all the members of the colony develop are normally laid by the queen. In this individual, the only female in the colony whose reproductive organs are fully developed, the ovaries are large and, in fact, she is to a considerable extent simply an egg-producing machine. The ovaries of the queen (Fig. 92) consist of two groups (*Ov*) of egg tubes or ovarioles (*ov*). These tubes are small at the anterior end where the eggs are beginning their growth and toward the posterior end the individual tubes, as well as the total mass, increase in diameter. At the posterior end, the tubules in each mass open into the anterior end of an oviduct (*OvD*). The oviducts from the two ovaries unite farther back into a common tube or duct, the vagina (*Vag*), which opens to the outside below the base of the sting. The posterior portion of the vagina is enlarged, forming the bursa copulatrix (*BCpx*).

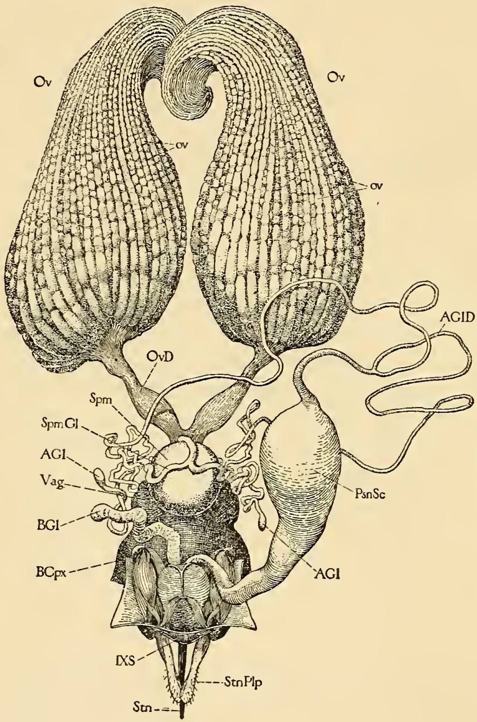


FIG. 92. — Reproductive organs, sting and poison glands of queen, dorsal view.

Opening from the vagina is the spermatheca (*Spm*), a sac-like organ which serves to receive the male sex cells, the spermatozoa, from the drone at the time of mating and to retain them until they are needed. Attached to this are two accessory glands (*SpmGl*) the duct of which opens into the duct from the spermatheca to the vagina. The duct from the spermatheca is S-shaped and is surrounded by muscles forming the "sperm-pump" of Breslau.[1] By the contraction of some of these muscles, the lumen of the upper end of the loop is enlarged and a small bundle of spermatozoa is taken from the spermatheca. By the contraction of other muscles, the sperma-

[1] Breslau, Ernst, 1905–06. Die Samenblasengang der Bienenkönigin. Zool. Anz., XXIX, pp. 229–323.

tozoa are forced on to the vagina. Cheshire[1] described this apparatus incorrectly by assuming that the muscles around the duct are sphincter muscles to hold back motile spermatozoa. The spermatozoa, according to Breslau, are not motile and no retaining muscle is needed. In copulation the spermatozoa are deposited by the drone in the vagina and must find their way to the spermatheca by this same duct. There is no special receiving duct as described by Cheshire. The spermatheca is not composed of muscle layers, as formerly supposed.

Cheshire estimates that a normal vigorous queen may during her lifetime lay 1,500,000 eggs. Since mating occurs usually but once, those eggs which are fertilized must receive spermatozoa from the supply stored up in the spermatheca at the time of mating. Since at each expulsion of spermatozoa a considerable number pass out and all but one are wasted, it is necessary that an enormous number be stored originally. Cheshire estimates the number at 4,000,000 but it is enough to know that millions are then stored. The marvelous feature of the phenomenon is that these minute cells are able to live for perhaps five years away from the animal in which they were formed (the drone) and at the same time are so highly specialized that they can take no nourishment. There is no multiplication of spermatozoa in the queen as has been hypothecated by various beekeepers.

The formation of the eggs has been studied by Paulcke.[2] In the early stages of the formation of the egg at the anterior end of the ovarian tubes, the future egg nucleus is surrounded by other nuclei which later form nurse cells. There is at first no visible differentiation, no cell boundaries being seen, but farther down the tube the nuclei are surrounded by cell walls. Gradually the future egg cells begin to enlarge and

[1] Cheshire, F. R., 1885. The apparatus for differentiating the sexes in bees and wasps. Jr. roy. micr. soc., ser. 2, V, pp. 1–15.

[2] Paulcke, W., 1900. Ueber die Differenzirung der Zellelemente im Ovarium der Bienenkönigin (*Apis mellifica*). Zool. Jahrb. Anat. u. Ontog., XIV, pp. 177–202.

the individual egg cells are separated by a number of nurse cells, 48 to each egg, according to Paulcke. The egg cell increases in size chiefly by an accumulation of yolk which serves as food for the future embryo, this yolk being supplied by the nurse cells, which finally are exhausted and absorbed into the yolk of the egg. The egg and nurse cells are surrounded by an epithelium which grows thinner as the egg enlarges and which finally breaks when the egg passes into the oviduct.

The egg is covered by a thin layer of chorion secreted around it by the epithelial cells and the boundaries of the cells may be seen in the lines which persist on the chorion, forming a delicate network on the surface. At the anterior end of the egg (where the head of the larva is formed and also toward the head of the queen) there is a peculiar arrangement of these lines, forming the micropyle. Here the spermatozoon which fertilizes the egg enters, but the mechanism has not been adequately described. In most insects there is a definite opening for the entrance of the spermatozoon and often a complex mechanism for the closing of the opening after fertilization. There is nothing so described for the bee egg.

Origin of the male sex cells.

The organs of the male (Fig. 93) in which the male sex cells originate are equally interesting. The spermatozoa develop in the testes (*Tes*), two organs homologous with the ovaries of the queen. The development of the spermatozoa probably occurs almost entirely during the pupal development of the drone and possibly not at all in the adult drone. From the testes, the spermatozoa pass through the vas deferens (*VDef*) into the vesicula semenalis (*Ves*) where they collect. The seminal vesicles open into the base of the accessory mucous gland (*AcGl*). These in turn open into a single duct, the ejaculatory duct (*EjD*), unusually large in the drone and curiously indented to conform to the structure of the vagina.

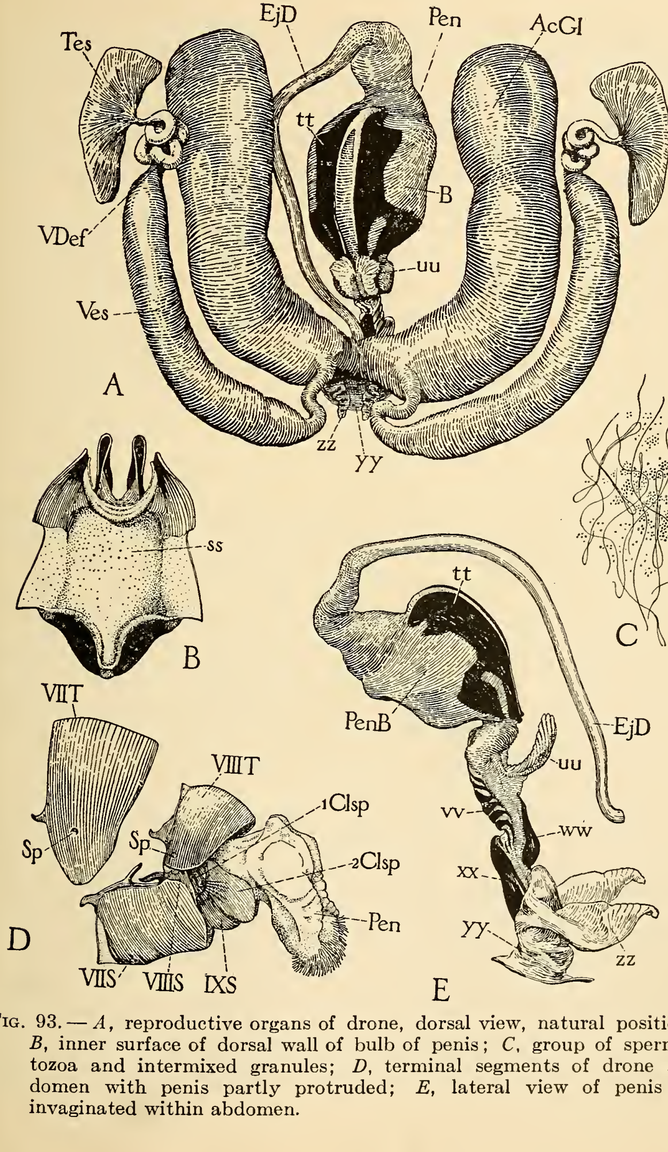


Fig. 93. — *A*, reproductive organs of drone, dorsal view, natural position; *B*, inner surface of dorsal wall of bulb of penis; *C*, group of spermatozoa and intermixed granules; *D*, terminal segments of drone abdomen with penis partly protruded; *E*, lateral view of penis as invaginated within abdomen.

At the time of copulation, the penis, which is previously folded within the abdomen of the drone, is everted and projects into the vagina of the queen. The spermatozoa then pass through the ejaculatory duct as does presumably also the contents of the accessory mucous glands. The formation of the spermatozoa has been studied by Meves,[1] by Mark and Copeland [2] and by Doncaster.[3]

The sudden expulsion of the penis causes the immediate death of the drone. The structure of the penis may be readily seen by gently squeezing the abdomen of a drone, by which means it is everted. In this case also the drone dies immediately so that his death at the time of mating should not be attributed to any action of the queen. As has been previously stated (p. 69), mating occurs in the air outside the hive.

Parthenogenesis.

The chief reason why the reproductive processes require extended discussion in a book on practical beekeeping is because of the development of the drones or males from unfertilized eggs. In most species, the sex cells disintegrate unless they unite with the products of the opposite sex of the same species, but there are numerous instances in the animal kingdom in which egg cells are produced, which, without fertilization, are able to develop into normal adults. To this phenomenon the name parthenogenesis [4] is given.

[1] Meves, Fr., 1903. Ueber Richtungskorperbildung im Hoden von Hymenopteren. Anat. Anz., XXIV, pp. 29–32.

——, 1907. Die Spermatocytenteilungen bei der Honigbiene (*Apis mellifica* L.) nebst Bemerkungen über Chromatinreduction. Arch. f. Microsk. Anat. u. Entwick., LXX, pp. 414–491.

[2] Mark, E. L. and Copeland, Manton, 1907. Some stages in the spermatogenesis of the honey bee. Proc. Am. acad. arts and sciences, XLII, pp. 103–111.

[3] Doncaster, L., 1906. Spermatogenesis of the hive bee, *Apis mellifica.* Anat. Anz., XXIX.

——, 1907. Spermatogenesis of the honey bee. *Ibid.*, XXXI.

[4] For a more extended discussion, see Phillips, E. F., 1903. A review of parthenogenesis. Proc. Am. philos. soc., XLII, No. 174, pp. 275–345.

In 1745, Bonnet described the parthenogenetic development of plant lice and just one hundred years later Dzierzon announced his theory that the drone is likewise a product of an unfertilized egg. This later paper, published in the Eichstädt Bienenzeitung, was the beginning of a long and heated discussion in which the leading zoologists of the day took part. Briefly his theory was as follows: (1) the queen is able "at pleasure" to lay either worker or drone eggs, the drone eggs being deposited just as they leave the ovary [1]; (2) all eggs in the ovary are eggs which would normally develop into males and if fertilization occurs the sex is changed to female. It is well to divide Dzierzon's theory into these two parts for they are not equally capable of proof.

The facts observed in the apiary on which this belief is based are as follows: (1) If a queen is unable to fly out to mate or is prevented from mating in some other way she usually dies (p. 70) but if she does lay eggs, as she may, after three or four weeks, the eggs which develop are all males; (2) if when a queen becomes old her supply of spermatozoa is exhausted, her offspring are all males; (3) if a colony becomes queenless and remains so for a time, some of the workers may begin egg-laying and in this case too only males develop. The author has found that many eggs laid by drone-laying queens fail to hatch and, in fact, are often removed in a short time by the workers. This makes it impossible for us to accept Dzierzon's statement that all eggs laid by such a queen become males and the statement must be modified as follows: all of those eggs laid by a drone-laying queen which develop become males. The potentialities of the eggs which never hatch are not known. In addition to the facts here stated, the theory of the parthenogenetic development of the drone is supported by investigations of the phenomena of development in the egg.

[1] Onions (1912, South African fertile-worker bees. Agricultural Journal of the Union of S. Af., May) claims that in South African bees females are also produced parthenogenetically. The claim is supported by considerable evidence. See also Van Warmelo, D. S., *ibid.*, 1913, who denies this statement.

Sex determination.

The determination of sex is one of the most earnestly debated questions in zoology. Numerous theories have been proposed, most of which are not now seriously considered. From the observations and conclusions of Dzierzon and other observers it was long held that sex in bees and similar forms (ants and wasps) is determined by the presence or absence of fertilization. These species were seemingly an exception to the phenomenon observed in most species. Of recent years, sex determination has been the object of numerous investigations and it is now quite generally accepted that sex is inherited in accordance with the same laws which govern other phenomena of inheritance. It is, of course, impossible to attempt to record here or even to outline the observations which lead to this theory or to elaborate the theory, as has been done by various authors. It is now held that one of the chromosomes (the bearers of hereditary characters) of the sex cells bears the sex-determining character. If we take into consideration the important fact that not all the eggs of an unfertilized (drone-laying) queen hatch, then the bee does not appear as an exception in Nature. It seems clear, however, that the statement of Dzierzon that all the eggs in the ovary are male eggs cannot be accepted and it is, in fact, not improbable that the eggs destined to be females die for want of fertilization, while the eggs destined to be males, not requiring fertilization, are capable of development. It should be understood that the casting of doubt on Dzierzon's theory of sex determination does not invalidate his theory in so far as it pertains to the development of males from unfertilized eggs.

In view of the fact that drone eggs are usually deposited in the larger cells, the theory has been advanced that the pressure on the abdomen of the queen when she is about to lay an egg in a worker cell, by some reflex, causes the spermatheca to open, thereby enabling the egg to be fertilized. This is known among American beekeepers as the Wagner theory. Since fertilized eggs may be laid in comb foundation when the side walls are only started and since drone eggs are often laid in worker cells, this simple explanation cannot be accepted.

From the various phenomena observed in connection with parthenogenetic development, it appears that fertilization of the egg serves two purposes; it brings to the egg the hereditary characters of the male parent and also stimulates the egg cell to develop by cell division. If development can occur without this stimulation, the resulting individual contains the hereditary characters from one parent only. It should perhaps be mentioned that in plant lice both males and females sometimes develop from unfertilized eggs while in certain Lepidoptera only females develop from unfertilized eggs. The male sex is not a necessary result of parthenogenetic development.

The theory that drones develop from unfertilized eggs has not been accepted without protest. From the beginning, it has been assailed by the publication of evidence and arguments which were supposed to contradict the theory. In the author's paper, to which reference has been made, the various contrary views are outlined and the interested reader is referred to this paper for references to the literature on the subject up to the date of publication (1903). Of recent critics, none is so insistent as Dickel, a German beekeeper, who claims that fertile queens cannot lay unfertilized eggs and that sex is determined by secretions of the nurse bees. These fantastic theories with others of a similar character have been adequately overthrown by Dickel's critics and need not be discussed at length here.

Practical applications.

The development of males from unfertilized eggs is a fact of importance in various phases of apiary work. If, for example, an Italian queen mates with a black drone, the workers and queen offspring are hybrids,[1] while the drone

[1] Exception is sometimes taken to the use of the word hybrid as applied to a cross of two races, in which sense it is used by beekeepers. This

or male offspring is pure Italian. This fact is important to the breeder, for drones from mismated queens are just as good for breeding purposes as those from purely mated queens. It is true that this has been denied by various writers but the denial is based chiefly on variation in the color of the drones, it being overlooked that color is not a safe criterion for the purity of race of either queens or drones. Color is a much more stable characteristic in workers. The parthenogenetic development of drones must be considered in planning any breeding work with bees. In the selection of breeding material it does not necessarily follow because the workers of a colony have the quality desired that the drones of that colony will be best for breeding purposes, since the hereditary characters of the workers come from two parents while those of the drones come from only one of the two.

Hermaphrodite bees.

Many cases are recorded [1] of bees which show both male and female characters. These hermaphrodites or androgynous bees may have male characters on the head and female characters in the abdomen or they may be divided longitudinally in various combinations of characters. There is a mixture of male and female characters, varying in different individuals, in both external and internal organs. It is a peculiar fact, not easy of explanation, that when such cases occur there are often many in the same colony. Boveri [2] suggests that in such cases fertilization is delayed until after cell division has begun and that only part of the cells receive

criticism is probably based on the belief that sterility is characteristic of hybrids, as in the case of the mule, or it may be based on the belief that the word should be applied only to crosses of true species. There seems to be no objection to the word as beekeepers use it. It is most commonly applied to crosses of Italian and German bees.

[1] v. Della Torre, K. W. u. Friese, H., 1899. Die hermaphroditen und gynandromorphen Hymenopteren. Berichte d. naturw.-med. Ver. Innsbruck, XXIV.

[2] Boveri, Th., 1901. Ueber die Polaritat des Seeigel-eies. Verh. Ges. Wurzburg (N. S.), XXXIV, pp. 145–176.

the male chromosomes. While this theory would readily explain the great variation in such hermaphroditic bees it is based on the assumption that sex is determined by fertilization, which may be questioned.

Eggs which fail to hatch.

In some cases, one of which came under the author's observation, queens are normally mated and lay eggs, but all the eggs fail to hatch. This is perhaps due to some abnormality of the queen, and in the case examined it appeared that the failure to hatch might have been due to the evaporation of the water in the protoplasm through the unusually thin and soft chorion of the eggs. Similar cases were described by Claus and v. Siebold [1] and also by Leuckart.[2]

[1] Claus u. v. Siebold, 1873. Ueber taube Bienen-eier. Zeit. f. wiss. Zool., XXIII, pp. 198–210.

[2] Leuckart, R., 1875. Ueber taube u. abortive Bieneneier. Arch. Naturgesch., XL.

CHAPTER IX

RACES OF BEES

The honeybee, so well known to beekeepers, has certain near relatives which are of interest, and it is quite probable that a careful study of the various phases in the behavior of these bees would throw considerable light on similar phenomena in the honeybee. The honeybee is usually considered as representing the apex of the evolution of the bees (Apidæ), in that the social organization is the most complex found in this family of insects. The ants (Formicidæ) and wasps (Vespidæ) represent lines of parallel evolution in social life which has resulted in insect communities, comparable, but by no means identical, with that of the honeybee.

TYPES OF SOCIAL BEES

Among the Apidæ are three great types of social bees, the bumblebee (Bombus),[1] the stingless bees (Melipona and Trigona) and the honeybees (Apis). The simplest forms, the bumblebees, have smaller colonies which die out during the winter, leaving the species to be continued from fertilized queens which hibernate. The stingless bees are tropical insects which store their honey and pollen in spherical vessels and rear their brood in "combs," one cell in thickness. In the honeybee colony, the architecture is the most perfect and the honey and pollen are stored and the brood is reared in hexagonal cells, which combine to form a comb two cells

[1] For an excellent discussion of the biology of English bumblebees, consult Sladen, F. W. L., 1912. The humble-bee, the life history and how to domesticate it. London: Macmillan and Co.

in thickness. The bumblebees and stingless bees fill a cell with pollen and honey, the queen then deposits an egg on this mass and the larva is not further fed or cared for. On the other hand, the queen honeybee lays her eggs in empty cells and the larvæ are fed a specially prepared larval food as they require it. For a further discussion of the more primitive bees as well as of the probable evolution of the Apidæ, the reader is referred to the interesting paper of v. Buttel-Reepen.[1]

SPECIES OF THE GENUS APIS

In the genus Apis there are other interesting honeybees but which have no special practical value. It is of interest to note first that specimens of Apis have been found in fossil form, preserved in amber. v. Buttel-Reepen mentions *A. adamitica* and *A. meliponoides*, the latter transitional between Melipona and Apis. Among recent species of this genus are *A. dorsata*, the giant bee of India, with its varieties *zonata* and *testacea* of the Philippines and the Malay peninsula, *A. florea*, a dwarf bee of India with several varieties and finally *A. mellifica*,[2] the honeybee with the numerous varieties to be discussed later. Unsuccessful efforts have been made to introduce the giant bees into Europe and America, among which may be mentioned the trips of Benton, 1880 and 1905, and Dathe, 1883. Dathe succeeded in getting living dorsata bees to Germany but the effort was fruitless. The last mentioned trip of Benton was at the expense of the U. S. Department of Agriculture. Dorsata builds a single comb in the open air, usually suspended on the limb of a

[1] von Buttel-Reepen, H., 1903. Die stammesgeschichtliche Entstehung des Bienenstaates sowie Beitrage zur Lebensweise der solitaren und sozialen Bienen (Hummeln, Meliponinen, etc.). Leipzig: Thieme.

[2] For a discussion of the propriety of *mellifica* as the specific name of the honeybee, see v. Buttel-Reepen, H., 1906. Apistica. Beitrage zur systematik Biologie u. s. w. Mitth. aus dem Zool. Mus. Berlin, and also the English translation of his paper "Are Bees Reflex Machines?" (Medina, O.: Root, 1907). See also p. 37 of this book.

tree; there is no distinction between drone and worker cells and these bees do not take kindly to confinement in a hive.[1]

VARIETIES OF THE SPECIES MELLIFICA

In the classification of insects, differences in structure and color are the characters on which classification is usually made, but in the differentiation of the varieties of honeybees there are no constant differences in these characters to guide the student. The varieties are established by beekeepers because of recognized and well-marked differences in the behavior of the bees from various regions. They are, however, valid biological varieties. While there are color differences, these are of little value in attempting a classification. Since beekeepers usually refer to these divisions of the species as races, this term is here adopted. Roughly the races are divided into three groups, (1) the eastern races, (2) the European races and (3) the African races. Certain characteristics of these groups are valid but the grouping is somewhat artificial. The principal races are here discussed in the order suggested by this grouping, the names given the races being indicative of their origin.[2]

Egyptian.

These bees are somewhat smaller than the races best known to American beekeepers, the abdomen is slender and

[1] For further data concerning the various species of the genus Apis, consult the above mentioned papers by v. Buttel-Reepen as well as the following: —

Gerstacker, 1862. Ueber die geographische Verbreitung und die Abanderungen der Honigbiene nebst Bemerkungen über die auslandischen Honigbienen der alten Welt. Reprinted in v. Buttel-Reepen's Apistica. Partial English translation by Dallas, Ann. and mag. of nat. history, 1863, III series, vol. 11.

Koshewnikov, G. A., 1900–1905 [Material for the study of the genus Apis] Russian.

Additional references are given in the v. Buttel-Reepen papers.

[2] None of the races of the honeybee is native to America. The German bees were introduced early in the history of the country and are often designated native bees, but this is an error. After their introduction they

pointed and the cells of the comb are also said to be somewhat smaller. The first three segments of the abdomen are light yellow to reddish yellow with black border, being brighter than Italians. The abdomen is covered with grayish white hairs. The abdomen of the queen is marked with reddish brown on the first segment and the color areas are variable. Queens and drones are small and the queens are prolific. These bees sting furiously and are not subdued by smoke. They do not, according to v. Buttel-Reepen, form a winter cluster and therefore cannot withstand cold weather. Drones are reared in large numbers; the cappings are "watery";[1] the queen cells are small, very numerous, clustered and smooth. Fertile workers are abundant and are said to be present even when there is a laying queen. These bees were introduced into Germany in 1864 and to England and America in 1867. Here they attracted considerable attention but were promptly abandoned as worthless.

Syrian.

There are two races of bees in Palestine, one of which is, according to v. Buttel-Reepen, identical with the Egyptian. The other is known among American beekeepers as the Holy Land bees. The Syrians are larger than the Egyptians and in color they resemble Italians. These bees swarm excessively, build many queen cells and winter poorly. Many virgin queens go with after swarms and do not kill each other until one is mated. Young queens lay drone eggs in the first month. These bees were introduced into America in 1880 by Jones and Benton but were soon abandoned as valueless. They were introduced by Hopkins into New Zealand in 1883.

multiplied rapidly and were soon found in the woods. It was formerly a common saying that a swarm always flies westward (to new territory).

[1] Some races of bees fill their honey cells more completely than others and when the honey is in contact with the capping it gives the honey an appearance that is described as watery. When the capping is separated from the honey by an air space the capping appears white (or yellow, depending on the color of the wax). In general the black races seem to produce whiter comb cappings than more yellow bees.

Cyprian.

This bee has been given a thorough test by American beekeepers. It is somewhat smaller than the Italian and the abdomen is pointed, with three yellow bands, similar to that of Italians but somewhat lighter in color. The queens are small and very prolific. These bees winter well unless the colony wears itself out by breeding in winter. The workers are exceptionally cross, are not subdued by smoke and do not run on the combs. They build many queen cells (less than Syrians). Sent (unsuccessfully) to America by Gravenhorst in 1877 and first imported by Stahala in 1879: additional shipments by Jones and Benton in 1880. They have been widely advertised and tested but were abandoned because of their unmanageable qualities.

Grecian.

These bees resemble a hybrid between Italians and Germans. So far as known they have not been shipped to America. They were sent to Germany in 1860 by v. Roser.

Caucasian.

These bees vary in color from three bands of yellow on the abdomen to black or gray according to the region from which they come. The ones introduced into America have shown virtually no yellow color, having come from the more northern parts of the Caucasus. The yellow examples are said to resemble Italians markedly. This is the most gentle race known, although they defend their hives well against robbers. They seldom enter the wrong hive, winter well, cap their honey cells white and are, in the main, desirable bees. The hybrids are not gentle. They were first taken from their native country by Butlerov in 1877 and were shipped to Germany in 1879 to Vogel, who described them carefully. The first exportations were chiefly the yellow strains. In 1880 Julius Hoffman, Ft. Plains, New York, received two colonies of these bees but condemned them because they did not work on buckwheat! Later Rauchfuss Brothers, Denver, Colorado, imported queens of this race and recommended them. Following this, additional queens were imported and American bred queens were distributed by the United States Department of Agriculture several years ago.

The gentleness of this race is universally admitted, but Caucasians have some faults which have caused them to be abandoned by most beekeepers who have tried them. They use propolis most lavishly and in the autumn often build a wall at the entrance, leaving holes only large enough for single bees to pass (Fig. 94). They also build many burr and brace combs. The dark color makes it difficult to tell when the queens are purely mated and the dark queens are difficult to find on the combs. An additional factor which has led to the lack of interest in this race is the rapid spread of European foul brood within recent years. This has virtually necessitated the use of Italian bees in many localities and has discouraged experimentation with other races. There are still several prominent beekeepers who are enthusiastic in their praise of the Caucasians.

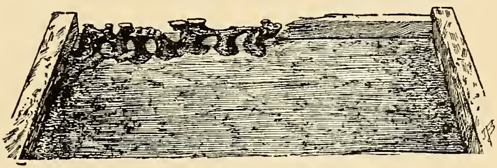


Fig. 94. — Propolis at entrance, built by Caucasian bees. The entrance block on one side made a propolis wall unnecessary there.

Italian.

This is the most popular race of bees among the best American beekeepers. The bees of Italy vary considerably in color, those in the north of the country being virtually identical with the German bees in color. The typical "three-banded" Italians are found farther south and in Sicily there is a still lighter strain. Some investigators believe Italians to be a cross between the German and

Egyptian bees. Typically, the yellow color covers three segments of the abdomen, the head and thorax and posterior segments of the abdomen being black with some traces of yellow on the mandibles, and the hairs have a yellow cast. The legs are brown. Queens and drones are variable in color from solid black to the yellow found on workers. Italians are gentle (but not equal to Caucasians in this respect), less prolific than the eastern races but usually better than black bees, build few queen cells, rarely develop fertile workers, keep the hive clean, drive out wax-moths, winter well, do not run on the combs, swarm less than Carniolans and some eastern races and cap their honey less white than Germans, Carniolans and Caucasians. The rearing of brood is quickly curtailed in a dearth of nectar and they cease rearing brood in the autumn sooner than most races. An important characteristic of Italians is the resistance to European foul brood. In this respect, they have been compared chiefly with German bees, to which race they are vastly superior.

Italian bees were sent to Switzerland (by v. Baldenstein) in 1843, to Germany in 1853, to England (by Neighbor) in 1859 and to France about the same time (by Hamet), to Australia in 1862 and again in 1880, to German Guinea in 1887, from California to New Zealand in 1880, from Germany to Ceylon in 1882 and from Italy to New Zealand (to Hopkins) in 1883, to Guam in 1907 (from Hawaii by Van Dine).

The first importation of these bees to America has been a matter of some dispute and was the basis of a sharp controversy. Their introduction marks an important milestone in American apiculture, almost equal in importance to the invention of the movable-frame hive. About 1855, Samuel Wagner and Edward Jessop of York, Pennsylvania, made an unsuccessful importation of an Italian colony, which died en route. In the winter of 1858–59, Wagner, Langstroth and Colvin (Baltimore) sent an order to Dzierzon (Germany), which was not delivered. Later in 1859, they received seven living queens [1] from Dzierzon and reared two or three queens that fall, but the imported queens all died the following winter. On the same steamer that brought these queens, Mahan (Philadelphia), who had made a trip to Europe for these bees, brought over "one or more" queens (of doubtful purity). In June 1860, Wagner and Colvin received another consignment. In the meantime, S. B. Parsons (Flushing, L. I., New York) was commissioned by the Agricultural Division of the Patent Office to procure ten colonies, which he purchased from Herman of Tamins (reported by him January 3, 1860) and shipped from Havre, reaching the United States in May. In the annual report of the Division of Agriculture submitted January 29, 1861, the Superintendent reports that the effort was unsuccessful "owing to inattention to the instructions given by the agent of the Office." C. J. Robinson later asserted that he and Mahan had solicited an order from the Commissioner of the Patent Office in 1859 authorizing Mahan to proceed to Italy and procure bees. This request was refused but it was claimed that this instigated the movement to have Parsons (an agent of the Division then in Italy) get the bees. Robinson states that Parsons bought ten for the Government and ten for himself (this second purchase is denied by the friends of Parsons) and that he reported that all the bees consigned to the Government died. At any rate, Parsons in 1860 placed at least some of his stock in the hands of Cary, Langstroth, Quinby and others and the sale of Italian queens began in 1861. Riley, then Chief of the Division of Entomology, in 1892 claimed for the Government the credit of the first importation direct from Italy. Rose (New York) received colonies in 1861 and Colvin continued shipments from the Dzierzon apiary in 1863–64. Various other early shipments were made, and now many queens are received annually. In the early days of the enthusiasm

[1] A cage dated May 1859 in Dzierzon's handwriting was found by C. H. Lake after he purchased the Colvin apiary (Beekeeper's Instructor III, No. 12, 1881).

over Italian queens they often sold for twenty dollars each. Italian bees are now found everywhere that beekeeping is conducted and are usually considered preferable to all others. In the United States, special attention has been given to the breeding of Italian bees and it is probably true that better Italian stock can now be obtained in America than in Italy.

To distinguish differences in strains of Italian bees and in part to provide trade names, various names have been given by American beekeepers to certain types. The five-banded or "Golden-all-over" bees have been bred specially for an increase in the yellow color on the abdomen. The red clover Italians sold several years ago were supposed to have a tongue-length above the average, sufficient to allow them to get nectar from the red clover blossom. Various strains are distinguished by the name of the breeder. The specially yellow bees are not usually considered as desirable for commercial beekeeping as the typical Italians, which are commonly designated as three-banded or leather-colored.

German.

These bees are black in color and are generally known among American beekeepers as "Black bees." It is of interest to note that according to Dzierzon there were yellow bees in Germany before Italians were introduced and this helps to explain the variation in the German bees. v. Buttel-Reepen, following distinctions made by Dzierzon and other early writers, divides the German bees into two varieties, the typical variety and the heath bees. The typical variety is native to Germany, Russia, Scandinavia, Denmark, Holland, England, Switzerland, Austro-Hungary and parts of other European countries. The heath bee is darker than the typical variety, swarms excessively and is especially adapted to honey-flows coming in late summer (buckwheat, heather): young queens in after swarms lay drone eggs abundantly the first season. This variety is found in Hanover, Holstein, Oldenburg and Holland. There is a possibility that there are two varieties of German bees found in the United States, as is so often claimed, and that these have arisen from these two natural varieties.

The German or black bees found in the United States seem to combine many of the undesirable qualities of all other bees. They are less prolific than Italians, they (and especially crosses with Italians) are cross but respond to smoke, they build more queen cells than Italians and develop fertile workers more readily (less in these last respects than the eastern races), they do not clean the hive well or resist moths completely, they run badly on the combs and fall off from the corners of the combs during manipulation and they swarm more than Italians. Their greatest fault is that they succumb so rapidly to European foul brood that it is most difficult to rid a colony of black bees of this disease. They cap comb-honey white and winter fairly well, but their nervousness is against them in this respect. While these bees are condemned by the best American beekeepers, some of the leading beekeepers of Europe (especially in Switzerland) claim them to be superior to Italians. Since no effort has been made to improve these bees in America, this may account for this difference of opinion.

The German or black bees were introduced into New England (probably from England) in 1638. In 1644, John Eales was brought to Newburg from a neighboring town to instruct the people in beekeeping, indicating an early interest in the industry, but he later became a town charge. Black bees reached West Florida not later than 1763, Kentucky in 1780, New York in 1793, west of the Mississippi River in 1797, Cuba in 1764, San Domingo in 1781, New South Wales in 1822, Tasmania in 1831, New Zealand in 1839, Brazil in 1845 (or earlier), Chile about 1848, California in 1853, Columbia about 1855 and Argentine in 1857. Harbison took 116 colonies (with a loss of only six) from Pennsylvania to California via Panama in 1857. The same year (August 20th) the first bees were shipped from San José, California, to Hawaii.

Carniolan.

These bees are grayish-black in color and the claim that yellow bees were native to parts of Carniola is often questioned. Professor Francis Jager is authority for the statement that the bees of the Wippach valley (Vipavska dolina) are yellow. Carniolan bees are large, gentle (second only to Caucasians), prolific, swarm excessively, are good honey-gatherers, build numerous queen cells, collect little propolis, winter admirably, cap their honey white and do not run on the combs during manipulation. It is claimed by some beekeepers that they resist European foul brood as well as Italians: this should be thoroughly investigated by disinterested persons. They are native to Carniola, Austria.

These bees have been shipped repeatedly to Germany and other European countries and to America. While they have some ardent advocates in the United States, they are losing ground, especially on account of their swarming proclivities and the black color, which American beekeepers do not fancy. Queen breeders have distinguished other races, which are not distinct from the Carniolan, among which are the Banat (Banater) race, of recent importation into America, and the Dalmatian which appeared in American literature in the eighties. The names of other provinces have been used as trade names for different breeders.

African races.

While several races of bees have been distinguished from Africa, in addition to the Egyptian previously discussed, very little information is at hand concerning these bees in the hands of beekeepers. A yellow race, described as *Apis adonsoni*, is found in parts of Africa, having the abdomen a darker reddish-yellow than the Egyptian. On the north coast of Africa is found a black bee, known among beekeepers as Tunisian, Punic or North African. This race extends well into the continent. The bees of this origin that have been tried in the United States are extremely cross, propolize excessively and winter badly. They are not now known to be present in the United States. A separate race of black bees is described from Madagascar and other islands and still another from Togoland. It is well known that honeybees are abundant in parts of Africa and careful explorations would doubtless reveal many interesting facts concerning these bees. Onions [1] claims that in the South African race the unmated workers lay eggs which develop into female bees. As the continent of Africa becomes more settled by white men and as apiculture advances, we may expect some interesting additions to our knowledge of the African races of bees.

Asiatic races.

v. Buttel-Reepen (Apistica) places *A. indica* as a variety of *A. mellifica.* It is a smaller bee, which is said to bite rather than sting. It crosses with previously described races. Several sub-varieties are indicated.

Chinese-Japanese.

These bees are placed by v. Buttel-Reepen as sub-varieties of *indica.* The Chinese bee has a heavy coat of long dirty gray hair; the Japanese bee lacks this.

BEST RACE OF BEES

To answer the question as to which race of bees is best is difficult. For comb-honey production, the German, Carniolan and Caucasian races have the advantage of capping the honey white but the German bees are especially subject to European foul brood, Carniolans swarm excessively (especially in comb-honey production) and Caucasians propolize badly. Without going further into the merits and demerits of the various races, it may be as well to give the almost unanimous verdict of American beekeepers,

[1] Onions, G. W., 1912. South African "fertile worker-bees." Agricultural Journal of the Cape of Good Hope, May. See also Van Warmelo in the same journal, 1913.

which is in favor of the Italian race. It is probably true that the tests made cannot be considered as free from prejudice but the decision was made years ago and no special reason has been presented for changing it. Since this race became popular it has been carefully bred and it is easier to get good stock of this race than of any other in the United States. It was the first race brought to this country in the effort to improve on the early introduced black bees and proved so vastly superior that it soon took a firm hold on American beekeepers. It is doubtful whether any other race will be accepted as better or even as good by the majority of beekeepers and certainly no markedly better race has been tried in this country.

CHAPTER X

REGIONAL DIFFERENCES WITHIN THE UNITED STATES

Before discussing the different methods of manipulating bees in the successful production of honey, it may be helpful to point out some of the fundamental differences found between various parts of the United States in regard to the sources of honey and in climatic conditions, which influence the choice of the proper system of manipulation. In the American literature on beekeeping, these differences are frequently mentioned and the word "locality" in the beekeeper's vocabulary has come to be used as an all-inclusive argument or excuse for his particular practice and often partially to cover his ignorance of the actual reasons for differences observed. This term "locality" is the subject of the present chapter. As will be shown later, two apiaries but a few miles apart may give quite different results, not only in the amount or source of crops but in the effect of certain manipulations, and the facts here presented help to explain these differences. Since migratory beekeeping is practiced only between two unlike regions, this subject is also discussed in the present chapter.

The system of manipulation to be followed and the manner in which honey may best be prepared for market depend on the color and quality of the honey and perhaps especially on the length and intensity of the nectar-flow. While the chief sources of honey are discussed in another chapter, it may be helpful here to present in outline the combination of floral and climatic conditions which so strongly influences the business of honey-production and guides the beekeeper in choosing suitable locations for his apiaries.

Variation in intensity of honey-flows.

In general, the nectar-flows increase in rapidity or intensity as one goes northward and with this rapidity in the honey-flow usually comes a shortening of the period during which nectar is secreted. As a rule, the northern honeys are lighter in color, although there are many exceptions which will be pointed out later. In the more northern localities, the beginning and end of the honey-flows are usually sharply marked, while in the South there is a gradual increase in the honey-flow to the maximum and a correspondingly gradual cessation of the honey-flow.

Variation in the value of plants.

There is a striking difference in the value, from a beekeeper's standpoint, of plants according to locality, and the causes of these phenomena are in most cases not understood. A few of the more striking examples will serve to illustrate this variation. White clover yields nectar most abundantly in the northern range of this plant, while farther south the flow of nectar from this plant is less intense and the honey is often somewhat darker. Alfalfa yields nectar freely in the irrigated districts of the West, but is usually of no value to the beekeeper east of the Mississippi River. Buckwheat is the source of large honey crops in parts of southern New York and Pennsylvania, while in Indiana and Illinois it secretes much less nectar, again increasing in value to the beekeeper in Michigan. Exceptions to these general statements sometimes arise because of abnormal climatic conditions. For example, a heavy honey-flow from alfalfa was recently obtained in the vicinity of Syracuse, New York. This was probably not due to the plants becoming acclimated but occurred in a dry season. In some seasons white clover yields well much farther south than the limits previously given. Other examples are given later.

BEEKEEPING REGIONS

It helps to an understanding of the differences in the practices of beekeepers in various parts of the United States if we divide the country into honey regions. This, as any experienced beekeeper will at once recognize, is a more or less arbitrary division and many exceptions might be cited to the following classification. In the main, however, the nature of the honey-flows justifies such an arrangement, and this plan is still more permissible if we consider the systems of manipulation found most advantageous by beekeepers. These regions may first be divided into general and restricted, depending chiefly on their area. The general regions are those not only of considerable extent, but of greater influence on the choice of manipulations.

General regions.

These are five in number and the division is based on differences in climatic conditions found in the United States. The placing of the sage region in the rank of a general region is justified mainly by the size of the crops obtained there in favorable seasons.

(1) *The white clover region* includes eastern Canada, the New England States, except along the coast, and a belt along the northern United States as far west as the Dakotas. It is limited to the west by the arid region and again reappears on the Pacific coast, both in the United States and Canada. The southern boundary is approximately Mason and Dixon's line and the Ohio River. In this region, in addition to white clover, alsike clover, sweet clover, basswood, tulip poplar and locust contribute to the honey crops and, with the exception of that from tulip poplar, the honeys from these sources are light in color. Alsike clover is steadily increasing in importance with its wider planting for forage, while basswood is rapidly disappearing because of the extensive cutting of this tree for lumber. In this region the honey-flows are rapid and relatively short and the main

honey-flow is usually preceded by a honey-flow from spring flowers (fruit bloom, dandelion) followed by a dearth. In the more northern localities this interval is brief or entirely absent. After the main honey-flow there is usually a period when no nectar is available, followed again by a late summer or fall honey-flow (buckwheat, asters, goldenrod or Spanish needle, according to locality). This region is suitable for comb-honey production better than any other part of the United States, on account of the intensity of the honey-flows and the light color of most of the honeys. The necessity for a rapid building up of colonies in the spring and the difficulty of swarm control make necessary special systems of manipulation in this region. The wintering problem is naturally most acute here also. Most of the American literature on beekeeping in both books and journals is based on systems applicable to the white clover region. The honeys of this region are in great demand, probably because the honey-consuming public is better educated to the flavors obtained here. In this region are thousands of beekeepers with only a few colonies, although the number of specialists is increasing satisfactorily.

(2) *The alfalfa region* is located in the West, where this plant is chiefly grown for forage. Alfalfa is at its best as a nectar-producing plant under irrigation and usually at high altitudes. Colorado, Utah and Idaho are now the largest producing States in this region. Sweet clover is also an important contributor to the nectar supply in some sections. The honey of this region is usually of fine flavor and light in color, but alfalfa honey quickly begins to granulate and in consequence would seem best adapted to extracting. The honey-flow is not so rapid as in the white clover region, which also makes this region less favorable for comb-honey production. However, many beekeepers of this region produce comb-honey extensively. The system of manipulation is different from that in the white clover region because the honey-flows are usually longer and swarming is less difficult to control. The number of honey-flows de-

pends on the number of crops of alfalfa that are harvested in a season. This region is steadily increasing in importance, and a market is rapidly being built up for alfalfa honey. In this region, honey-production is conducted chiefly by extensive beekeepers.

(3) *The south-eastern region*, which varies greatly in the sources of honey throughout its extent, and which is an area of abundant rainfall, lies south of the white clover region and extends west to eastern Texas. The various rather distinct subdivisions of this territory might well be placed among the restricted honey regions, except that certain things in common in the honey-flows make the same type of manipulations necessary. Among the important plants of this district are sourwood, cotton, tulip poplar, tupelo, manchineel, mangrove, titi, palmettos, citrus trees, gallberry and partridge pea, with nectar from clovers in some sections in favorable seasons. Sweet clover is valuable in some localities. Most of the honeys are amber, and the chief characteristic of this region is a succession of honey-flows, often intergrading. The honey-flows are usually not rapid. This region is therefore best adapted to extracted-honey production. Swarming is much less troublesome than in the North. Beekeeping is developing in this region, but there is opportunity for many more beekeepers, there being now relatively few who rank as professionals. Colonies of bees may usually be bought at low prices in box-hives. This region is perhaps the best in the United States for commercial queen-rearing, except in parts of Florida where dragon flies are troublesome.

The diversity of conditions in this region is well shown in the accompanying map (Fig. 95), which was prepared by E. G. Baldwin, De Land, Florida, who has studied the beekeeping possibilities of his State quite thoroughly. It will be seen that the sources of nectar are quite distinct geographically. The geographical position of this State and the diversity of soil and climatic conditions strongly influence the growth of the honey plants. In this State two localities only a few miles apart may be quite unlike, when viewed from the standpoint of the beekeeper. This is also true in many other parts of the United States.

(4) *The semi-arid region of the south-west* is located chiefly in the arid and semi-arid parts of Texas and Arizona and here too the honey plants are of somewhat restricted distribution. Among the plants which are important to the beekeeper are mesquite, horsemint, catclaw, huisache and guajilla. Most of the honey produced in this region is extracted, although a large number of beekeepers produce bulk comb-honey (chunk honey), cut from large combs (without sections) and placed in cans in which extracted-honey has been poured to fill the spaces. Such honey is usually sold locally. Beekeeping in this region is largely in the hands of professional beekeepers.

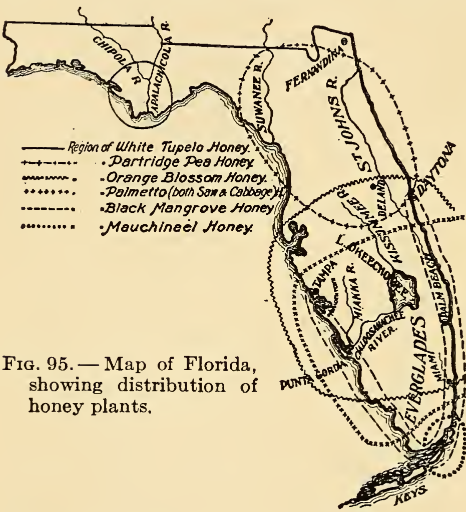


Fig. 95. — Map of Florida, showing distribution of honey plants.

(5) *The sage region* is confined to the cañons of southern California and should be considered a restricted region except for the fact that sage honey wields so important an influence on the honey market that the region may justly be placed among those of major importance. The various sages are all heavy yielders under favorable conditions and there is usually no other honey source of importance where this honey is produced. The influence of rainfall on the honey crop of this region is discussed in the chapter on honey

sources. If the crops of sage honey were uniformly heavy, this would be an ideal region for comb-honey production, for sage honey is mild in flavor, water-white and does not easily granulate. However, successful comb-honey production necessitates a rapid flow, which often fails to appear in this region and most of the honey is extracted. Here too there are many professional beekeepers, although a considerable number are not modern in their methods of manipulation and equipment.

In addition to the geographical limits ascribed to these main regions, other localities situated outside the prescribed boundaries might well be included with certain of the general regions in discussing the type of flow. For example, California, north of the sage region, is comparable with the South, and along the Pacific coast to the north there are localities which belong to the white clover region.

Restricted regions.

In addition to the more general divisions named, there are other localities with special advantages for the beekeeper, but more limited in extent, which lie within the boundaries of the main divisions. As previously mentioned, the southeastern region is virtually composed of a number of such restricted regions. The list here given will be recognized as incomplete and is intended merely as a suggestion. Many more restricted regions will be recognized from the discussion of the sources of nectar. Among the more important limited regions may be mentioned those in which the following plants secrete nectar.

(1) *Buckwheat.* — The honey of this plant is dark and of strong flavor, suitable chiefly for manufacturing purposes. The variation in the secretion of nectar from buckwheat has been mentioned.

(2) *Sumac.* — Valuable locally in New England. Another species of the same genus yields a surplus in limited areas in Georgia.

(3) *Spanish needle* (numerous species). — Heavy yielders

of amber honey in the autumn in swamps. Among the best-known regions in which these plants are of value may be mentioned the lower Delaware River and Illinois River valleys and the Kankakee swamp.

(4) *Willowherb.* — Important in northern Michigan in burned over forest areas.

(5) *Sweet clover.* — In some sections, especially in limestone regions, this plant is exceptionally abundant and is the source of large crops of honey of a slightly greenish color. It is especially valuable in northern Kentucky and southern Indiana.

(6) *Blue thistle.* — Important in the Shenandoah valley.

(7) *Raspberry.* — Northern Michigan where the forests have been burned over and in parts of New York.

(8) *Beans.* — In southern California, where beans of various kinds are grown in great quantity, beekeepers find it profitable to move their apiaries to the bean fields after the sage honey-flow. The honey is white, of excellent flavor and granulates quickly.

(9) *Heartsease.* — Mississippi valley. A heavy yielder of nectar in late summer.

Variation within a region.

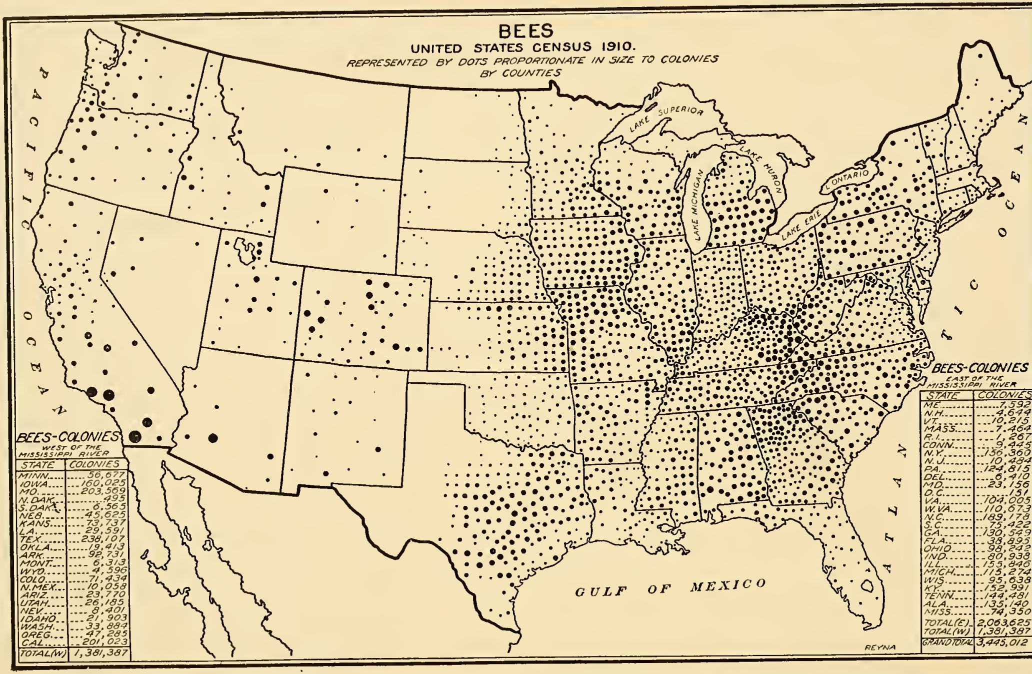
It must not be understood that the territory within either a general or a restricted region as here defined is equally good throughout. The cutting of forests, the extensive cultivation of some plant which restricts the growth of honey plants, local differences in soil or drainage, the presence of large towns and a multitude of other factors may so reduce the number of individual honey plants where they would normally grow as to make extensive beekeeping unprofitable. On the other hand, the cutting of forests may make a region better by allowing a honey plant to spread (*e.g.* willowherb) or the planting of some nectar-yielding species, either under cultivation (*e.g.* alsike clover, alfalfa) or in waste places (*e.g.* sweet clover), may greatly increase the value of a region to the beekeeper. In fact, the entire alfalfa region is a man-made honey region. These factors, many of which are due to human interference with the natural environment, must be considered in choosing locations of apiaries and in manipulating colonies.

Climatic influences may change an area from year to year. A lack of sufficient rainfall, for example, may kill white clover in certain areas and not in others. This occurred during 1914, when a severe drought killed clover over much of Illinois, while an abundance of rain fell in northern portions of the State, there being marked differences in localities only a few miles apart.

DISTRIBUTION OF BEES IN THE UNITED STATES

The relative importance of the various honey regions is indicated by the number of colonies of bees found in each one, although care must be exercised in examining these data to avoid misinterpretation. The only source of information on this subject is the United States Census, and the data from this source are not complete. However, while the number of colonies reported is far too low, it may perhaps be assumed that approximately the same percentage is omitted throughout the United States. The accompanying map (Fig. 96) was prepared in the Bureau of Crop Estimates of the Department of Agriculture from data furnished by the Census of 1910 and the author is indebted to this Bureau for permission to use it here. In this map will be found a dot for each county where bees are kept, the size of the dot being proportionate to the number of colonies reported.

In the white clover region, it is evident that the more northern localities are most thoroughly stocked with bees. In the alfalfa region bees are less abundant, and this is true also in the sage region. The amount of honey produced in these regions is far below that of the moist regions of the country, but the honey goes to market in large shipments, because of the larger number of specialist beekeepers, and



BEES-COLONIES WEST OF THE MISSISSIPPI RIVER

STATE	COLONIES
MINN.	56,677
IOWA	160,025
MO.	203,569
N. DAK.	495
S. DAK.	6,565
NEB.	45,625
KANS.	73,737
LA.	29,591
TEX.	238,107
OKLA.	19,413
ARK.	92,731
MONT.	6,313
WYO.	4,596
COLO.	71,434
N. MEX.	10,058
ARIZ.	23,770
UTAH	26,185
NEV.	8,401
IDAHO	21,903
WASH.	33,884
OREG.	47,285
CAL.	201,023
TOTAL(W)	1,381,387

BEES-COLONIES EAST OF THE MISSISSIPPI RIVER

STATE	COLONIES
ME.	7,592
N.H.	4,644
VT.	10,215
MASS.	7,464
R.I.	1,267
CONN.	9,445
N.Y.	156,360
N.J.	10,484
PA.	124,815
DEL.	6,410
MD.	23,156
D.C.	151
VA.	104,005
W. VA.	110,673
N.C.	189,178
S.C.	75,422
GA.	130,549
FLA.	38,895
OHIO	98,242
IND.	80,938
ILL.	155,846
MICH.	115,274
WIS.	95,638
KY.	152,991
TENN.	144,481
ALA.	135,140
MISS.	74,350
TOTAL(E)	2,063,625
TOTAL(W)	1,381,387
GRAND TOTAL	3,445,012

FIG. 96. — Map of United States, showing distribution of colonies of bees according to the Census of 1910.

as a result these crops are important in determining the wholesale price of honey.

The enormous number of colonies in the southern States is a surprise. In the fifteen States usually included in the division of southern States are found forty-five per cent of all the colonies in the United States. In this region the box-hive and the farmer-beekeeper are still found in large numbers, there being few specialists except in Texas. Because the industry has not developed on modern lines, most of the honey from the South does not reach the larger centers of distribution, and it therefore has little influence on the wholesale honey markets. The number of colonies of bees found in the South is proof of the wonderful opportunities for the development of the industry, for many of these colonies are given no attention. As one beekeeper expresses it, these bees would die, if they could, to escape the ill-treatment to which they are subjected, but the environment is so favorable that they increase in spite of mismanagement.

Attention should also be called to the larger number of colonies in southern New York and northern Pennsylvania, where buckwheat is plentiful. The other restricted honey regions seem to have less influence on the number of colonies.

This map will repay considerable study in connection with other phases of beekeeping. To one familiar with the distribution of the diseases of the brood of bees in the United States [1] it is clear that there has been a severe loss from this cause, as indicated by the smaller dots in regions where diseases are most prevalent. New England was formerly well stocked with bees, but many colonies have been destroyed by disease. Certain areas in Pennsylvania, Ohio and Indiana, where disease is abundant, are inadequately provided with bees. One important reason for the larger number of colonies in the South is probably the scarcity of disease.

[1] Phillips, E. F., 1911. The occurrence of bee diseases in the United States (Preliminary report). Circular No. 138, Bureau of Entomology, 25 pp.

MIGRATORY BEEKEEPING

By this expression beekeepers designate the moving of apiaries from place to place during a single summer to take advantage of two or more honey-flows which do not occur in a single locality. This has been practiced since ancient times, and most extensive beekeepers cherish the hope that some day the subject may be sufficiently understood so that they may move their bees several times a season and thereby keep them working almost all the year. Some elaborate plans have been made for moving bees from south to north as the seasons advance, but most of the trials have been failures. Since success in beekeeping depends on an intimate knowledge of the honey sources of the locality and of the best manipulations to obtain maximum crops, such migratory beekeeping would necessitate detailed knowledge of many sections, so that the beekeeper may know when and where to move his colonies to advantage.

The Mississippi River has long been considered an ideal avenue for transporting colonies in migratory beekeeping, especially since there is no better way to ship colonies than by boat. It has been proposed that the beekeeper place his apiary on a flatboat in the South in early spring and move northward by night, allowing his bees to gather nectar by day, and following the season as it extends northward. This plan so well illustrates the limitations of migratory beekeeping that it may be critically examined. One of the chief difficulties is the fact that the beekeeper must know just where to anchor after each move so that his bees will be in range of the best forage and this would involve too careful a study of the valley to make the plan practical. This objection might be overcome but there is a more fundamental difficulty which has not been sufficiently considered by those who have cherished this dream. If one species of plant furnished the main nectar-flow throughout the Mississippi valley, the beekeeper could move northward to prolong the gathering period, but this is not the case.

There are many plants which furnish nectar in the various portions in the valley and if the apiary were moved northward the bees often would leave behind them a honey-flow from another source. If migratory beekeeping from south to north and then back south with the closing season proves successful it will probably be within the nectar-secreting area of a single species of plant or perhaps of two species, one for each direction of the journey. The Mississippi River plan was tried several years ago on a rather extensive scale without success.

The experiment of moving an apiary south for the winter for the purpose of making increase has recently been tried. If one is raising bees for sale and has a heavy demand for colonies that may pay but the chances of success in following this plan for honey-production are small.

The limitations of migratory beekeeping, in so far as present successes indicate them, have not been previously pointed out. They are approximately as follows: The movement of bees must not be from one general region to another, as from the white clover region to the alfalfa region, but from a location where the flora is that of the general region to a restricted region where the honey-flow comes at a different time, usually later. For example, it has been found profitable to practice the following plans in migratory beekeeping: (1) from white clover to sweet clover, buckwheat, Spanish needle or heartsease, (2) from sage to bean or (3) from one of the restricted regions in the South to another. As previously mentioned, the honey-flow at the temporary out-apiary usually comes after the main honey-flow at the permanent apiary. In most such cases, the conditions demand the production of extracted-honey, as comb-honey production and migratory beekeeping are not well suited to each other.

In considering the possibility of migratory beekeeping it must be decided whether it is desirable to move the bees or simply the beekeeper. In other words, if the trip is a long one involving considerable expense and danger of loss in moving a large number of colonies, it may be cheaper or easier for the beekeeper to own two or more lots of bees and supplies. The expense of transportation and the danger involved are probably the factors which determine the feasibility of moving from south to north or from sage in California to alfalfa in Utah or Colorado. In the South, especially where bees can be purchased at a low price, it would not seem profitable to move apiaries over long distances. The shipping of bees in wire-cloth cages may in the future remove the present limitations.

It would certainly seem that a northern beekeeper is not embracing all his opportunities if he quits work when his bees can no longer get nectar, while there are still hundreds of places in the South or even in the tropics where he might maintain apiaries with profit in the winter. When it is recalled that the professional beekeeper is a relatively new factor in beekeeping, it may still be expected that the future development of the industry will show an increase in migratory beekeeping, or at least in migratory beekeepers.

OVERSTOCKING

The bugbear of the specialist beekeeper is the fear that he will overstock his localities, that is, place in each apiary so many colonies that there will not be enough nectar available to permit the colonies to store approximately the maximum profitable surplus. Since there are few places in the United States that are now overstocked, this subject worries the beekeeper more than the facts warrant. Some beekeepers have found it practical to keep several hundred colonies in one apiary. E. W. Alexander, Delanson, New York, found it more profitable, in an exceptionally good buckwheat region, to keep over 700 colonies in one yard than to establish out-apiaries. In the South and West large apiaries are not infrequent.

While it is desirable to keep bees in as few places as possible to avoid duplication of apparatus and time lost in transportation, there is another factor to be considered. The size of an apiary should be determined chiefly by the number of colonies that the beekeeper can manipulate in a single day during the honey-flow. If he finds that he can usually care for seventy-five colonies in a day under his system of management, then that number is ideal for his apiaries. He can then arrange his out-apiaries so that each will receive a visit as frequently as the conditions demand. The amount of work that can be done in a day will increase with experience and the out-apiaries correspondingly may be increased in size, for they should be large enough to furnish a full day's work, unless there is some means of rapid transportation available. With modern transportation facilities the distance to out-yards is of less importance than formerly and many beekeepers now have motor trucks to carry an extracting outfit and other apparatus and supplies from one apiary to another. Considering the day's work as the determining factor in the size of the apiary, the out-apiaries may be more numerous and closer together than would be the case if each yard were increased to the maximum. In the present undeveloped condition of the beekeeping industry and with so many localities almost untouched by bees, it is not wise to run any risk of overstocking. The location of out-apiaries should be determined by the available forage, the minimum distance between them usually being determined by the distance that bees can fly.

DADANT OUT-APIARIES

To illustrate the problem which confronts the beekeeper in the establishment of out-apiaries there is here reproduced a map (Fig. 97), made from one by C. P. Dadant, Hamilton, Illinois, of the apiaries near his home in 1891. He then owned the Home, Sherwood, Villemain and Sack apiaries, the other four shown being apiaries of other beekeepers. All of these are located on land sloping toward the Mississippi River. The Sherwood apiary was the best, giving crops in the spring and fall. The Villemain apiary appears to have been in the poorest location, the range of the bees being restricted by the river, but it was near the only basswood grove in the country and the bees gathered honey in the fall from the islands. The Sack apiary seems to have been too near other apiaries but was actually second only to the Sherwood yard. The bees did not work more than a mile along the bluff but went three miles to the river, having the bottom lands covered with fall flowers within their range of flight. They were separated from the adjacent apiaries by hills and timber. The two small circles show sites of former apiaries, used before the Sherwood apiary was established. The bees in the home apiary were only a mile and a half from abundant pasturage on an island but did not reach it, although they sometimes went two miles or more in another direction.

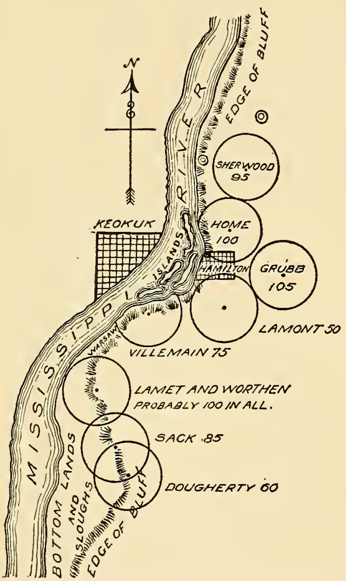


Fig. 97. — Map showing distribution of Dadant apiaries, Hamilton, Ill.

This description of conditions in 1891 [1] may not represent the condition of the Dadant apiaries to-day. The map, however, shows the locations decided upon in that region by an experienced beekeeper who had kept bees in that district for twenty years. It shows that distance from one apiary to the next is not the sole consideration but that contour of the land, timber tracts and other barriers must be taken

[1] Dadant, C. P., 1891. Arrangement of out-apiaries. Gleanings in Bee Culture, XIX, pp. 60-61.

into account. Similar maps and descriptions of out-apiaries appeared in the same journal at about the same time, one of the apiaries of E. France, Platteville, Wisconsin, and another from A. E. Manum, Bristol, Vermont. The effect of contour of the land is especially well illustrated in the Manum map. It would probably profit any extensive bee-keeper who has several out-apiaries to make a similar map of his region, especially if he includes the honey sources.

CHAPTER XI

THE FIRST STEPS IN BEEKEEPING

Many persons begin beekeeping accidentally. The interest of many of the present beekeepers in the honeybee has first been aroused by a swarm passing over the premises or perhaps lighting on a tree near by. The desire not to allow anything to go to waste or not to allow a valuable article to elude him, coupled perhaps with a dare-devil impulse to risk a combat, has induced many a man or woman to attempt to hive the stray swarm. Or perhaps there is a temptation to exhibit one's prowess before the other members of the family. Having hived the swarm in a box or barrel with no loss of life or limb — and bees are never easier to handle than when swarming — it is by easy steps that one goes on until an attack of what is commonly known as "bee-fever" has developed, from which recovery seems hopeless. If a swarm is caught and put into a box, the owner should obtain a modern hive as soon as practical and lodge his new possession in a home where they may be manipulated. The necessary equipment is discussed in Chapter II.

Purchase of colonies.

There are those, however, who decide to begin beekeeping without this accidental impulse. The desirability of beginning on a small scale may be again emphasized here. Colonies should if possible always be purchased near at hand to prevent the loss which may follow, especially if colonies must be transported by inexperienced persons. The further advantage in this procedure is that the former owner may usually be induced to assist in the moving and he will also prove helpful in the early days with the bees. It is best to have the bees already housed in the hive which is to be adopted but if this is not possible then colonies in any hive or in boxes or barrels may be purchased and transferred (p. 245). Transferring is a difficult operation for a novice, in fact it is not relished by an experienced beekeeper, and is to be avoided. Early in the summer is usually the best time for making the start, although the price charged for colonies is usually higher at that season. There is less opportunity for making such mistakes in management as will result in loss of bees during the first few months of ownership if these come during the summer. It matters little what race or strain of bees is obtained at the beginning except that it is desirable to avoid bees with too great a percentage of black blood in them, such bees being difficult to manipulate. After the apiary is established any desired race may be obtained by removing the queens and replacing them with mated queens purchased from commercial queen breeders. If these are introduced to replace the old queens of the colonies, the progeny of the new queens will rapidly replace the offspring of the discarded ones as they die from natural causes.

Purchase of bees to be shipped from a distance.

Another method of buying bees which is growing in favor is to buy them by weight, without frames. Bees are now easily shipped in cages specially constructed for the purpose, even though the journey require several days. By this method the possibility of carrying some brood disease is obviated and there is less likelihood of damage to the bees by the breaking or melting of combs or by suffocation during the journey. Nuclei or small colonies with frames may also be shipped a considerable distance. These will usually build up to full colonies during the season if bought early, but of course surplus honey can scarcely be expected the first year from such a small colony. Still another plan is to buy an empty hive and leave it with some beekeeper so that a swarm may be hived in it, after which it is removed to the desired location.

Requirements in purchased colonies.

If there is opportunity to examine the colonies before purchasing them, there are several important things which should be insisted upon: (1) get as little drone comb or crooked or defective comb as possible; (2) see that the colony is free from disease (p. 397); (3) the colony should be provided with plenty of honey and (4) the amount of brood should be adequate for the time of year. It is perhaps asking too much of the beginner to expect him to determine whether disease is present in colonies purchased. In many states and counties there are official apiary inspectors whose duty it is to give advice on the subject of disease and these men may be asked to assist in this work. At any rate, even the novice can tell whether there is any dead or discolored brood and it is at least safe not to accept colonies in which any discolored brood is found, normal brood being pearly white. Formerly the sale of bees was believed to bring ill-luck and the customary way to acquire colonies was to go at night to the apiary and after the removal of the colony, to leave coins to the value of the bees on an adjacent hive. The possibility of an insufficient pile of coins or perhaps none at all is probably a factor in causing modern beekeepers to prefer to sell bees according to present-day methods. The beginner can scarcely be advised to adopt the ancient manner, for the custom might be found faulty when explained to a magistrate.

How to learn beekeeping.

To acquire skill in manipulating bees and to learn the proper management of the apiary so as to obtain maximum results, the best method is to spend some time in the apiary of an experienced beekeeper. If one contemplates making beekeeping an important part of the occupation, this is especially to be desired. It is usually possible to arrange for employment at a small wage in the apiary of a specialist for a season. Not all extensive beekeepers, however, manipulate their bees well and many of them fail to get the maximum returns through faulty systems, especially in comb-honey production, but after some experience in such an apiary the prospective beekeeper is better able to read the details of manipulations understandingly, and he can correct in his own practice the mistakes which may have been taught him by his teacher.

Value of reading.

The many books on bees all have points of merit and reading the various journals devoted to beekeeping is to be commended. Reading alone does not make a beekeeper. The "book-beekeeper" may be well informed concerning the behavior of bees and may know the different systems of management so that he can discuss them in detail, but only by practice do these things become an actual part of his beekeeping equipment.

Merits of beekeeping courses.

A good way to learn beekeeping is to attend some school where a thorough course in this subject is given. Until recently beekeeping was not included in the work of the agricultural colleges in the United States, but interest is now being aroused in this work and it is spreading in a manner to give deep satisfaction to those interested in the development of the industry. In the apiary of an experienced beekeeper, the beginner perhaps gets more personal attention than he does in a class, but usually in the rush of honey-production, the theoretical side of the work is neglected and frequently the beekeeper is not able to offer much help to his student on such subjects. Consequently when he begins to keep bees for himself, he may find local conditions quite unlike those in the apiary in which he worked and, not knowing the fundamental facts about bees, he may be at a loss to know what to do. In a regular course of study, the proper emphasis may be placed on the various subjects, although naturally there is less opportunity for practice with the bees. The ideal plan is to take the prescribed course and then spend the following summer in the apiary of the best beekeeper available. The student is then able to understand more clearly what he sees and hears and is better able to recognize and perhaps mentally to condemn the little peculiarities in practice which one encounters occasionally in the manipulations of practical beekeepers. If the teaching of beekeeping is conducted wisely, it should result not only in increased knowledge of bees, but in the training of more professional beekeepers.

Beginner's outfit.

It is only with experience that one is able to judge of the comparative merits of different hives and other equipment, but the beginner usually desires definite information concerning the equipment which should be purchased. The giving of such advice is attended with some risk, for one hesitates to advise an equipment which may be discarded when the beekeeper becomes more familiar with the business. In the following lists, the choice is made on the basis of the equipment which is preferred by the majority of good beekeepers and not alone on the author's personal preferences.

General equipment: —

Bee veil.
Smoker — medium size.
Gloves (for the beginner only).
Some kind of hive tool — a screwdriver will answer.

For each colony: —

Bottom board of $\frac{7}{8}$ inch material.
10-frame Langstroth hive — preferably single-walled.
Self-spacing frames, punched for wiring.
Medium brood foundation, $1\frac{1}{4}$ lb. for each hive body.
Telescope cover.

For comb-honey production (minimum):—

3 supers for 10-frame hive (if possible one made up for sample). The $4\frac{1}{4}$ inches square section, $1\frac{7}{8}$ inches wide, is usually preferred. The purchase of only one super to the colony is to be condemned.

Thin foundation, 2 oz. to super. For the beginner the use of small starters of foundation is sometimes preferable. If full sheets are used, 8 oz. to the super should be provided.

For extracted-honey production:—

2 extra hive bodies identical with those used in brood chamber, with full sheets of comb-foundation (see p. 28 concerning spacing devices in surplus chambers).

1 2-frame non-reversible extractor.

1 Bingham uncapping knife.

For bulk comb-honey production:—

3 10-frame supers with shallow extracting frames.

$\frac{1}{2}$ lb. thin-super foundation for each super.

CHAPTER XII

THE APIARY SITE

In the establishment of a commercial apiary, the chief requisite is proximity to the sources of nectar. To fulfill this, it is essential that the honey resources of the region be studied carefully. While it is possible to keep bees in almost all of the habitable parts of the United States, it is not everywhere profitable to practice extensive beekeeping, so that if one contemplates making honey-production a major portion of his business, it is best to go to the best available location rather than to struggle along in a mediocre locality. A second requisite is ease of transportation to the apiary and to market.

Apiary grounds.

In the North, a plot of ground sloping to the south or east is usually preferable and in any region it is advisable to face the apiary so as to protect the entrances of the hives from the prevailing winds. If the contour of the land or a near-by forest does not afford protection from the wind, a windbreak may be planted. A row of evergreens is efficient in the North and is serviceable in winter when it is most needed. A solid fence or building is less desirable, since such a windbreak, instead of breaking the force of the wind, often simply deflects the currents into the midst of the apiary with disastrous results. In moist regions, a slope is desirable for drainage. The hives should be so placed that they receive sunlight in the early morning. This is helpful in winter and perhaps equally so in summer as it starts the bees to the field earlier, so that they get the nectar from plants which furnish it only in the mornings. If possible, the apiary should not be near the public road and should be situated where the bees will not prove a nuisance to passers-by or sting live-stock. If the only convenient location is near the road, the line of flight of the bees may be deflected upwards by a high hedge or a solid fence, for after they fly over such an obstruction they will keep above the line of travel on the road and will not molest teams or pedestrians. This is an important consideration as bees sometimes sting horses fatally. The apiary should preferably be located away from the clothes-drying yard so that they will not spot the clothes with their feces. This applies especially in the North, and this objection may largely be overcome by removing the cellar-wintered bees when no clothes are to be hung out. Perhaps it would be more in keeping with the usual practice to advise that no clothes be hung out just after the bees have been placed on their summer stands.

The hives should, if practicable, occupy the higher ground of the plot chosen for the apiary, so that in carrying heavy supers to the apiary house the load will be carried downhill and the empty supers uphill. Such an arrangement will materially reduce the labor in a commercial apiary.

Exposure to the sun.

While exposure to the sun is to be advised in the early morning, it is often well to protect the hives from the sun in the middle of the day, so that the bees will not hang out in front of the hive and to prevent the melting down of combs. On the other hand, too dense a shade is not advantageous and usually it is not best to locate an apiary in woods. To provide shade, the hives may be placed in two rows under a shed or arbor with the hive entrances to the outside (Fig. 98). Such sheds usually run north and south, but in hot, dry countries an east and west direction is sometimes better. In temperate climates, sheds are not in favor, but many beekeepers use shade-boards, so constructed that they extend about a foot in all directions from the hive except to the north. These must be held in place by a heavy weight and are rather objectionable because they have to be removed each time the colony is manipulated.

As the extreme of protection from the sun's rays may be mentioned the house apiary, in which the entrances to the hives are through holes in the wall of a specially constructed house. Such arrangements meet with little favor among American beekeepers because of the difficulty in manipulating the colonies inside the house. In Europe, however, the beekeepers often construct elaborately designed and decorated house apiaries (Fig. 8) in which an American commercial beekeeper would find himself seriously hindered.

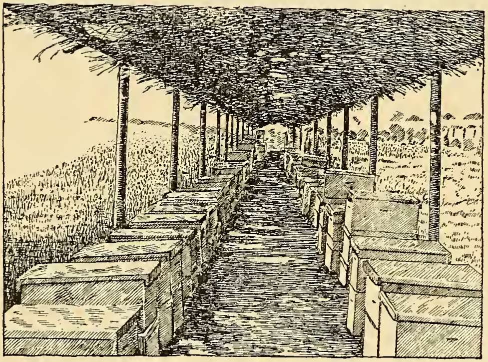


Fig. 98. — Apiary in the West, shaded by thatched shed.

Care of the apiary grounds.

The ground on which the hives are located should be smooth so that a wheelbarrow or cart may be utilized in carrying supplies or honey. This is also desirable if a lawnmower is used to keep grass and weeds from obstructing the entrances. High grass about the entrances is a hindrance to the bees on returning to the hive and should be avoided. Few commercial beekeepers find time to use a lawnmower during the rush season, but prefer to lay boards in front of the hive or to kill the grass with salt. It is sometimes convenient to pasture one or more sheep in the apiary inclosure. Raising the hives above the grass on high stands is another solution of the difficulty, but is not desirable in a heavy flow of honey, since bees often fall to the ground with their loads and since the stands may break down under the weight of honey.

Arrangement of hives.

The hives may be variously arranged according to the preference of the beekeeper. Each hive should be inclined

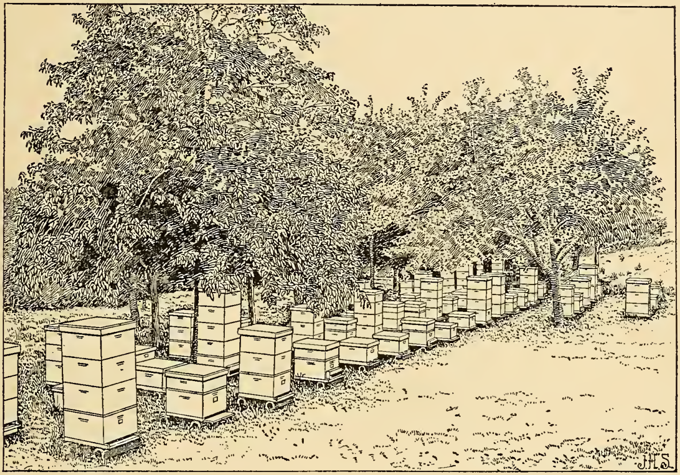


Fig. 99. — Former apiary of the Bureau of Entomology, College Park, Md. The use of this apiary for experimental work accounts for the divergence in the height of the hives. The hives were here arranged singly about four feet apart.

so that the entrance is about an inch lower than the back of the hive to prevent water from collecting on the bottom board. It is usually desirable that the hives be so placed that the beekeeper will not need to pass in front of the hive entrances as he goes about his work. The usual practice is to place hives in rows either close together on a slightly raised platform or singly on individual stands. The placing of hives in pairs on a single stand is also common. Where economy of space is a consideration, it is found advantageous to place hives close together in groups of four, back to back, two facing east and two west. This allows a space beside each hive for the beekeeper while manipulating and is greatly to be preferred to hives in long rows close together. Where space will permit, the placing of hives singly (Fig. 99) is preferable.

Number of colonies in one apiary.

The number of colonies which may profitably be kept in one apiary depends entirely on the nectar supply. In the white clover region, it is considered best to have not more than one hundred colonies in an apiary, with apiaries located at least two miles apart. This number can be increased in many localities. In the other general honey regions of the United States, it is usually profitable under favorable local conditions to keep from 200 to possibly 500 colonies in one apiary. There are so many factors to consider in determining this point that no general rules may be laid down. Since this is not a question which the beginner is called on to answer, it may be advised that the beekeeper decide each case individually from a study of the honey flora, the experience of other beekeepers and his own experience.

Out-apiaries.

In locating an apiary away from the central apiary, usually called an out-apiary or out-yard, easy transportation, especially to the main apiary, is most desirable. It is also an advantage to have the out-yard, especially one in which comb-honey is produced, near to the home of some person who can hive swarms which may issue in spite of precautions taken, and to protect the colonies from depredation. If these things are not practical, it is better to have the bees where they are not easily seen from the highway.

Conveniences less essential in out-apiaries.

In establishing an out-apiary, the points previously mentioned should be considered as desirable but not essential.

Since bees may be kept on roofs, in woods and in other places lacking many desirable features, it will be seen that it is not profitable to consider the desirable features too seriously. Another distinction should be made. If the out-apiary is permanent, it will pay better to plan the location thoroughly. However, many commercial beekeepers, especially those outside the white clover belt, find it well to change the locations of their out-apiaries to meet changing conditions in the region and they therefore do not find it profitable to consider the conveniences in equipment and in apiary planning to any great extent. To the commercial beekeeper the only essentials are the things which bring the greatest return. The amateur can better afford to spend time cutting grass and arranging hive stands since his living does not depend on the crop and he has fewer colonies for which to plan.

CHAPTER XIII

THE MANIPULATION OF BEES

The work which the beekeeper does with his bees has for its object an increase in their productiveness. Bees gather nectar and pollen when they are available in response to their own instincts to gather; they build wax when it is needed if space and food are available. The duties of the beekeeper are not concerned with creating these impulses. However, bees do not always work so as to accomplish the most efficient results, when measured by the commercial standards of the beekeeper, and the care which he bestows on his bees serves to provide conditions suitable for the turning of their natural instincts into those channels which will yield the greatest profit.

Disturbance to be reduced to a minimum.

Bees should be handled so that their work will be disturbed as little as possible, for the manipulations of the beekeeper are only accessory to their labors. Stings should be avoided. This is not so much because they are painful, but chiefly because the odor of the poison irritates bees and makes them difficult to manage. A veil (Fig. 26) and a good smoker (Fig. 24) are practically indispensable. By the use of smoke, the bees may be quieted so that they may be handled readily, the guards are disorganized and the bees gorge themselves with honey, after which they are not easily provoked to an attack. Too much smoke must be avoided as it disorganizes the entire colony and considerable time elapses before the bees fully return to their normal activities.

Hasty movements and the jarring of the hive are to be avoided. The organization of the bee's eyes enables it to see movement more readily than still objects. On seeing bees flying about the face, the beginner often strikes at them or moves quickly to escape the sting, thus provoking an attack. It requires quiet nerves not to jerk a frame or even to drop it when the hand in which it is being held is stung.

Equipment for manipulation.

Aside from a smoker, veil and hive-tool, the beekeeper needs no other equipment in opening a hive, but the beginner may find gloves (better those with the fingers removed) desirable. If special clothing is worn in the apiary, and it is desirable for both comfort and economy not to wear one's best, white suits are most satisfactory. They are the most comfortable in the heat of summer and the beekeeper has a good excuse for this comfort because they are best for apiary use.

When to handle bees.

The best time to open hives is in the middle of warm days, especially when the bees are busily engaged in collecting nectar. Bees should never be handled at night nor on wet, cold days. It is not always possible for the extensive beekeeper to choose the ideal time but it is well to plan to open hives in favorable times, not only for the comfort of the operator but principally because it interferes least with the work of the colony.

Opening a hive.

Before opening the hive, a little smoke should be blown in the entrance. When the cover is slightly raised, a little more smoke should be directed over the frames before the bees have an opportunity to escape. If the frames are covered by a mat or oilcloth, which is not desirable but often used, the outer cover may be entirely removed and one corner of the mat lifted to admit smoke. The covering then may be removed and the manipulation begun. In case the bees become troublesome at any time during the work, as they probably will if it is continued for a time, more smoke may be blown over or directed down between the frames to disorganize new guards. No directions need be given as to the way to recognize trouble and it need only be stated that the most common fault is to use smoke too freely. During all manipulations the operator should stand at the side or back of the hive and not in front of it, to prevent interference of bees leaving and returning to the hive.

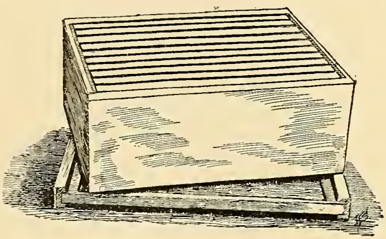


Fig. 100. — Hive-body resting on cover during manipulation.

If one wishes to examine the brood chamber when the colony is in two or more hive bodies or has comb-honey supers, the hive cover serves as a good support for the removed bodies. They are placed diagonally on the cover (Fig. 100) with only four points of support, thus avoiding the crushing of bees. If a second body is removed, it may be placed out of line on the first in the same manner. If the bees show signs of robbing, combs in removed bodies should be more carefully protected.

Remedies for stings.

Various remedies for stings have been advocated but they are all valueless. The puncture made by the sting is so small that no liquid can enter it after the sting is removed and the opening has closed. As soon as practical, immediately if possible, the sting should be removed, care being taken not to squeeze the attached poison sac. This can be done by scraping the sting out with a knife blade or the finger nail. After this is done the injured spot should not be rubbed and the usual advice of the beekeeper is to "forget it." Bathing with liniment or any other irritation serves only to spread the poison through the tissues. The intense itching soon disappears. As a comfort to the novice, it may be stated that repeated stings usually cause an immunity to the poison to develop, after which no after-swelling occurs. In case of severe stinging, the injured parts may be covered with an ice bag or with cloth wet with ice water.

Removing frames.

After the frames are exposed, the propolis which often fastens them may be loosened by prying gently with a hive-tool and the frames may be crowded somewhat closer together to permit the removal of one of them. It is immaterial which frame is removed first, unless the special object for opening the hive determines it. In cool weather the propolis may be brittle and care should be taken not to jar the hive as this is broken.

During manipulation, a side frame is often removed and leaned against the hive to allow more room for moving the other frames. In leaning a frame against the hive, it should be in a nearly upright position to prevent breakage and leaking of honey. The frame on which the queen is located should not be left outside the hive unless necessary, for she may crawl away and be lost. The frame should be leaned against the hive on the side away from the operator so that he will not be annoyed by bees crawling up his legs. In all the handling of the colony, bees should not be crushed, for this excites the others, and if frames are crowded too closely together the queen may be killed.

Handling frames.

In examining a comb, it should be held so that if any bees fall they will drop into the hive, except when it is necessary to carry away a frame for some purpose. Freshly gathered nectar sometimes drops out if the comb is improperly handled. If this falls into the hive the bees clean it up, whereas outside the hive it may cause robbing and is at least untidy. The beginner should early form the habit of keeping combs in a vertical position. While sometimes it does no harm to tip a frame, it is rarely necessary and may cause honey to leak or the comb to break, especially if the frame is not wired. As a comb is taken from the hive, it should be lifted by the ends of the top-bar, two hands being used. This brings the comb up vertically with one side toward the operator (Fig. 101). To examine the reverse side without tilting the comb, raise one end of the top-bar until it is perpendicular (Fig. 102), turn the frame on the top-bar as an axis until the reverse side is brought into view, and then lower to a horizontal position with the top-bar below (Fig. 103). In actual practice these steps are not taken successively but the turning on the top-bar is simultaneous with the raising and lowering of the end of the frame. This is a good operation for the beginner to practice a few times.

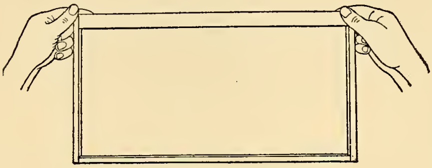


Fig. 101. — Handling a frame, first position.

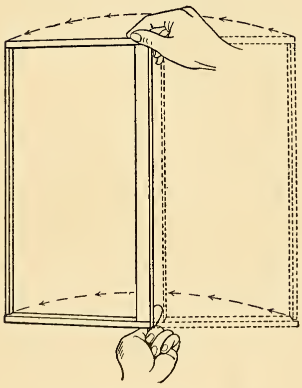


Fig. 102. — Handling a frame, second position.

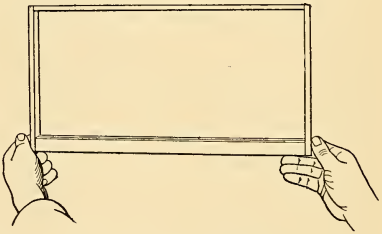


Fig. 103. — Handling a frame, third position.

Desirability of straight combs in manipulation.

The use of comb-foundation in the frames is desirable to insure uniform comb, all of worker cells, except in places where the foundation may sag or become torn. Drone comb is undesirable except in raising drones for queen-rearing. The use of comb-foundation in wired frames insures straight combs and reduces the danger of bees being crushed in removing or in returning frames. A frame-hive with combs built crosswise is more difficult to handle than a box-hive and this should never be permitted. The entrance of the hive should be exactly horizontal so that the combs will hang parallel with the sides of the hive and so that the outer ones are not fastened to the hive-body, if they are properly spaced at the top. The back of the hive should be about one inch higher than the front to allow condensed moisture to escape. A hive leveling device made by Burton N. Gates is shown in the accompanying illustration (Fig. 104) which needs no description. This has been found useful, especially with the tile hive-stands used in the Bureau of Entomology apiary.

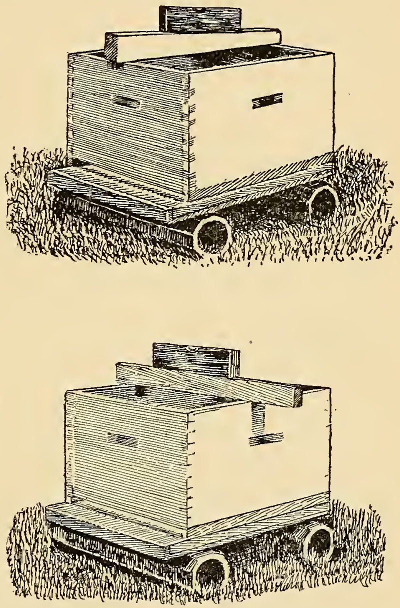


Fig. 104. — Hive leveling device. In the upper figure the wedge-shaped piece is on edge so that when the top is level the hive entrance is one inch lower than the back. In the lower figure the wedge is on its side.

Closing the hive.

In closing a hive, after the frames are replaced and spaced properly, the cover should be put on in such a way as to crush no bees. If necessary the bees may be driven down by the use of smoke, but if bees are on the top edges of the hive, the cover may be slid on from the end or side so that none will be crushed.

OCCASIONAL MANIPULATIONS

In the discussions which follow, manipulations will be described which may be useful at almost any time or at different times in the season but which are not part of the regular work of most apiaries. The plan followed in this book is to give the various manipulations in the order in which they are used during the season. The manipulations discussed under this heading are most frequently useful in the spring.

Feeding.

To stimulate brood-rearing or to provide stores in the spring, in preparing colonies for winter and at other times during a shortage of stores, it may be necessary to feed the bees. Obviously, it is desirable to allow the bees to keep sufficient honey and if this can be done it is always preferable to feeding. No better stimulation to heavy breeding in the spring can be found than adequate protection and an abundance of stores, but a large amount of food is needed at this season and the beekeeper should feed if he finds that he has failed to leave enough. In small hives, the giving of additional stores in the spring is usually desirable, either in the form of combs of honey or as a syrup.

The feeding of sugar syrup to produce comb-honey has of course been tried and some beekeepers have believed that the product is honey. This is not the case and the fraud may readily be detected. Fortunately, even at the lowest prices of granulated sugar, the sections actually cost the beekeeper more than he gets for pure comb-honey and this fact effectually keeps adulterated comb-honey off the market.

What to feed.

Honey from an unknown source should never be fed, because of the danger of introducing disease. Beekeepers usually feel that it is cheaper to feed sugar syrup because of the higher market value of honey, but no food for bees better than honey has yet been found. If extracted-honey is fed, it should be somewhat diluted. The best plan is to give combs of honey.

As a substitute for honey, a syrup made of granulated sugar is best. For spring feeding, a thin syrup may be used, even as dilute as two parts of water to one of sugar (by volume). Ordinarily equal parts of each are used. For supplying winter stores, a thick syrup, $2\frac{1}{4}$ to $2\frac{1}{2}$ parts of sugar to one of water, is preferable. To prevent granulation of the sugar in the thick syrup, it is inverted (changed chemically to levulose and dextrose) by the addition of a teaspoonful of tartaric acid to 20 pounds of sugar while the syrup is being heated to dissolve the sugar crystals. In early spring and late fall, syrup may be fed while warm and fall feeding should be done as rapidly as the bees will take the syrup. In making syrup, the greatest care must be taken not to allow it to be discolored by scorching the sugar; it should be as clear as if made with cold water. Glucose, other cheap syrups or molasses and the cheaper grades of sugar should not be fed to bees, especially for winter stores, since they contain substances indigestible to bees, causing dysentery.

Candy and cube sugar are sometimes used for supplying bees in winter after their stores are exhausted. These should be used only in emergency and nothing but granulated sugar should be used in making candy for this purpose. A soft white sugar, known in the trade as "coffee A," placed in a division board feeder is sometimes used as a stimulant to brood-rearing.

Slow feeding to prevent robbing is sometimes desirable during extracting or other manipulations or while rearing queens. A thin syrup of one part sugar to nine of water is used, being fed in large feeders in the open.

Fig. 105. — Division board (Doolittle) feeder.

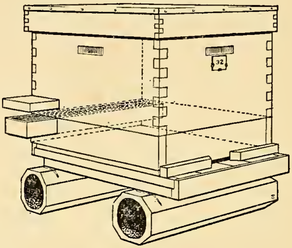


Fig. 106. — Alexander feeder in collar under hive-body.

Feeders.

There are numerous types of feeders, used for different purposes. The division board feeder (Fig. 105) is hung in the hive like a frame. It may be filled without being re-

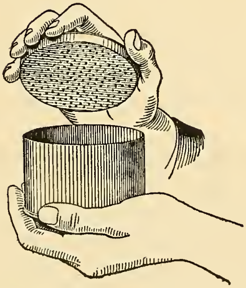


Fig. 107. — "Pepper-box" feeder.

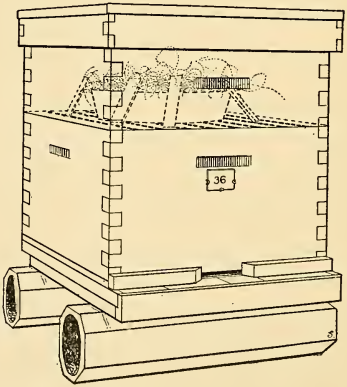


Fig. 108. — Pan in super arranged for feeding.

moved and a float must be used to prevent bees from drowning. The Alexander feeder (Fig. 106) is useful mainly for stimulation. It may be placed under the rear of the brood-chamber if the bottom board is moved forward, but this often causes robbing and a better plan is to place it in a collar under the brood-chamber as shown in the illustration. For feeding small quantities, a "pepper-box feeder" (Fig. 107) may be inverted over the brood frames in an empty hive-body. Mason jars may be used in the same way, special pierced covers being sold by dealers in beekeeping supplies. For rapid feeding in the fall, a large pan in an empty super (Fig. 108) is perhaps best. Green grass should be thrown in the syrup to give support to the bees while feeding, this being better than excelsior or chips as it does not absorb the syrup. The empty super and pan may be placed under the brood-chamber for late feeding, in which case the bees take the syrup more rapidly.

Uniting.

If a colony becomes queenless in late fall, it is usually not profitable to give it a queen, but it may be united with a normal colony to save the bees. It is not wise to try to winter weak colonies, but if two or more are united to make a strong colony, keeping the best queen, the risk in wintering is reduced and better results are obtained in the spring. It is also more profitable to unite weak colonies in the spring than to build them up.

Influence of hive odor.

Every colony of bees has a distinctive odor by which bees recognize individuals from their own colony, normally resenting the entrance to their hive of those from other colonies. In uniting colonies, the different odors may be hidden by smoking both vigorously. Tobacco smoke may be used, but if too much is employed the bees become stupefied. If bees are stupefied by tobacco smoke, chloroform or other anæsthetics, they lose their memory of former locations and may be united and placed wherever desired, but American beekeepers rarely have occasion to use such methods. During a honey-flow, when the field bees are coming in heavily laden with nectar, the field bees of two colonies that are close together may be allowed to enter one hive and they do not molest each other. The queen to be saved should be caged for a day or two to overcome the danger of the strange bees killing her. When brood-rearing is reduced, as in the fall, the colony odor is apparently less influential, for less precaution is necessary in uniting.

Learning the new location.

Field bees return to the location of their hive and they remember the old location and return to it if the hive is moved. If two colonies to be united are not close together, they should be moved gradually nearer, perhaps a foot every day that the bees can fly, until they are side by side. The bees learn each location in succession and after uniting they will not return to the original position and be lost. If it is necessary to move the colonies faster, they may be put into the new place and a pile of brush or weeds or a slanting board placed in front of the entrance so that when the bees fly out they will perceive a change and learn the new location. If it is desired to unite two weak swarms, this may be done simply by placing them together, either in the hive or on the hive entrance. Swarming bees abandon the memory of the old location (p. 180); they are full of honey and may be placed anywhere. The better queen should be saved and the other removed or the bees may separate into clusters. Swarms may be added to newly established colonies if desired.

If queenless colonies are found in early spring which are to be united with normal colonies, the usual practice is to place them on top of the normal colony. Few bees return and there is usually no trouble as such bees seem ready to go to any colony.

Transferring.

In increasing the apiary, it is sometimes profitable to buy colonies in box-hives because of their small cost. They should, of course, be transferred to movable-frame hives as speedily as possible, for bees in box-hives are of small value as producers, because of the impossibility of manipulating the combs. The advice is often given to beginners to buy colonies in box-hives and transfer them, but this advice is questionable. There is no more trying work connected with beekeeping, unless possibly it is the moving of a large apiary, and if a beginner can successfully transfer a colony from a box-hive he has proved his right to become a beekeeper.

The best time to transfer colonies, if there is opportunity for choice, is the spring (during fruit bloom in the North) when the amount of honey and the population of the colony are at a minimum. However, the work can be done at any time during the active season, but there should be nectar coming to the hives so that while combs are exposed robbing will not be induced. If necessary, transferring may be done in a tent or cage of netting or wire cloth to keep robbers away, but the odor of honey may cause excitement in the apiary. If the field bees are out of the hive, the work is lessened.

Methods.

There are several methods of transferring and one may be chosen according to the plans and wishes of the beekeeper.

Plan 1. — The box-hive is set a few feet to one side and in its place is put a hive with movable frames, containing full sheets of foundation or drawn combs. As the field bees return, they go at once to the new hive. The box-hive is turned upside down and a small box is inverted over it. The box-hive is now pounded continuously (the operation being known as drumming or driving) in such a manner as to transmit the jar to the combs and the bees desert their combs for the upper box. They cluster in this box like a natural swarm and they may then be thrown in the new hive. If possible, the queen should be seen so that the operator may be sure that she is off the old combs. It is necessary that she be obtained, unless one desires to requeen at this time, in which event the old queen should be captured and the new one may be run in with the bees and will be promptly accepted. The box-hive containing the brood is now placed right side up in a new location. In 21 days all of the worker brood will have emerged and possibly some new queens will be reared. These bees may be driven out and united with their former hive-mates by allowing them to run in the entrance. They should, however, be compelled to go through perforated zinc or a queen and drone trap (Fig. 30) to keep out the young queens. The old combs may now be melted after removing the honey. By this method straight combs are obtained. If nectar is not being collected, the newly established colony should be fed.

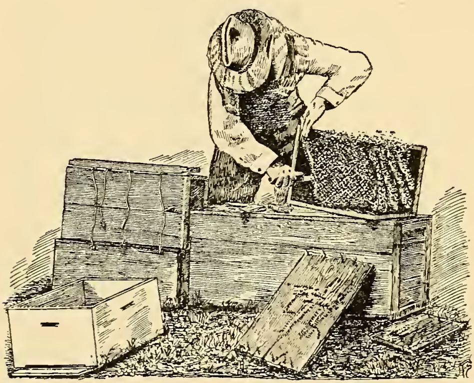


Fig. 109. — Cutting combs from a box-hive.

Plan 2. — Wait until a swarm issues from the box-hive and then move the old hive to a new location. The swarm is then placed in a new hive on the old stand and it is further increased by returning field bees. After 21 days the bees which have emerged are united with the bees in the new hive, as described under Plan 1.

Plan 3. — If the beekeeper desires to save the combs in the box-hive, the bees may be drummed into a box, after which the brood combs and any other good combs are cut out (Fig. 109) and fitted into frames, being fastened with string, rubber bands or strips of wood until the bees have an opportunity to repair them. These frames are hung in a hive on the old stand and the bees are then allowed to run in. The cutting of combs, especially those containing brood and honey, is a disagreeable job and, since combs from a box-hive are usually of little value, this method is not recommended.

Plan 4. — Another method which is in some respects better than those just given is to place the box-hive with its largest surface uppermost. If the bottom is now open, it is closed except for an entrance and a piece is removed from the upper side of the box-hive. The hive in which the colony is to be located is now put over the large opening and all cracks and openings around it are closed. The upper hive is filled with drawn combs or, if these are not available, with sheets of foundation. When the queen needs more room for egg-laying, she will go to the upper hive and, after she is located there, a queen excluder is put between the box-hive and the new hive to prevent her return. As the brood emerges below, the colony becomes established above. If there is difficulty in getting the queen to go to the new hive, the box-hive may be drummed. After the brood in the old combs has all emerged, the bees may be drummed from the box-hive and it may be treated as desired.

Transferring from walls of houses.

Swarms often locate in the walls of houses and it is sometimes necessary to remove them to prevent damage from melting combs. If the cavity in which the combs are built is accessible, the method is the same as in transferring under the third plan, except that drumming is impractical and the combs must be cut out with the bees still adhering to them. A liberal use of smoke will subdue them. If it is impossible to open the cavity without doing considerable damage to the building, a bee-escape (Fig. 19) may be put over the entrance so that the bees can leave but cannot return, any other openings to the combs being carefully closed. Even better than a bee-escape is a cone of wire-cloth eight inches high with a hole at the apex just large enough for a single bee to pass. This is tacked on the house and the bees issue through the hole in the apex but do not find it again to return. A hive (with drawn combs in it if possible) is then placed so that its entrance is as near as practical to the entrance which the bees have been using. A queen should soon be introduced to the bees in the hive. The old queen does not desert her combs and continues laying eggs, but, as her colony is depopulated, the amount of brood rapidly diminishes. As brood emerges, the young bees also leave through the wire-cloth cone and join the bees in the hive until in four or five weeks the queen is left practically alone. When nearly all of the bees are out of the cavity and there is little or no brood, the bee-escape is removed, the entrance to the cavity is made larger if possible and if there is no honey-flow, the bees rob their old home and carry the honey to their new hive, leaving only the empty combs. These will usually do no damage as wax-moths soon destroy them. The entrance to the cavity should now be carefully closed to prevent another swarm from taking up quarters there and the hive is removed. This method takes considerable time, but is often best where the cavity is inaccessible. It is often difficult to close the cavity to prevent the bees from establishing a new entrance when a bee-escape is placed over the one to which they are accustomed.

Transferring from hollow trees.

The method to be used will depend on the accessibility of the cavity and the value of the tree. Usually the bees cannot be drummed out and the combs must be cut out after subduing the bees with smoke. If the colony is high in the tree and the tree is felled, the bees are disorganized by the jarring so that they can be handled easily. The hunting of colonies in the woods is interesting and the cutting of a bee tree is an experience which everyone interested in bees should have, but the time consumed is considerably more than the value of the bees and honey justify. It does not pay to build up the apiary in this way if the beekeeper's time is valuable.

Preventing robbing in the apiary.

At any time during warm weather, bees are inclined to rob other colonies, if there is no honey-flow. Every precaution should be taken to prevent this. Feeding often attracts other bees and, if there are indications of robbing, it should be deferred until late in the day. Honey left where bees can get it or combs left out of the hives during manipulations may at times lead to serious robbing.

As soon as robbers are noticed, manipulation should be discontinued and the hives should be closed. If serious robbing occurs, the entrances should be contracted and the hive fronts wiped with a cloth moistened with kerosene or carbolic acid. If brush is thrown at the entrances, robbers are less likely to enter. Outdoor feeding to prevent robbing is described in a previous section (p. 242).

A wire-cloth cage, five feet square and six feet high, may be used if manipulations are necessary during a time when robbing is probable. This cage should not be closed at the top and bees which fly from the colony under manipulation escape, while robbers will rarely enter. A folding tent or cage made of mosquito netting may also be used. A smaller wire cage closed at the top may be set over a colony that is being robbed.

If the cause of robbing is suddenly removed, this may produce more excitement than if the robber bees were allowed to complete their work. For example, if a colony is being robbed and is suddenly removed to save it, the robbers turn their attention to other colonies, or if a piece of exposed comb has attracted robbers, its removal may divert them to more serious devastation.

The beginner in beekeeping may mistake the play flights of young bees for robbing, but after the latter has once been observed this error will not be repeated. Bees appear old soon after they begin robbing; they are dark and thin, their actions are nervous, and the hairs on the body are lost, probably by being torn off by defending bees and by squeezing through narrow openings.

When a colony is abnormal, as in queenlessness or disease, it may be robbed of its stores slowly, without any excitement, usually by the bees of a single colony.

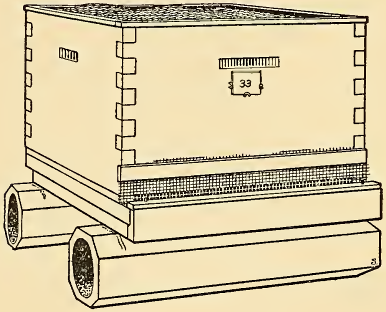


Fig. 110. — Hive ready for moving. In this case the bottom board is left on.

Moving bees.

In migratory beekeeping, in bringing purchased bees to the apiary and under various other circumstances the beekeeper will find it necessary to move bees. The frames must be fastened firmly in place. If self-spacing frames are used, especially if there is considerable propolis on them, no precautions need be taken to prevent the swinging of the frames, but it is often desirable to nail a $\frac{3}{8}$-inch strip over the tops of the frames so that they cannot fall out of place if the hive is tipped. Abundant ventilation should be given, the amount depending on the temperature. In cold weather, the entrances may simply be closed with a block and the cover fastened securely, but in extremely hot weather it is desirable to remove the cover or both the cover and the bottom board and nail on wire-cloth (Fig. 110). A 2-inch collar may be fastened to the top of the hive-body and wire-cloth put above this, to give clustering space for the bees. Colonies rarely suffer from exposure during moving so that the beekeeper should not err by giving inadequate ventilation. In transporting colonies on a wagon, the length of the frames should be across the wagon bed, while on a train they should be parallel with the length of the car.

It is customary to ship colonies in hives with combs, but recently the shipping of bees in wire-cloth cages without combs has been practiced. This has much to commend it, especially in reducing the danger of introducing bee diseases into new locations. The cages contain numerous slats on which the bees hang, and they are provided with food for the bees en route. The bees are put into the cage by means of a funnel, either with or without a queen. Bees are now regularly sold by the pound in such packages and shipped to all parts of the United States. It is probable that as this method is perfected it will be used in migratory beekeeping, thus avoiding danger of carrying disease to the home apiary and reducing the transportation charges.

ELIMINATION OF NON-ESSENTIAL MANIPULATIONS

While it is necessary in any discussion of beekeeping which aims at completeness to describe the various manipulations which may be needed during the course of the year, the beekeeper should early in his experience establish a system for the care of his bees so that unessential movements and manipulations may be avoided. If bees are kept solely for pleasure, it matters little whether they are disturbed in their work, and the time of the beekeeper need not be considered an important consideration, but when bees are kept for profit, these factors become vital. Every manipulation which does not benefit the beekeeper by increasing his profit should be ruthlessly eliminated, and every time a colony is opened it should be for some definite purpose.

Two essentials.

There are two factors necessary to the production of the maximum honey-crop over which the beekeeper has no control. He cannot govern the weather or produce honey-plants with profit. There are on the other hand two other factors with which his work must deal. His efforts should be for the purpose (1) of getting plenty of bees of the right age in time for the harvest and (2) of keeping these bees in proper condition for gathering the maximum crop. The first essential is far-reaching and obviously includes the entire care of the colonies to prevent starvation or loss from other causes. It applies especially to the work in the spring. The second essential applies chiefly to the control of swarming. It is well for the beekeeper to keep these two essentials always before him and to ask himself, when he plans any work with the bees, whether it comes under one of these heads.

The beekeeper may profitably go one step further in the analysis. For example, stimulative feeding in the spring is mentioned earlier in this chapter. He should first of all determine whether stimulative feeding is more profitable than the giving of abundant stores. If he finds that he gets more bees by stimulative feeding, he should then determine whether he gets enough more to justify the expenditure of time and money, or whether he can get a larger total crop by keeping a few more colonies, combined with the giving of abundant stores. An example taken from life may not be amiss, the names being here omitted. Two beekeepers are located in exceptional situations which may be assumed to be equally good. One of these men is skilled in the improvement of his stock and has made significant progress, but the work occupies considerable time. The other beekeeper feels that he has not the time for this (and he may not have the skill), but he keeps 100 colonies more than his co-worker. In the case just given the beekeeper with the larger number of colonies makes more money, but this illustration is by no means given to discourage breeding work. It shows, however, that for that particular region the greater profits come with extensive beekeeping, while in other regions more intensive work might yield better financial returns.

Both men have the same object in view — to produce workers on time for the harvest. Both are successful while all about them are beekeepers with indifferent or poor success, attributed probably to bad luck.

Increase in efficiency through system.

Not only must these essentials be emphasized, but the necessary manipulations must be systematized. After some effort in this respect, the beekeeper is usually astonished at what may be accomplished. This may be illustrated by another case. This beekeeper began work with bees on a business basis after keeping a few colonies for pleasure for several years. At the beginning of his experience he taught school, thus having his Saturdays for the bees as well as the summer vacation. At first the vacation was six months, but later the school year was increased, giving him only three months. By systematizing his work, he was able to do as much as formerly and gradually increased his colonies to 250 in three apiaries, all run for comb-honey. He then gave up teaching and accepted a position which kept him away from his bees except during thirty days' vacation in the summer. At first he was frequently near his bees so that if any work was necessary he could arrange to have it done by others. Finally he accepted another position which took him entirely away from his old home and he now goes back just before the honey-flows and leaves as soon as they are over. He still produces comb-honey and is still successful. He has probably almost reached the maximum number of colonies that he can run for comb-honey in so short a time. It is obvious that many manipulations usually considered necessary must be eliminated in these apiaries. By leaving plenty of stores and by giving the bees abundant protection many of these are rendered unnecessary. This case is not by any means recorded as ideal, but it illustrates what the elimination of superfluous manipulations may accomplish.

Anyone can produce honey in a time of plenty, but only the good beekeeper gets an adequate return in less abundant seasons. The ideals toward which the beekeeper should work are: (1) to handle the bees as little as possible; (2) to manipulate them only when he has some definite object in view; (3) to follow a definite system, not based on rules but on a knowledge of bees, capable of modification as occasion may arise, but working for one end — maximum honey-production.

CHAPTER XIV

SPRING MANAGEMENT

In attempting to give the work of the apiary in chronological order, it is difficult to decide where to begin. To a large degree, success depends on the results obtained in wintering, so that preparation for winter might be considered the first step in the annual cycle, and practical beekeepers usually so consider it. However, winter is a period during which the beekeeper has little work with his bees, and it is perhaps better to begin the cycle with the first evidences of activity outside the hive. As has been shown, bees do not hibernate, and consequently their early flights are not evidences of an awakening after a period of inactivity. With their first return to the open air in the spring, the beekeeper knows that the active season with his bees has arrived.

As will be shown in the chapter on wintering (see also p. 91), bees are often compelled to retain their feces for long periods in winter. This, together with the excessive generation of heat, may deplete the colony, causing conditions known as spring dwindling and dysentery, one or both of which may be present.

It will also be shown later that it is not desirable to manipulate bees in winter. Brood-rearing may begin during the severe weather of January or February in the North in colonies wintered out of doors, but this can scarcely be considered as an activity of spring.

With the opening of the earliest spring flowers and the accompanying rise in temperature, the bees venture forth to get the small amounts of nectar and pollen thus provided.

As the weather becomes warmer the supplies rapidly increase and the bees are greatly stimulated to build up the colony. The old bees that emerged the previous autumn have been called upon, under ordinary winter conditions, to expend considerable energy, and their ability to do the collecting and the inside work in the spring is in general in inverse ratio to the expenditure of energy in the winter. Brood-rearing, however, begins before or as soon as new supplies come to the hive, provided, of course, that the colony is normal, and as the first bees emerge they in turn increase the capacity of the colony for brood-rearing, so that with a good queen and other favorable conditions the brood is rapidly increased.

Object of spring manipulations.

The main object of the work in the spring is to insure an abundance of bees in time for the harvest. In the more northern localities, summer comes on with a rush and often the principal nectar-secreting plants are in bloom so soon after cold weather that the colony is frequently not in condition to obtain the maximum crop, or there may be a period in the spring when, from lack of nectar, the bees are not stimulated to the maximum breeding. If left to themselves and if honey is already present in the hive, bees will naturally rear brood and thereby rapidly increase the size of the colony, and the work of the beekeeper is to provide the most favorable conditions for the manifestation of this instinct.

Prevention of drifting.

Colonies which are wintered in the cellar need not be put in the same locations that they occupied the previous year, when they are removed. In setting them out, some care is necessary to prevent mixing. If they can fly as soon as they are set out, they may rush forth and then be unable again to locate the proper hive, in which case they often "drift," that is, bees enter the wrong colonies with the result that some colonies will be increased in size at the expense of others. If bees can be set out at night or on a cloudy or chilly day, this is generally avoided. The entrances may also be reduced or, if necessary, may be closed with wet cloths.

Spring protection.

If the colonies have been wintered in the cellar, breeding will normally not begin so soon as in colonies that were left outside. When the hives are carried to their summer stands, the bees are subjected to sudden changes in temperature and to low temperatures and, unless the wintering has been exceptionally good, they may be able to withstand adverse conditions less well than colonies that were wintered in the open. It is therefore preferable to provide packing for these colonies, even if it is only a wrapping of waterproof paper over the hive. After colonies are removed, the bees need a cleansing flight to rid themselves of the accumulated feces and they should be put out at a time when this will probably soon be possible.

First examinations.

During early breeding, the beekeeper ought to have no occasion to open a hive, but, if he finds that certain colonies are not up to standard, he may choose a warm day to open them to do whatever conditions may demand. After a winter away from the bees, the beekeeper is usually anxious to look at them. On a fine warm day when the bees are flying freely, he should make his first general examination of the apiary but, if he has previously supplied the colonies with abundant stores and has them protected from changes of temperature, he may well put off a general examination of the apiary. If he desires to learn whether the bees have sufficient stores he can determine this by lifting the hive, or the size of the cluster may be determined, without breaking the propolis which seals the cover, by looking at the combs from below.

On the first examination, the beekeeper should look especially for queenless colonies. If any are found, it is best to unite these with normal colonies, although queens may now be obtained early from southern breeders. He should also examine the stores, for bees require large amounts of food during the spring and, while they usually get considerable nectar, it rarely is enough to provide stores for excessive breeding. If food is needed, it may be given rapidly in the form of a thick sugar syrup, or it is even better to give combs of honey. If hives are soiled with the spottings of dysentery or if there are dead bees present, the hives may be cleaned out somewhat, but the first examination should be brief, unless the weather is exceptionally warm.

Spring dwindling.

The old bees die rapidly and are replaced by young bees, which, in a good colony, emerge more rapidly than the old ones disappear. If, on the contrary, mortality among the old bees exceeds the rate of emergence, the condition arises which is known as spring dwindling. Obviously, prevention is better than treatment, but by giving extra protection and by making the collection of stores unnecessary by feeding, the energy of the old bees may be conserved so that it is utilized chiefly in rearing brood and the colony may often be saved. The brood-chamber may also be reduced to conserve the heat of the cluster.

Need of water.

Bees need water for brood-rearing and it sometimes happens in the spring that bees are lost in trying to obtain it. If there is no water close at hand, it is often advantageous to provide a watering place in a warm sheltered spot in or near the apiary.

Uniting.

If exceptionally weak colonies are found, it is economy not to attempt to build them up, but to unite them. In uniting colonies in the spring, two weak colonies should not be placed together, but a weak colony should be placed with a strong one. If desired, the number can be restored by subsequent division. This is one of the most important points in spring management.

Cleaning the hives.

When the weather becomes settled, it is desirable, especially where comb-honey is produced, to subject the hive to a spring house-cleaning. If the bottom board is cleaned of débris and the propolis is scraped from the frames and rabbets, it will not only facilitate future manipulations but, when the sections are put on, there will be less propolis available to discolor them. Beekeepers, however, are not so devoted to a spring house-cleaning as are housewives. While Caucasian bees were kept in the apiary of the Bureau of Entomology the removal of propolis in the spring was practically a necessity. This may be done quickly in the spring, while the propolis is brittle. Dr. Miller uses a hoe to remove propolis and burr combs from the top-bars of the brood frames.

Equalizing the colonies.

Not all colonies increase in population equally fast, even with the best of management. The differences may be due to a variety of causes. If some colonies have more stores than they need, thereby reducing the space available for brood-rearing, combs of honey may be removed and given to colonies that need more stores, returning to the rich colonies empty combs removed from those to which honey is given. Similarly, if some hives contain more brood than the average, colonies may be equalized by taking combs of emerging brood with the adhering workers away from those abundantly supplied, giving them to weaker colonies, care being exercised not to transfer the queen. The weakest colonies in the apiary should be assisted in this way only after all the others are equalized; then they are given any frames of brood still available, and are thus built up as rapidly as possible. Another method of equalizing is to shake bees from the frames of a strong colony in front of the entrances of those to be helped. The young bees go in and are accepted, while the field bees return to their original hive. The queen must, of course, not be shaken in this way. The advantages of having colonies develop at about the same rate and of reaching the honey-flow equally strong in bees, are as follows: (1) the colonies are ready for a given manipulation at the same time, thus allowing the work to be well systematized; (2) less hive-bodies are needed than if strong colonies are given supers in accordance with their individual needs; (3) when properly done, equalizing probably results in an actual increase in the total number of bees in the apiary, since every queen is more nearly capable of egg-laying to her full capacity and no queen is restricted by having only a small number of workers to feed her brood; (4) less manipulation is necessary when the honey-flow begins (especially in comb-honey production) in sorting combs of brood and in reducing the brood to one hive-body, if this is practiced; (5) the brood is compact and this is especially desirable in comb-honey production.

The work of equalizing colonies is considerable and the beekeeper must determine for himself whether it is profitable. In the management of out-apiaries, this work necessitates extra trips which come at a time when the average beekeeper has all the work that he can do. Making colonies all in one mold often fails to bring to light the deficiencies of some queens and the superior qualities of others for breeding stock. If a brood disease is present or is even known to be present in the neighborhood, there is danger in moving combs about so freely.

Clipping queens.

The clipping of the wings of queens is advantageous in the control of swarms, as will be shown later, and to find queens in the spring is easier than later. In clipping the queen, she is lifted from the comb, held securely but gently between the thumb and index finger of the left hand and a wing is cut off with fine scissors. The queen may be held with her wing against wood, when it may be cut with a sharp penknife, but scissors are safer, at least for the beginner. Some beekeepers clip the queen's wing when she is introduced, in case queens are mated from nuclei, but some colonies may rear queens without the knowledge of the owner and an examination for unclipped queens in the spring will greatly reduce swarms which issue with queens capable of flight. Some beekeepers, so that they can tell a queen's age, clip opposite wings on alternate years or make a distinctive cut each year. It may perhaps be well to warn the beginner against clipping the wings of an unmated queen. If egg-laying is progressing regularly the queen is of course mated.

Summary of favorable spring conditions.

The conditions favorable to the rapid increase in the size of the colony in the spring may be restated as follows: (1) a large number of vigorous workers, due to successful wintering, (2) a prolific queen, (3) abundant stores properly located in the hive so as to be easily accessible to the bees, (4) favorable weather conditions, (5) fresh pollen and nectar and water for the bees, (6) a prolific race or strain of bees, (7) good brood combs of worker cells in quantity sufficient for the needs of the colony.

QUESTIONABLE MANIPULATIONS

The manipulations previously discussed in this chapter are not all practiced by all beekeepers but they are not the subject of controversy. On the other hand, there are two spring manipulations that have been the subject of much discussion by beekeepers and they are still in dispute. These are spring stimulative feeding and the spreading of the brood.

Stimulative feeding.

So long as nectar is coming to the hive in abundance, the colony is stimulated to the maximum brood-rearing possible in proportion to the population. Frequently, however, there are periods when from a lack of nectar-secretion or inclement weather, no fresh supply of food is obtained. It is asserted by some that the feeding of a thin sugar syrup at this time in small quantities acts just as a natural honey-flow, stimulating the bees to greater activity in brood-rearing and resulting in the maximum strength of colony at the time of the honey-flow. Since feeding requires some manipulation of the colony which is not beneficial in inclement weather, many beekeepers believe that by providing an abundance of food in the fall or by giving stores rapidly in the spring the colony receives all the stimulus to brood-rearing that it should have and that stimulative feeding is not desirable. This is obviously a question especially for the northern beekeeper. If a colony is short of stores, combs of honey may be given it. If a colony has wintered well, has a good queen, is in a large hive abundantly supplied with stores and is well protected from changes in temperature, it is doubtful whether it can be stimulated to much greater brood-rearing than these conditions will bring about. Even if stimulative feeding results in increased brood-rearing, as it may under some circumstances, the beekeeper may still find it to be an unprofitable practice. If he is managing several apiaries, the work of going to all of them daily, or even less frequently, is considerable, and he may find it more profitable simply to operate more colonies to make up for the difference. If stimulative feeding is practiced, it is usually best to feed warm syrup in the evenings so that the bees will not fly as a result of the feeding and so that robbing will not be started.

Spreading the brood.

Spreading the brood is an even more debated question. If the brood-cluster is divided and an empty comb is inserted, the bees will attempt to cover all the brood and, in so doing, that part of the empty comb which intervenes will be kept warm enough so that the queen will lay eggs therein. When this new brood is well started, the manipulation may be repeated and still more eggs will be laid. This is attractive in theory but in practice is attended with danger. The bees may not attempt to cover both portions of the divided brood, resulting in loss, or, because of exceptionally cold weather, they may contract the cluster and leave the outside brood to die. The beginner should by all means leave the amount of brood to be determined by the bees, confining his work to the supplying of protection, stores and room for the expansion of the brood.

If the giving of abundant protection, stores and room for the maximum advantageous expansion of the brood will cause the colony, from its own instinct, to reach its maximum strength in time for the storage of the crop, then additional manipulations in stimulative feeding and in spreading of the brood, even though they may do no harm, are non-essential. They are, therefore, to be condemned for the commercial apiary. If the favorable conditions enumerated do not bring the necessary strength of colony and if stimulative feeding will, then these manipulations are justifiable. If the period for brood-rearing previous to the beginning of the honey-flow is short, rapid brood-rearing becomes more important. This is usually the case in northern localities. It is safe to say, however, that stimulative feeding and spreading of the brood should not be practiced early in the spring but should be confined to a period of six or eight weeks just previous to the particular honey-flow for which the beekeeper is building up his colonies. If the main crop is in late summer, the beekeeper need not force his bees in the spring. In some localities, the season is made up of a series of honey-flows of about equal importance. If there are long intervals between honey-flows, the beekeeper must see that brood-rearing is at its best during a period of six or eight weeks before each flow.

Substitutes for pollen.

Beekeepers have repeatedly noticed that during a shortage in the supply of pollen, bees will pack meal or sawdust on their legs, just as they do pollen, and will carry it to the hive. There are also reports of coal dust being carried in this way. After observing bees carry in rye flour from a neighboring mill, Dzierzon put some in the apiary where the bees could get it readily and they carried it in eagerly. It is still held by many beekeepers that bees should be given rye flour or pea, oat or corn meal in the spring, these being considered more suitable foods than wheat flour. These substitutes are chemically not very similar to pollen, and observations as to the effects of them on the development of the brood are badly needed. In fact, it can scarcely be said that we know that the giving of substitutes for pollen is serviceable in brood-rearing, and one cannot but wonder what Dzierzon's advice would have been if his apiary had been near a coal mine. Because of the unusual things that bees do, we are not justified in concluding that the giving of substitutes for pollen is useless, however, and no harmful results are recorded from the practice. It is a promising field for study, for there is sometimes a scarcity of pollen just when it is most needed.

CHAPTER XV

SWARM CONTROL AND INCREASE

At the close of the chapter on the manipulation of bees, it is pointed out that success in honey-production depends (1) on getting bees in time for the harvest and (2) on keeping them in the proper condition for storing. The first requirement is discussed in the chapter immediately preceding. However, if a colony of bees builds up rapidly to full strength, the beekeeper is confronted by the problem of preventing it from dividing its forces, thereby causing him to fail in getting the maximum crop, or even to get no surplus from it. This second problem is mainly involved in swarm control, but also includes the providing of other conditions favorable for storing.

Loss from division of the working force.

In the days of the box-hive, success in beekeeping was measured by the number of swarms that issued, but the beekeeper now knows that he cannot increase the number of his colonies during a honey-flow without curtailing his crop, unless the increase is made from brood that would emerge too late for the resulting bees to assist in gathering nectar. Success in manipulation is now measured by the results the beekeeper attains in preventing swarming. If swarms issue, as they will at times in spite of every known precaution, the beekeeper then aims to use the bees so as still to keep them together and thus to overcome the danger of a reduced crop. Because the experienced beekeeper so well knows that swarming endangers his crop and also that swarms may be lost, the usual statements concerning the beauty of a swarm fail to meet a ready response from him. To him, swarming is the one great handicap in beekeeping.

The necessity of keeping the bees together cannot be overestimated. If a colony is divided just before or during the honey-flow, the two parts fail to produce as much surplus honey in that honey-flow as the same bees would if they had remained in one colony and in normal condition. Furthermore, when bees are preparing to swarm, their condition is not so favorable for gathering. Whether there is some physiological difference or whether the lack of concentrated effort in gathering is due to an unbalanced condition of the colony population is not known, but the results of the swarming preparations are shown in a decrease in the crop. In successful honey-production, it therefore becomes essential that every effort be made to reduce and to overcome the tendency to swarm.

Variation in swarming.

It is interesting to note that, in any region, swarming usually occurs at a certain season or seasons and rarely occurs throughout the entire active season. It is most common in those sections of the North in which the main honey-flow occurs in early summer. If there are two heavy honey-flows, swarming may occur in connection with each one, although it is usually less troublesome in the later one. The crowded condition of the hive in the production of comb-honey is favorable for the development of the swarming tendency and, since the early summer flows of the North are the best for comb-honey, the control of swarming is most difficult in northern comb-honey apiaries.

That many comb-honey producers crowd their colonies more than is necessary or desirable will be shown in a later chapter, but, even with the most skillful manipulation of the supers and with the proper manipulations throughout, there is always more crowding than is necessary in extracted-honey production. Swarm control is therefore chiefly a problem for the northern comb-honey producer, and from these men we have obtained the best systems for controlling swarming and also the most light on its cause.

In the South, where the honey-flows are longer and less intense, swarming is less frequent, and this is also true in the irrigated regions of the West. In those regions of the tropics where the honey-flows are practically continuous, there may be a kind of swarming season, but swarms are so much less frequent that the northern beekeeper would not consider the control of swarming a serious problem in such a locality.

Variation in colonies in respect to swarming preparations.

In any apiary and in almost any season, colonies differ greatly in their propensity to swarm. (1) There are some which show no indication of swarming. These are the very best for honey-production and the beekeeper should aim to increase their number. (2) Other colonies show a tendency to swarm by starting queen cells, but may be deterred either by cutting out the newly started queen cells or by taking away some combs of brood. (3) Still other colonies are more persistent and will swarm if the honey-flow continues unless they are subjected to some radical manipulations. (4) Some colonies whose queens fail swarm in connection with the supersedure of the old queen.

"Of 160 colonies run for comb honey that were fair subjects for comparison, 13¾ per cent went through the season without ever offering to start queen-cells; 12½ per cent started cells one or more times, but gave it up when their cells were destroyed; and 73¾ per cent seemed so bent on swarming that they were treated by being kept queenless 10 or 15 days. The colonies that were left with their queens all the time averaged 36½ per cent more sections than those that were treated. But that's better than they would have done if left queenless for 21 days, which would be the case practically if swarms were shaken." — C. C. Miller, 1905, "Gleanings in Bee Culture," XXXIII, p. 1174.

Direction of the beekeeper's efforts.

The work of the beekeeper in swarm control may be divided into two phases, for his manipulation of a colony depends on his recognition of the degree of persistence in swarming which a colony exhibits. He may try to increase the number of colonies which make no preparations to swarm and may prevent swarming in the colonies which respond to simple measures. To these manipulations may be given the name preventive measures.

However, the beekeeper finds some colonies which he knows from experience cannot be kept from swarming by cutting out queen cells, by the removal of a frame or two of brood or by other simple expedients. To describe the difference which the beekeeper recognizes is somewhat difficult, but, in general, if the larvæ in the queen cells are still small, preventive measures may be used. In cases of the building of queen cells obviously due to supersedure or when the working force is relatively not so strong as the brood, an artificial swarm should not be made. To the more drastic measures, used on colonies with advanced larvæ in the queen cells which will persist in their preparations to swarm, the name remedial measures [1] is proposed.

PREVENTIVE MEASURES

These may be grouped under the three heads given below. Whatever the system of management, the earliest manipulations in swarm control will usually be preventive measures, for the beekeeper cannot know very far in advance which colonies will fail to respond to the less drastic manipulations and in any event these will deter swarming in the larger number of colonies.

[1] In Demuth's bulletin on "Comb Honey," he uses the term "control measures," but the words "preventive" and "control" are not mutually exclusive.

Breeding.

Some beekeepers make a practice of requeening colonies which swarm with young queens which are the progeny of queens whose colonies have not swarmed, in an effort to eliminate swarming by selection of non-swarming stock. In a sense, this work has failed, for after years of such selection the bees still swarm under favorable conditions, but the testimony of many practical beekeepers indicates that the percentage of colonies that swarm under proper management is reduced by selection of non-swarming stock. Since the men who are making this selection are, at the same time, improving the manipulations in swarm control and are becoming more skilled in this work, it is somewhat difficult to measure the value of this effort. Since requeening from good stock is a highly commendable practice for other reasons, it seems advisable to choose breeders from those which have not swarmed, wherever possible. If breeding queens are chosen from the colonies which show the best results in honey crops, these queens will usually be from colonies that have not swarmed during the season.

Mechanical devices.

Efforts have been made to devise a hive which will give to the bees an environment in which the swarming tendency will usually not be developed, a well-known example of which is the Aspinwall hive, with slatted frames between the combs. Similar slats between the frames of ordinary hives have been used. Since a non-swarming hive is needed especially in the production of comb-honey, it would appear that there should be provision for more crowding of the bees than is given in the Aspinwall hive, but it is perhaps too early to pass judgment on the efforts in this line. A deep (two inch) bottom board with a large entrance (Miller, "Fifty Years among the Bees") leaves space under the frames in which may be placed a slatted rack during the active season. This provides abundant ventilation and room for bees and may act as a preventive of swarming, although it is not so claimed by Doctor Miller. The use of large hives in the production of extracted-honey, which so successfully reduces swarming, may be considered as the giving of an environment unsuitable for the development of the swarming tendency rather than the control of swarming by manipulation.

Preventive manipulations.

The most common methods of preventing swarming are by manipulation, probably because success, if attained, is immediately recognizable. Greater progress has been made in the devising of manipulations for this purpose than is shown in breeding or in the invention of mechanical devices. The manipulations used by the beekeeper in swarm prevention fall into the following classes: (1) the introduction of young queens (preferably from superior stock, possibly the progeny of queens whose colonies have not swarmed); (2) the prevention of crowding in the brood-chamber previous to the honey-flow, the crowding incident to comb-honey production being brought about only after supers are put on. This is often accomplished by giving an extra hive-body for early brood-rearing, so that there is abundant room for brood and stores; (3) the use of bait sections or extracting combs (Fig. 133) in the first super in comb-honey production, thus inducing the bees to begin work in the supers promptly to avoid excessive and unnecessary crowding in the brood-chamber; (4) the proper manipulation of supers in comb-honey production (p. 314) to reduce crowding as far as possible (possibly also to remove young bees from the brood-chamber); (5) the use of only good worker comb in the brood-chamber, to reduce the number of cells unavailable for worker eggs; (6) ventilation (by raising the hive on blocks, or by large entrances); (7) shade, to prevent overheating; (8) the removal of combs of brood which are replaced by empty combs or sheets of foundation to relieve the congestion (see also this manipulation under remedial measures); (9) the removal of queen cells soon after they are started, since if queen cells are well advanced, their removal is not so effective in preventing swarming. This usually requires an examination of the brood-chamber once in seven to ten days.

Miller's methods.

To make these manipulations clear, it may be well to recapitulate by describing the system used by C. C. Miller. To provide abundant bees in time for the harvest, as well as to eliminate any tendency to early swarming, strong colonies are given an extra hive-body, during the rapid spring breeding, all the combs being built to the bottom bar of the frame so far as practical. Colonies are requeened whenever a queen shows signs of inability to keep up the full strength of colony, these queens being from mothers whose colonies have not swarmed. When the honey-flow begins, a single hive-body for each colony is filled with full combs of brood (any additional combs of brood being used in other less populous colonies, for increase or for other purposes) and each colony is given a super containing one or more bait sections, into which the bees go at once, if the honey-flow permits.[1] Doctor Miller is a master in the manipulation of supers and the system used by him is described in a later chapter (p. 314). His hives have wide entrances (2 inches deep) and are protected by trees from the heat of the sun. Frequent examinations are made to remove newly started queen cells. The crops which Doctor Miller obtains are so much greater than those of other beekeepers similarly situated, or even than those in better locations, that his methods should be carefully studied. He uses the 8-frame Langstroth hive, but does not especially recommend it. It should also be added that Doctor Miller is a firm advocate

[1] Doctor Miller once asked the author, in all seriousness, what beekeepers mean by their reported difficulty in getting bees to work in the supers promptly. Probably his bees are so much better prepared to gather a surplus than are those of many beekeepers that in his own apiary he has not seen for years conditions which occur yearly in the apiaries of many beekeepers.

of the improvement of stock by selection and he attributes much of his success to his efforts in this line.

REMEDIAL MEASURES

The preventive measures previously mentioned are usually sufficient to control swarming in a colony used in extracted-honey production but, in the crowded conditions of the comb-honey hive, in a good season, there will probably be some colonies that will persist in their preparations to swarm. In a poor season, when the colony lacks the stimulus of nectar coming to the hive, it has not the conditions nor the number of bees necessary for swarming, but when conditions during early brood-rearing are favorable and when there is abundance of nectar during the main honey-flow, there is also usually a larger population, and preparation for swarming may be begun and often completed in most of the colonies in the apiary. It then rests with the beekeeper so to manage these colonies that, by keeping the bees together and by keeping them in working condition (p. 85), he may obtain practically as large a crop as if swarming had not occurred. He now aims not so much to prevent swarming as to satisfy the instinct and to overcome the evils incident to division of the working force. The method to be adopted depends largely on the size and location of the apiary. If the bees are all in one apiary, where they are under the immediate care of the beekeeper every day, the bees may be permitted to swarm naturally but, in comb-honey production especially, colonies in out-apiaries can be expected to produce more, without the loss of swarms, if by some remedial manipulation the swarming tendency is controlled to suit the convenience of the beekeeper. If an assistant is kept at each apiary, it becomes essentially like the home apiary, but it rarely pays to keep so much help.

Control of natural swarms.

Swarms which issue may be managed in several ways. (1) They may be allowed to fly into the air and cluster on some support, after which they may be hived and placed in the desired location. When the bees have clustered they may be shaken into a box or basket and then placed in front of the hive that they are to occupy. They should be placed so that some of the bees find the entrance promptly, otherwise the bees may begin their characteristic march in the wrong direction (p. 68). If the bees cluster on a limb which can be cut, this may be removed with the adhering bees and carried to the hive and the bees shaken off. If the cluster forms on the trunk of a tree or post or in some other place from which they cannot be readily removed, a box containing a piece of comb (Fig. 47) may be placed above and preferably in contact with the cluster and the swarm will soon move into the box, where it may be handled. Care should be taken to get the queen, as otherwise the bees may again take wing and return to her.

(2) If the queen's wings are clipped (p. 260), she is unable to fly with the swarm and, after leaving the hive, she falls to the ground. The swarm generally does not cluster if the queen is not with it or, if it does cluster, it soon takes wing and returns to the old hive, provided it does not have a virgin queen with it as is sometimes the case if swarming has been unduly delayed. In the meantime, the beekeeper should find the queen on the ground and place her with the returning bees, after adjusting the hives as described later.

(3) If a queen and drone trap (Fig. 30) is placed over the entrance, workers can leave, but when the queen attempts to leave she is retarded by the trap. She then, in her attempts to escape, usually goes into the upper part of the trap and is unable to return. The swarming bees then behave as they do when the queen's wings are clipped, and soon return. To allow the queen to go below with the bees it is necessary only to pull the tin slide which is shown partly drawn in the illustration. Here too the hives are adjusted as when the queen is clipped and of course the swarm is not left in the old brood-chamber. The inexperienced beekeeper should perhaps be warned not to leave a queen trap on the

entrance at all times for it will prevent virgin queens from leaving the hive to mate. Drones of course are also prevented from leaving and if they are abundant they may crowd the entrance, with disastrous results.

(4) As the swarm issues, a wire-cloth cage may be placed over the hive or fitted over the entrance. The bees then cluster in the top of the cage, without causing confusion in the apiary, and may be hived when convenient.

Automatic hivers.

Several years ago the desirability of some automatic hiving device was much discussed and numerous efforts were made to devise apparatus which would deposit or lead the issuing swarm to a new hive. These arrangements were devised to place the swarm in a new location and beekeepers now prefer that it be returned to the old location.

Location for the swarm.

After a swarm has issued, the old practice was to hive it in a new location, thus dividing the working force. The beekeeper should manipulate the two parts of the original colony so as to prevent such a division. A method sometimes used is to return the swarm without the queen to the old hive and about a week later (before the developing queens emerge) the queen cells are cut and the colony is requeened later. The usual method is to remove the hive-body containing the brood while the swarm is out and to return the swarm to a new hive on the old stand. By either of these methods, the swarm is augmented by the returning field bees and, if there were supers on the colony before swarming, they are kept with the swarm and the bees promptly return to their work. The most common error of the inexperienced beekeeper in swarm management is to put the supers on the "parent colony" (the one which retains the brood). The population of the parent colony is reduced by the loss of the field bees and after-swarming is thereby made less probable. These manipulations make it necessary that the beekeeper be present when the swarm issues, or soon after, and they are therefore not suitable for out-apiary management.

Disposition of the brood after swarming.

The so-called parent colony may be sufficiently populous to cast an after-swarm and should therefore be managed so as to prevent this and also so that the emerging bees shall be useful, especially if the honey-flow will probably be of long duration.

The parent colony may be broken up at once by the distribution of the brood to other colonies, while the adhering bees are added to the swarm. Another method is to destroy all queen cells except one and to allow the parent colony to remain intact. If the parent colony is left to requeen itself by the emergence of the developing queens, it often casts an after-swarm, so it is safer either to remove all queen cells except one or to remove them all and give a laying queen or virgin queen.

Still another method is to reduce the population of the parent colony just before the young queens emerge and to add the emerging bees to the swarm. If the parent colony is put back beside the swarm after the swarm is hived, is left there for a week and is then removed to a new location, it is so reduced when the virgin queens emerge that an after-swarm is not cast. A modification of this method to be preferred when the clipping of queens is practiced or when the queen trap is used is to set the parent colony to one side with its entrance about 90° from its former

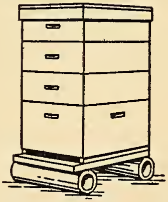


Fig. 111. — Manipulation to reduce population of parent colony — first position. Previous to swarming.

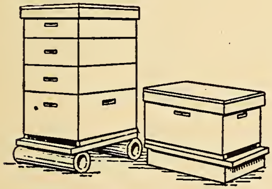


Fig. 112. — Manipulation to reduce population of parent colony — second position. Parent colony is now in hive without supers.

location (Figs. 111 and 112), so that all returning field bees join the swarm. As the brood emerges, the young bees become accustomed to the location of their hive. In a couple of days the parent colony is turned about half way around toward its former position (Fig. 113), and, after the bees again become accustomed to the change, it is moved to a position parallel to that of the new colony (Fig. 114). If within seven or eight days of the issuing of the swarm, the parent colony is removed to a new location, the young bees in flying out join the swarm, thereby considerably reducing the parent colony.

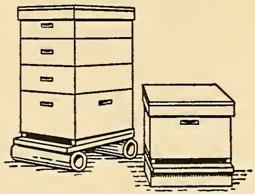


Fig. 113. — Manipulation to reduce population of parent colony — third position.

When the parent colony is moved, part of the bees may be brushed in front of the entrance of the swarm, leaving some to care for the brood but not enough to induce an after-swarm. The parent colony may be used for increase or the bees as they emerge may still be added to the swarm or to some other colony. Other methods of using some young bees or sealed brood to advantage will be found by the beekeeper. They may be used to build up weak colonies or, if the honey-flow will probably be long enough to warrant it, two parent colonies may be placed side by side. By giving one a queen and removing the queen cells from the other, they may be united about two weeks after the swarm issues, when most of the brood has emerged from the queenless colony, and they are then ready for supers.

Fig. 114. — Manipulation to reduce population of parent colony — fourth position.

What to use in the brood-chamber in hiving swarms.

The use of full sheets of foundation in the brood-frames has the marked advantage of resulting in straight combs of worker cells. The comb is built up rapidly, in fact so rapidly as to be considered a disadvantage at times, in that brood is so quickly reared that the increase in population may again induce swarming. The use of full sheets of foundation may increase the work done in the brood-chamber, at the expense of the surplus.

Narrow strips of foundation, perhaps an inch wide or less, may be used, and this usually results in slow progress in the construction of combs in the brood-chamber. The bees then do more work in the supers, if they have been started, and it is so long before the colony can rear much brood that they rarely attempt to swarm again in the season. However, combs built on strips of foundation often contain many drone cells, especially if the comb building in the brood-chamber progresses faster than the cells are filled with eggs by the queen or when comb is built outside the space needed for brood. If the parent colony has a brood disease, the use of strips of foundation is preferable, thus combining swarm management and disease treatment. When either strips of foundation or full sheets are used and partly drawn combs are present in comb-honey supers, the queen may go above to lay eggs and this should be prevented by the use of the queen excluder (Fig. 115) for a few days or until there is room for egg-laying below, when the excluder may be removed. If the supers are left off for a time, work will progress in the brood-chamber so that space for egg-laying will be available there and the queen will not go to the supers.

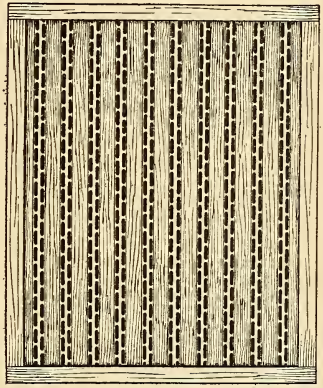


Fig. 115. — Queen excluder ("honey board").

One or two empty combs may be used in the brood-chamber, the remaining spaces being filled with frames containing full sheets of foundation. This prevents the storage of pollen in the supers and gives the queen a place to lay eggs at once, so that an excluder is not necessary. Swarms sometimes desert a hive containing only foundation, but some empty comb or a comb containing some unsealed brood will prevent this. The placing of foundation next to full comb often results in an unusual extension of the side walls of the comb and a restriction of the building out of the foundation.

Empty combs, or comb filled with honey or sealed brood, are also sometimes used. It is claimed by some that, just after swarming, bees secrete wax with a minimum expenditure of energy and with the least consumption of honey, and it is therefore believed that it is wasteful not to give the swarm an opportunity to secrete some wax in building comb. If the swarm is only moderately strong, the bees may confine their efforts chiefly to the brood-chamber, if empty combs are used.

In extracted-honey production, these questions do not arise, for the beekeeper can use whatever is most convenient and, by giving plenty of room for storage, the colony will rarely swarm again. It therefore does not pay to use strips of foundation in the extracted-honey apiary.

In comb-honey production, a swarm may be hived in the usual way and then in a day or two the brood-chamber may be temporarily contracted by substituting thick division boards for four or five of the frames (in a 10-frame hive), thus so reducing the room in the brood-chamber that the bees are driven to the supers. This method may be used during a honey-flow of white honey, which is preferable for comb-honey, and when there will probably be a later honey-flow of honey of a lower grade, which is good enough to use in building up the brood-chamber but not of fine enough quality for sections. If this contraction is practiced, and it is less frequent now than formerly, the contraction should be to about five frames, rather than a slight contraction to perhaps seven frames.

Remedial manipulations.

The remedial measures so far discussed are useful for colonies that have swarmed, in making the most of the parts of the divided original colony. However, these require almost constant attention in some seasons and this is necessary just when the beekeeper can least afford to give it, if he is managing a large number of colonies. Because of the desirability of the manipulations being in accordance with the plans and schedule of the beekeeper, rather than at the whims of the bees, as in natural swarming, beekeepers, especially producers of comb-honey, have tried many ways virtually to create the conditions which are found after swarming, but to do this with advantage to the crop. By such a system the comb-honey producer can maintain several apiaries, visiting them at regular intervals, with a knowledge that swarms will not issue in his absence, except in those cases where every rule seems to fail. However, the losses can be made so slight that it does not pay to keep an assistant at each apiary, if the proper measures are adopted. Fortunately for the beekeeper, bees give warning in advance of the probability of the issuing of a swarm by building queen cells. By examining each colony once in seven to ten days during the swarming season, the beekeeper can subject colonies making these preparations to the chosen manipulation, which may be a preventive or a remedial measure, depending on how far preparations for swarming have progressed. If the manipulations given under the title of Preventive Measures are inadequate, the colony may be handled with another end in view, namely, to satisfy the desire to swarm and to prevent permanent division. It is further possible, especially in apiaries where increase is desired, so to manipulate every colony before the swarming season arrives that there will be little swarming, even in comb-honey production, but since increase in the number of colonies during or just before the honey-flow is at the expense of the crop from that flow, beekeepers usually find it advantageous not to attempt to use remedial measures until necessary.

In the literature on swarm control, there are dozens of plans for accomplishing this end, and it is neither desirable nor necessary to give all of them or even all of the successful ones, for to attempt to do so would only be confusing.

Unbalanced condition of swarming colonies.

If the conditions which are found in natural swarming are examined, it will be recalled that, after the swarm issues, it receives no additional young bees for a period of at least 21 days (unless they are given by the beekeeper in accordance with some of the plans previously outlined). If, as seems not unlikely, one of the most important factors in the cause of swarming is a preponderance of young bees, this condition is rectified for the swarm and the bees become "satisfied." On the other hand, the parent colony rapidly increases the percentage of young bees (unless, again, they are removed by the beekeeper) and after-swarms are not uncommon, unless the beekeeper manipulates to prevent them. It thus appears that the restoration of the balance of the colony is important in bringing it to a condition in which the swarming tendency is lost and in which the storing instinct becomes dominant.

Break in the emergence of brood.

Whether this speculation is justified must be determined by future investigations, which are greatly needed. At any rate, and this is the point of importance to the beekeeper, those practical manipulations which are successful in the control of swarming, whether applied before or after queen cells are built, have for their result a single factor in common — a reduction or temporary cessation in the continuity of the daily emergence of brood. There have been numerous discussions of the principles of swarm control, for this is a problem which has attracted the attention of modern beekeepers to a marked extent, but so far as the author is aware the existence of a single underlying factor in all the methods devised was not shown previous to the discussion of this subject by Demuth. This elimination of the emerging bees, to be successful in its purpose, must occur just before or during the swarming season.

The various manipulations devised by beekeepers which bring about this condition and which have been devised to control swarming come under two headings: (1) The prevention or great restriction of egg-laying; (2) the removal of brood. Even if there were one best manipulation, a beekeeper would probably still prefer the one to which he has become accustomed, but there is so far no one method superior to all the others. As conditions vary from season to season, or even within the season, it becomes desirable that the beekeeper change his manipulations from time to time.

Restriction of egg-laying.

The most radical manipulation under this heading is the removal of the queen. She may be removed for a period of perhaps ten days and then returned (after the destruction of all queen cells), or she may simply be caged and left in the colony, to be released at the end of the period. Another method is to confine the queen to a single comb of brood and several empty combs, or to two or three frames filled with foundation in a hive-body below the one containing most of the brood, in which case the queen cells must be destroyed both before and after the period of separation of the queen and brood.[1] In any event, all queen cells must

[1] The removal of the queen has been recommended by Elwood, Quinby, Hetherington and France. Caging the queen was then advised by Doolittle and tried by Miller. The next step was to utilize the queen by keeping her in a nucleus (Miller) and a later development consisted in making the nucleus practically a part of the main colony. This was done by putting a comb or two of brood, without queen cells, in the lower body and then placing the queen and most of the brood on top of the hive, over a cover. Most of the bees are left with the queenless portion and because of the reduced population in the upper hive, the bees destroy the queen cells. In about ten days the body containing the queen and brood is put below and the body containing the few combs of brood is removed to be used as

be removed before the queen is returned or swarming may occur. These methods are employed only on colonies that have made active preparations to swarm (having advanced larvæ in the queen cells) and they are successful as a rule, if the swarming period is not prolonged sufficiently to allow time for the swarming tendency to be developed anew. The particular time for making colonies queenless must be determined by the stage in the development of the queen cells present in the colony preparing to swarm. If only young larvæ are found in the queen cells, the cells may simply be cut out as a precautionary measure against swarming, but if the queen cells are advanced, their removal will not prevent swarming and the colony should be dequeened. However, a colony with the queen temporarily removed or even separated from the brood is often not in the best condition for storing, especially when first made queenless, and these methods have sometimes been condemned because of this fact. Dequeening is to be preferred in obvious cases of supersedure or in colonies in which the working force is not large, but which still persist in preparing to swarm.

Requeening combined with dequeening.

Requeening is desirable whenever a queen is unable to keep up the population of the colony, and many beekeepers find it advantageous systematically to requeen every two years. The presence of a young queen was mentioned earlier as a preventive of swarming, but this is not a guarantee that

needed ("Put-up Plan," C. C. Miller). Another modification which followed this is described above, in which the queen is put below an excluder on one frame of brood and empty combs. Numerous beekeepers have advised requeening in connection with the dequeening, others have modified the plan by making the lower hive into a nucleus for queen rearing, while in one case it is recommended that a nucleus be established on the side of the hive in which the queen is mated, so arranged that by pulling a slide of perforated zinc, the queen is introduced to the colony after mating. These various systems are mentioned here mainly to show their relation to the fundamental principle of restricting egg-laying and also to suggest the various methods so that the beekeeper may choose the one best suited to his plans.

no swarm will issue, under conditions of a prolonged honey-flow. However, requeening combined with queenlessness for about ten days, after swarming preparations have begun, is a much more reliable procedure. The method used in rearing queens, in mating them and in introducing them to the queenless colonies will depend on the equipment and system of the individual beekeeper.

Removal of brood.

The removal of a frame or two of brood was mentioned earlier as a swarm-preventive measure in relieving the congestion in the brood-chamber, especially in comb-honey production. It obviously also has the effect of reducing the number of emerging bees for a period. If a colony persists in its preparations to swarm, a common remedial measure is to carry the removal of brood to the extreme (artificial swarming). In brief, the beekeeper does for the colony in advance of swarming just what the bees would do for themselves if left to their own instincts. The brood-combs are removed from the hive and the bees are shaken or brushed from the combs into a new hive-body. The brood-combs are then comparable to the parent colony, while the bees in the new hive make up the artificial swarm. The treatment of the various parts does not differ from the same procedure under conditions of natural swarming and need not be repeated. Since artificial swarms desert the hive sooner than natural swarms, desertion may be prevented by removing only a part of the brood at one time and, in fact, some manipulations do not call for the removal of all the brood.

This manipulation has been modified in a dozen ways by various beekeepers, but the essential principle remains the same. The differences in the directions for the making of artificial swarms are chiefly in the disposal of the two portions of the original colony. It is claimed by some that, to obtain satisfactory results, the bees must be smoked or otherwise manipulated until they fill themselves with honey, just as bees do in natural swarming. This usually occurs during the manipulations without any thought on the part of the beekeeper.

Mechanical appliances.

Various mechanical contrivances have been advocated for separating the brood and the adult bees. After the queen has been placed in a new hive, the bees are trapped out and induced to enter the new hive on which has been placed the supers. There is no additional principle involved in these devices and they are serviceable only in changing the work that the beekeeper has to do. They often do not reduce the amount of time and labor needed. Among these devices may be mentioned the Hand bottom board (provided with levers so placed as to force the returning bees into the desired hive) and Dudley tubes for trapping out workers, all of which have been described in bee-journals.

INCREASE

It is assumed in the previous discussion that increase is not desired, and in comb-honey production in the North, where the swarming problem is most acute, increase during the honey-flow is usually too expensive to be justifiable. If the apiary has been reduced by winter losses or in some other way, or if an apiary is being built up, the beekeeper may prefer to sacrifice honey for bees. In connection with the operation of the various plans for controlling swarming, there will often be brood that can be used for increase. Another method is simply to divide colonies into two or more equal parts, preferably providing each queenless portion with a queen cell, or better still with a queen, as soon as possible. To obtain increase and to assist in swarm control without decreasing the crop too greatly, combs of brood with some adhering young bees may be removed and made into nuclei to be allowed to build up and to be augmented with frames of brood from other sources as they are available.

In case the main honey-flow is in late summer (*e.g.* buckwheat) it is often possible to make increase in early summer and to have all the colonies up to full strength by the time the honey-flow begins. Increase in such a case may not result in any decrease in the crop and, in fact, it often brings an increase in the harvest.

In the North, in regions where the main honey-flow comes in early summer, it will usually be found more profitable to set aside certain colonies from which to make increase, rather than to deplete the colonies throughout the apiary in an attempt to make increase and produce a crop at the same time. It is possible to make increase and to produce the maximum crop of honey in an apiary within a single season, if conditions are favorable, but not to do these things simultaneously.

CHAPTER XVI

THE PRODUCTION OF EXTRACTED-HONEY

Before the invention of the honey extractor in 1865, honey was removed from the comb either by crushing it and draining off the honey or by melting it, allowing the whole to cool, leaving the wax on top. By these methods strained honey is produced, an article greatly inferior to modern extracted-honey. In extracting honey, the cappings of the honey cells of the comb are first removed with a hot knife, the comb is put into an extractor and is then whirled, the honey being removed from the cells by centrifugal force.

Increase in the production of extracted-honey.

The demand for extracted-honey is increasing, and it is estimated for the United States that, whereas 34.9 per cent of the honey produced in 1909 was extracted, in 1914 this had increased to 42.1 per cent. This estimate of the increase is conservative, and among professional beekeepers the increase in this period is doubtless greater. This is partly due to the demand for honey from bakers and confectioners, but a potent influence is the increased confidence of the consuming public that the extracted-honey on the market is not adulterated. For this confidence, the beekeeper is indebted to the enforcement of the numerous pure food laws. Beekeepers have consistently fought adulteration and have welcomed the enforcement of these laws in protecting them from the competition of unscrupulous jobbers who were formerly guilty of adding inferior syrups to extracted-honey.

Advantages of extracted-honey.

The fact that the combs may be repeatedly used increases materially the amount of honey produced by a single colony and thereby reduces the cost of production of a pound of extracted-honey. There is less secretion of wax and, since the secretion of a pound of beeswax is estimated as costing from six to twenty pounds of honey (and probably considerable bee vitality), this saving is considerable. In light honey-flows, bees often refuse to work in comb-honey sections, whereas they will store the available nectar if extracting combs are on the hive. Under comb-honey conditions the queen is often cramped for room and the population of the colony is thereby reduced, while in extracted-honey conditions she has abundant room, unless otherwise restricted. The larger comb area in extracted-honey production furnishes the bees plenty of cells in which to store fresh nectar, giving increased evaporating surface and thus hastening the ripening process. The beekeeper can care for more colonies in producing extracted-honey than in producing comb-honey. Swarming is more easily controlled and is much less prevalent because of the abundance of empty comb provided. Furthermore, in comb-honey production most of the work in the apiary requires skill and experience, while in extracted-honey production one man can furnish the skill for many colonies and can employ unskilled labor to help during extracting. In selling extracted-honey to the consumer there is the marked advantage of blending honeys from different sources, thereby obtaining a mixture which can be duplicated year after year.

Disadvantages of extracted-honey.

While more extracted-honey than comb-honey can be obtained from a colony in a season, this is balanced by the fact that the wholesale market value of a pound of extracted-honey is less than that of a section of comb-honey, the unit with which a pound of extracted-honey must be compared. However, year in and year out the advantage is probably still with the producer of extracted-honey, so far as financial return is concerned. In some localities extracted-honey does not sell as readily as comb-honey. In extracting honey and in heating it later to bottle it, some of the delicate aroma is lost but this usually is not sufficient materially to reduce the value of the honey as a delicacy.

Extracted-honey hives.

A hive at least as large as the 10-frame Langstroth should be used, for smaller hives do not provide sufficient room for the activities of a colony headed by a vigorous queen and large colonies are far more profitable than small ones. When a honey-flow begins, the hive should be ready with an extra hive-body containing frames of the same size as the brood-chamber already on top. The extra hive-bodies or supers may be given one after the other as the increase in surplus honey indicates, the empty super being usually put next to the hive containing the brood. If the beekeeper believes the local conditions warrant it he may give several hive-bodies at once. It is quite usual to space the frames in the supers farther apart than in the brood-chamber, giving eight frames equally spaced in a 10-frame body. This makes less combs to handle for a given amount of honey, and if the comb is cut deep in uncapping, more wax is obtained. It also makes uncapping easier.

Choice of storage combs.

White honey stored in cells in which brood has been reared is sometimes darkened slightly but most beekeepers find it too much work to keep the combs for breeding entirely separate from the storage combs. Colonies are also sometimes stimulated in the spring by putting a few brood-combs in the upper story to get the bees to go up promptly. This is especially valuable in swarm prevention. Usually the queen is allowed to go where she will in the hive to deposit eggs.

Use of extracting combs smaller than brood-combs.

An exception to the above statements concerning the size of the hive and supers is to be found when unusually deep brood-frames are used, when frames of Langstroth depth are often used for extracting combs. Some beekeepers also prefer to use shallow extracting frames, the length of the Langstroth frames but $5\frac{3}{8}$ inches deep, to obviate the lifting of such heavy supers as those of full Langstroth size. The latter frames are advantageous for bulk comb-honey production (p. 318).

Number of supers.

The character of the honey-flow will determine largely the number of surplus bodies used and the method of taking off the honey. In a slow honey-flow one surplus body is often sufficient and as individual combs are filled and sealed they are removed and the honey extracted. In a heavy honey-flow more bodies should be given at one time so that there will be room for ripening and storing the honey. In the latter case, whole hive-bodies are frequently taken away at one time.

Manipulation of the supers.

To confine the queen to the lower hive-body and prevent brood from being scattered throughout the hive, one of two methods may be employed. If a queen excluder (Fig. 115) is used the queen is kept below, but many honey producers object to these on the ground of expense and because they believe the workers are somewhat retarded by them. If the new supers are always placed directly above the brood-chamber and under the supers already on, there is little likelihood of the queen going above. Under these circumstances the order of the supers is practically the same as in comb-honey production (p. 314). Bees probably begin work in new combs more quickly if they are placed near the brood-chamber. In rapid honey-flows, however, bees go readily to the very top of the hive for empty cells without hesitation.

Need of abundance of drawn combs.

In any event, plenty of drawn combs should be available and they should be given to the colonies soon enough so that there will always be some empty comb in the hive. If the bees become crowded, the queen may be restricted in egg-laying and there is not room to spread out the nectar for economical ripening. The crowded conditions so commonly found in comb-honey production should be avoided in the production of extracted-honey. The advantage of fully drawn combs is especially evident in poor seasons, for then the bees may refuse to build combs but will store all the honey available if drawn combs are provided.

The giving of frames entirely or partially filled with foundation from which combs must be built, diverts a part of the colony to wax building and probably reduces the field force, although wax is secreted chiefly by young bees not yet ready for work in the field. Part of the honey is consumed in wax building. There may be some delay in starting work on the new combs, which in a heavy honey-flow results either in a loss of honey or in the cramping of the queen. The extracted-honey producer should supply himself with drawn combs in abundance as soon as possible. These may be obtained economically by hiving swarms on full sheets of comb-foundation. Another good method is to put eight frames in a 10-frame hive as an upper story, four on one side being full combs and the other four being frames containing comb-foundation. This is better than to alternate comb and foundation, in which case the combs are usually drawn out abnormally thick and the comb-foundation is drawn out slightly. Better combs are built during a good honey-flow for the corners are then filled more completely than in a small honey-flow. If desired the nectar obtained at the end of the main honey-flow may be utilized in comb building.

System in producing extracted-honey.

The extensive producer of extracted-honey may systematize his work so that it is necessary to visit each out-apiary only a few times a year. The number and time of these visits must be determined by the character of the honey-flows. Usually the honey from each floral source should be extracted separately and this necessitates a trip after each honey-flow. The apiaries should be of such size that either in one day or two all the extracting can be done, and to help with this work unskilled labor may usually be employed. Since the giving of plenty of drawn combs reduces swarming, it is usually not profitable to keep a helper at each apiary during the swarming season, for the few swarms that would be saved are worth less than the helper would cost. If the apiary can be located near the home of some interested person the swarms may be caught, but frequently it is desirable to put out-apiaries in rather desolate places, some distance from a dwelling. E. D. Townsend of Northstar, Michigan, manages a number of out-apiaries in northern Michigan on four trips a year. On the first trip (June) he gives each strong colony two 10-frame supers, each containing eight frames. On the second trip (July) and the third (after the honey-flows) he extracts, two trips being made to keep the clover and basswood honeys separate. In October he sees that the colonies are ready for winter, after which they are not again visited until June.

Removing honey from the bees.

Honey should not be removed from the hive for extracting until well ripened. When at least two-thirds of the surface of the comb is capped over the honey will be sufficiently thick, but the humidity should be considered in laying down a rule for this. In dry climates, such as the semi-arid regions of the West, the evaporation of the water in the nectar takes place rapidly and it is not necessary to wait until so much of the honey is capped. Conversely in regions of high humidity it is sometimes difficult to get honey well ripened.

When the time comes to extract, the usual practice is to remove the frames one by one, returning those not ready, and to brush or shake off the adhering bees. Bee-escapes (Fig. 31) may be used in removing bees from extracting supers but this is not usually practiced by extensive producers as it necessitates going to the apiary a day ahead and it is desirable to reduce the trips wherever possible. For the beekeeper with one apiary, these may often be used to advantage. A bee brush (Fig. 28) may be used for brushing off the bees or a bunch of grass or weeds will answer admirably. The combs practically free of bees are then taken to the house for extracting. For carrying these an ordinary hive-body with a cover answers very well and special handles may be put on it to facilitate carrying, or several bodies may be placed on a wheelbarrow or two-wheeled cart. Some beekeepers have arranged rails through the apiary on which trucks may be run for carrying full bodies in and for returning the empty combs. This is practical for fixed apiary locations but often the professional beekeeper wants to have no apparatus that cannot be moved if desired.

The greatest care should be exercised while honey is being taken from the hives that the bees do not begin robbing. This is especially necessary if extracting is done after the honey-flow has ceased. Should robbing begin, it is often best to stop work for the day, as robbing is not only most annoying to the beekeeper but detrimental to the bees. The feeding of a thin syrup out of doors is sometimes practiced to prevent robbing during extracting.

House for extracting.

The house where the extracting is done need not differ materially from the honey-house described previously (p. 23). If the apiary is on sloping ground, it is preferable to have the colonies above the house, so that the heavy full hives are carried down hill and the empty hives up. To reduce labor, it is desirable that there be an opening for admitting the honey to the house convenient to the uncapping outfit and that the extractor be near at hand.

These should be on a high level in the house, if practicable, so that from the time the honey runs from the extractor, its course is down hill to the final container. It is worth the effort to pay considerable attention to this feature, for if the honey must be lifted at any part of its journey a great amount of labor is involved in large apiaries where tons of honey are extracted in a season. If such an arrangement is not feasible, a honey-pump (Fig. 122) may be used, as is described later.

Portable extracting outfits.

In sections where at times it is desirable to move apiaries or where several out-apiaries are under one management, it is occasionally advantageous to have a portable extracting outfit which is virtually an extracting house on wheels. A well-screened wagon is fitted with uncapping cans, extractors (with power if desired) and all the necessary equipment. As the honey is extracted, it can be run into a tank under the wagon bed or into barrels or cans. If desired a tank wagon to carry the honey may accompany the outfit. Some beekeepers have found portable buildings (built in sections) preferable, in which case one is put in each apiary. If these are used, it is better to have a full extracting outfit at each apiary.

Uncapping.

When the full combs of honey reach the extracting house, the first manipulation is uncapping. This is done with a specially constructed knife, of which there are several types (Fig. 116). Of these the Bingham knife with heavy wide blade is best. The knife should be kept sharp, clean and hot, and when the usual knives are used, each operator is provided with two so that one may be kept in hot water, to

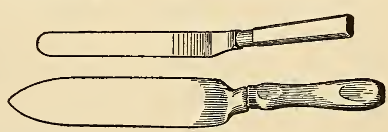


Fig. 116. — Uncapping knives: upper, Novice; lower, Bingham.

clean and heat it, while the other is in use. Recently a steam-heated knife (Fig. 117) has been put on the market which is highly recommended by those who have tried it. Steam is generated in a small boiler (such as a one-gallon honey can), passes through a hose into a hollow space in the knife blade, escaping through a small hole in the tip. Some European beekeepers use an instrument like a comb (Fig. 118) for uncapping, but this is too slow for American beekeepers.

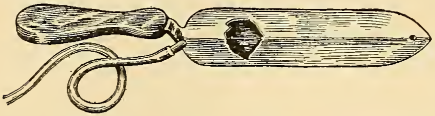


Fig. 117. — Steam-heated uncapping knife.

In uncapping, the lower end of the comb is placed on some support and the comb is slightly tipped so that as the cappings are cut off they fall away from the surface of the comb (Fig. 119). If the knife is first inserted at the lower end of the comb and brought upward with a sawing motion, the cappings fall away easily and cause no inconvenience or smearing. Some beekeepers prefer to begin cutting at the upper end, thereby utilizing the weight of the knife in cutting the comb. The upward cut is practiced by most extensive beekeepers.

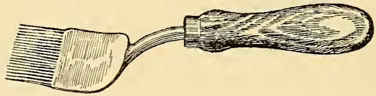


Fig. 118. — Comb for uncapping, used in Europe.

Cans for cappings.

The uncapping should be done over some sort of receptacle into which the cappings will fall. Hutchinson used a simple, cheap and satisfactory outfit, consisting of a barrel hung with bent wires on the edges of a galvanized iron tub. Across the top of the barrel is nailed a board through which is driven a nail with the point upward. One of the end bars of the frame is placed on this nail point and after one side is uncapped, the frame is turned on the nail. Some beekeepers prefer to bore a one-inch hole in the cross piece into which the projection on the bar of the frame is inserted.

Another cross piece on which to scrape wax and honey from the knife is an advantage. The cappings drop into the barrel and the honey drains into the tub below through cracks in the barrel. The advantage of this cheap mechanism is that when one barrel is well filled with cappings, the outfit may be set aside to drain and another one substituted. More elaborate tanks (Fig. 120) have been devised for this purpose which have the advantage of durability and permanence. These tanks may be made either of sheet metal or of wood lined with tin. A screen is arranged in the box on which the cappings fall and the honey drains into the lower space.

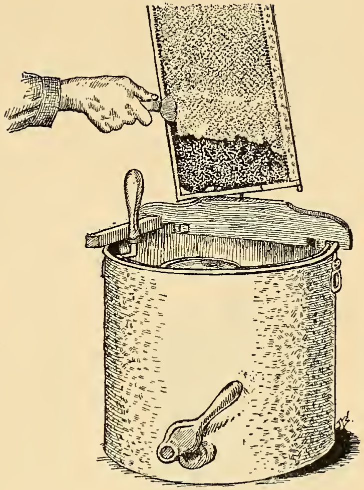


Fig. 119. — Capping melter. This also shows the proper method of removing cappings.

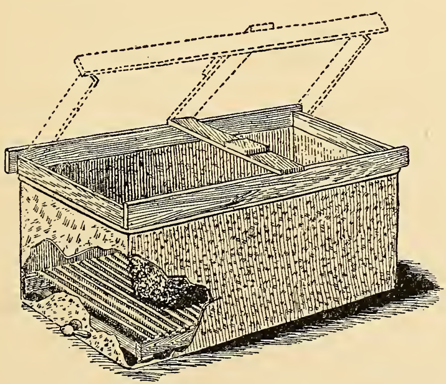


Fig. 120. — Tank to receive cappings.

Capping melters.

A later development in uncapping cans is a piece of apparatus in which the cappings are melted at once and the honey and melted wax run out. Honey is then quickly drawn off from the bottom of the receptacle leaving the wax to cool on top of a little of the honey. A small capping melter (Fig. 119) is now marketed, but for extensive operations it is preferable to make a larger tank (Fig. 122) on this principle. In these melters the honey and wax come in contact only with the inner wall of a water jacket and do not touch metal which is in direct contact with the flame. The objection has been raised that the heating of the honey in this way discolors it, but if it runs off and is separated from the melted wax quickly this is reduced to a minimum. Apparatus of this type has been adopted by numerous extensive producers. The relief from the care of a great mass of cappings at the end of extracting certainly appeals to the extensive beekeeper.

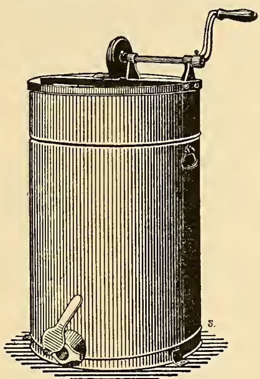


Fig. 121. — Extractor with stationary can.

Types of extractors.

After the comb is uncapped on both sides it is ready for the extractor. The development of the extractor from the first simple clumsy machines is of interest and illustrates nicely the progress of beekeeping in recent years. Following the announcement of the invention [1] of the extractor in Italy, the first type marketed in the United States consisted of a revolving can into which frames were placed in pockets and the can was revolved by means of a handle directly attached. The next step, and a most important one, was to make the can stationary (Fig. 121), the frames being placed in baskets attached to a central axis which is driven with a gear. The "Novice" extractors (1869) are of this type,

[1] The removal of honey by centrifugal force was discovered accidentally. de Hruschka gave his son a comb on a plate. He put this in a basket and, boy-like, swung the basket around him. de Hruschka noticed that some honey was drained out and thereby got the basic idea for the extractor.

Fig. 122. — Power extracting outfit. Capping melter of large capacity (on left), 8-frame automatic reversible, friction-drive extractor, gasoline engine, honey-pump and strainer.

the baskets being close to the axis giving the greatest practical centrifugal force for a given velocity of the comb. These are made for two and four frames and are still used. The next advance was in making the reversible extractor, in which the baskets are hung by one edge on pivots, so that when the honey is removed from one side, the basket can be turned and the other side extracted without removing the combs from the baskets. From this it was a short step to the automatic reversible machine in which it is not necessary to bring the reels to a full stop to reverse the baskets. When first inserted, the baskets are placed so that in their revolutions they are pulled by their hinges. After one side is empty, the speed is checked by means of a brake on the central axis and the momentum of the baskets throws them around on the hinges exposing the other side of the comb. Soon after this improvement was made, the driving rod was provided with a slip-gear so that, after the reels are well under way, the gear is thrown out and the reels revolve while the driving gear stands still. From this point progress has been chiefly in the application of power to the extractor and in increase in size. We now have extractors driven by gasoline or electric motors having a capacity of four, six, eight (Fig. 122) and even twelve frames. These large outfits are capable of handling tons of honey in a season. The latest improvement is the application of the friction drive in place of gears, by which any speed may be obtained by changing the position of one of the friction members, but the special advantages are smoothness in starting and reduction of noise. Extractors of all the types mentioned except the early revolving can extractors are still manufactured and each type is suited to certain apiary conditions. Obviously only professional beekeepers need a large power outfit, but there are a great many of these, as evidenced by the unexpected number of sales of such equipment. It is claimed that the power driven extractors clean the combs more thoroughly than do hand driven machines.

Extracting.

In extracting, care must be exercised not to run the extractor too rapidly as this may break or crush combs, especially new or unwired ones. It is a good practice to extract some honey from one side, to reverse and extract the other side clean and then go back to complete the extracting on the first side. With fragile combs, the honey on the inner side may be forced against the midrib of the comb so strongly as to crush it if the comb is revolved too

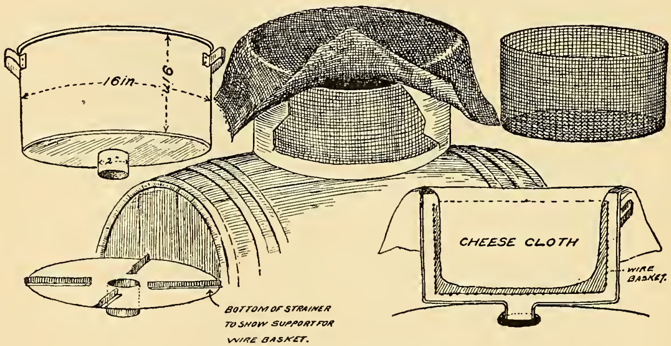


Fig. 123. — Honey strainer.

rapidly in extracting the first side. In placing combs in the extractor, those of about the same weight should be placed opposite each other to prevent swinging of the extractor, thus making it easier for the operator and less wearing on the machine. The honey is thrown against the side of the extractor can and runs down and out an opening provided at the bottom, usually equipped with a honey gate (as in Fig. 121) so that it may be quickly and securely closed.

Straining the honey.

Since particles of cappings naturally adhere to the comb and since other foreign matter may get into the honey, including an occasional bee, the honey should be strained as it leaves the extractor. For small operations, it may simply be run through a cheese-cloth bag, greater surface being given by supporting the cheese-cloth on wire netting (Fig. 123). Another type is known as the gravity strainer. In this, the honey runs into a tank with a partition having an opening at the bottom through which the honey can pass to another compartment. No honey flows from the outlet until it fills the strainer to the level of the upper outlet and most of the larger foreign particles rise to the top in the first chamber allowing the honey to pass off relatively free from foreign material. Gravity strainers are widely used and can readily be made to any desired capacity. They are usually combined with a strainer of cheese-cloth (Fig. 122) to get out more of the impurities.

Storage tanks.

From a strainer of any type it is advantageous to run honey into a tank so that particles that pass the strainer will have an opportunity to rise to the top, the honey always being drawn from the bottom. Many beekeepers, however, run honey directly from the strainer into cans or barrels. The extra settling in the tank not only removes more small particles of wax, but allows air bubbles to escape and also allows any surplus water to evaporate in dry weather. Large tanks of a capacity of several tons are often used by California beekeepers (Fig. 124). If the tank is outside the extracting house, it should be covered tightly to keep out robber bees as well as dirt. Outdoor tanks are not

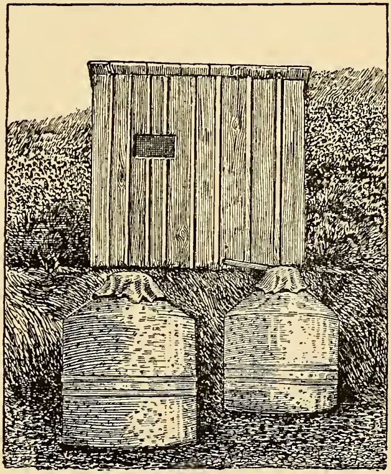


Fig. 124. — Honey storage tanks.

practical except in the dry regions of the West where it does not rain during the honey season. To aid in keeping out bees and dirt, the western honey tanks have a relatively small opening at the top.

Reduction of the lifting of honey.

If the extracting house can be so arranged that the honey will flow from one piece of equipment to the other, much lifting is avoided. Honey is usually run into tanks through pipes and if desired these may be utilized in carrying the honey from one house to another or to tanks some distance from the extracting house. Care should be taken to keep these pipes clean. If the honey cannot be run by gravity through its entire course, a honey-pump (Fig. 122) may be used and the usual practice is to attach this to the extractor so that it may be driven by the same power that runs the extractor. The whipping of honey in a pump tends to induce granulation so that honey should not be pumped after being heated for bottling (p. 324).

Returning combs to the hives.

After the combs are emptied, they may either be returned to the bees to be refilled, if nectar is still coming in, or may be returned to be cleaned of honey and then removed for storage. If the honey-flow is still on, empty combs may be put on a hive as the full ones are removed, but during a light flow of honey or a dearth of nectar this may cause robbing and undue excitement in the apiary. In this event, the combs should be kept in the extracting house until the end of the day. If the combs are returned simply to be cleaned, a half dozen hive-bodies may be put over one colony and the bees will soon clean all of them. After the surplus combs are emptied, they may be left on the colonies to prevent their destruction by wax-moth larvæ or they may be stored in a light, well-ventilated room or in hive-bodies where they should be watched and fumigated when necessary.

CHAPTER XVII

THE PRODUCTION OF COMB-HONEY

Comb-honey is honey as stored in the comb by the bees, the size and shape of the comb being determined by the small wooden box (section) provided by the beekeeper and the comb being sold with the section still surrounding it. The development of this style of package is readily traced back to a period previous to the invention of the modern hive. Formerly boxes were put on top of the box-hive or skep in which the bees built comb and stored honey. The next step was to make these boxes of a number of units comparable to the modern section and to compel the bees to build one comb in each unit. From this it was a short step to separate sections with partitions (separators) between.

Purity of comb-honey.

The purchaser of a section of comb-honey may feel sure that he is buying a pure product of the bees, since comb-honey cannot be adulterated with profit. It is impossible to make an artificial comb, fill it with syrup and cap it over so that it even roughly resembles the work of the bees. By the use of modern apiary appliances, comb-honey is produced that is so attractive and uniform in appearance that the claim is often made that it is manufactured. An examination will, however, show that no two sections are

Note. In the preparation of this chapter, the author is indebted to his colleague, Geo. S. Demuth, for invaluable assistance. Mr. Demuth's bulletin "Comb Honey" (U. S. Dept. Agric., Farmers' Bulletin 503) should be read and studied by every producer of comb-honey.

identical as they would be if machine made. To show its confidence in the purity of comb-honey, the National Bee Keepers' Association in 1904 offered $1000 for a single section of manufactured comb-honey which would even approximately resemble the work of bees and a similar offer was made considerably earlier by A. I. Root, Medina, Ohio. Needless to say, no person has been able to claim these prizes.

The "Wiley lie."

This calls to mind an episode which at the time caused beekeepers of this country much anxiety. H. W. Wiley stated in "Popular Science Monthly" in 1881, in an article on prevalent practices in food adulteration, that artificial combs of paraffin were being filled with glucose, capped to imitate the work of bees, and sold as comb-honey. In this statement he was entirely wrong and he publicly admitted the error later, there being, however, some basis for his misunderstanding since he had been informed of efforts along this line by a New England inventor. "Popular Science Monthly" did not have a circulation large enough to cause much trouble from such an erroneous statement, but unfortunately it was called to the attention of some prominent beekeepers. They dubbed it the "Wiley lie" and continued to magnify the harm that would come from it and to re-publish the error with denials until the story was spread throughout the country. The last chapter in this incident was the anonymous re-publication of the original statement and a collection of denials in an effort to hinder the passage in Congress of the Food and Drugs Act of June 30, 1906, now so familiar to all consumers of food. It should be made clear that this effort was not perpetrated by any organization of beekeepers, although an attempt was made to make it so appear. The only fault that can be found with the beekeepers is that they did not refrain from discussing the matter and they thereby probably did the industry far more damage than did the original statement, for it appeared that they might be covering their own misdeeds. Occasionally some ignorant or sensational writer even now succeeds in repeating this error in print, but beekeepers promptly demand and usually receive a public correction. There is not the slightest basis for the misrepresentation.

Decrease in comb-honey production.

With the invention of the honey extractor, some enthusiasts predicted that soon no comb-honey would be produced, but this prophecy has not been fulfilled. Comb-honey has a place in the American honey trade which cannot be filled by extracted-honey. However, a gradual change is taking place and the percentage of the total honey crop that is produced in sections is decreasing annually. Professional beekeepers have found that they can care for more colonies when producing extracted-honey, thereby increasing their profits. The spread of the brood diseases is rapidly eliminating the beekeepers with small apiaries for whom comb-honey is more convenient and, while the number of colonies in the United States is increasing, the sale of sections is steadily decreasing. There are other reasons for this change which appear later under the enumeration of the disadvantages in comb-honey production.

Demand for fancy comb-honey.

The American markets are now demanding only fancy comb-honey and the inferior grades and darker comb-honeys find a poor sale. To be successful in competition with extracted-honey, comb-honey must be a fancy article, appealing to the fancy trade. For this reason, which is becoming more evident every season, there are still many beekeepers who produce comb-honey who should change to extracted-honey, and it is to be hoped that this transition will continue until all the grades of comb-honey which now injure the market are eliminated. On the other hand, there will be increased profits for the best grades of comb-honey, and the beekeepers in favorable localities may find it profitable to increase their production of honey in sections.

Advantages of comb-honey.

The advantages in the production of comb-honey are numerous. As stated in the previous chapter, some of the delicate aroma of the finest grades of honey is lost in extracting, but this is retained to the full in comb-honey. In the production of comb-honey by the small beekeeper, less expensive equipment is necessary. The handling of the honey is a clean job and there is an attractiveness about the product that makes the handling of it a pleasure. The wholesale price of comb-honey is higher than that of extracted-honey, but the amount obtained from each colony is usually less, so that the return is about the same in either case. In a good honey-flow the advantage is with the comb-honey producer who uses proper methods of manipulation, while in light honey-flows only the producer of extracted-honey gets all the crop. The section is a convenient package for retail trade. In this connection it should be noted that in comb-honey production the beekeeper prepares the honey for the consumer while extracted-honey is more often sold in wholesale packages. When extracted-honey is blended and bottled it usually brings as high a retail price as comb-honey, but in this case the beekeeper does not do all the work and the bottler gets a good share of the profits. Comb-honey meets with more ready sale in most markets than does extracted-honey.

Disadvantages of comb-honey.

Comb-honey ships poorly and consequently there is often considerable loss from breakage, on which account some wholesale honey dealers refuse to handle it. In colonies run for comb-honey, swarming is a much more serious problem than in the larger hives with plenty of empty comb space used for extracted-honey. In light honey-flows, bees work little or not at all in sections, for bees are induced to build comb and store honey in small sections with difficulty and there is often a loss before they begin work properly. A serious drawback is that if honey in the comb granulates it is almost a total loss, and usually the only way to save anything is to melt the wax and honey and market them separately. The section of honey is a difficult package for the retail merchant to handle and the careless clerk may often spoil a section by running his thumb into it. For this reason and also for the sake of cleanliness, comb-honey sections in sealed cartons appeal strongly to retailers and consumers.

Restrictions in comb-honey production.

In view of the demands of the market and the tendency toward the production of only the best grades of comb-honey, there are certain restrictions which should apply in its production. Where the honey is dark or where honeys from various sources are mixed in the combs by honey-flows intermingling, extracted-honey should be produced. Honeys which granulate quickly, although they may be of fine color, are undesirable for comb-honey production. The recent increase in the sale of alfalfa comb-honey has caused many grocers to hesitate to buy any comb-honey, for fear previous unpleasant experiences may be repeated and leave them with unsalable granulated comb-honey on hand. Where the honey-flows are slow or intermittent, extracted-honey production will be found more profitable. These general restrictions will of course not apply in certain local market conditions. For example, there is demand for buckwheat comb-honey in some limited regions, whereas on the general market it has no sale. It is evident from a survey of the whole field that many beekeepers who now produce comb-honey are doing it to their own detriment while an increase in the production of comb-honey in the more northern clover sections would be beneficial to the honey markets. The limitations in comb-honey production will possibly increase the price of the better grades of comb-honey and make it profitable for some northern beekeepers again to produce comb-honey. The restrictions here enumerated obviously require that comb-honey be produced by specialists, for the careless beekeeper and the man who can devote but little time to his bees cannot hope to produce the finer grades of comb-honey, except by the accidents of exceptional honey-flows.

Honey-house.

The apparatus for the extensive production of comb-honey is rather complex. The first requirement is a building for storing apparatus, preparing supers and caring for the crop. This building should be rat-proof and is frequently built over the cellar in which the bees are wintered, for commercial comb-honey production is largely restricted to the North. In managing out-apiaries, it is customary to carry out the empty supers and bring them back completed to the central workshop. The place in which the comb-honey is stored should be the warmest room in the building and should be arranged for artificial heat when necessary. It should be sealed to keep out insects and to allow fumigation.

Hives for comb-honey.

The best hive for comb-honey is a matter of dispute. While the Langstroth hive is used more than any other, the number of frames to be used is much debated. If the locality will permit of the building up of the colony to fill ten frames completely, a hive of this capacity is preferable, but in many places this is virtually impossible and an eight-frame hive gives better results. Of course the colony occupies the same hive throughout the year and the need of abundant stores in winter gives the preference to the ten-frame hive but, by care, the disadvantage of the smaller capacity of the eight-frame hive for winter stores may be overcome. Whatever hive is used, for the production of fine comb-honey accuracy in the manufacture is far more essential than if it were to be used in extracting. The bee-spaces should be accurate and if self-spacing frames are used care should be exercised that the deposits of propolis do not force them out of place. Sectional hives, in which the brood occupies two or more shallow hive-bodies, are preferred by some beekeepers, especially among comb-honey producers. While they have much to commend them, they do not seem to gain in popularity.

Evolution of the section.

The early development of the section was suggested in an earlier paragraph. The first ones were made of four pieces of wood and, after the wide adoption of the Langstroth frame, sections $4\frac{1}{4}$ inches square became in a sense standard, since eight of these sections fit into a Langstroth frame (of special construction, Fig. 134). In 1873, Alexis Fiddes, Centralia, Illinois, made a one-piece section by folding thin strips of wood on a saw-cut at the corner and to him probably belongs the credit of making the first section of this type. In 1876 he described these in a note in "Gleanings in Bee Culture." In 1876, two firms put such sections on the market but it appears that previously other beekeepers had made them on this plan. In 1883, Jas. Forncrook, Watertown, Wisconsin, claimed a basic patent on these sections and brought suit against A. I. Root, Medina, Ohio, for infringement. A decision of the Circuit Court in 1884, upheld by the United States Supreme Court in 1888, declared this patent valueless on the ground that originality was not substantiated. Fiddes is credited with first making such sections. Following this decision, the manufacture of one-piece sections became general and they practically replaced the four-piece sections, except in certain limited localities where they are still used. They are now made with a V-shaped groove which folds more easily and is stronger than the former method of cutting. Basswood is used in making these.

Types of sections.

There is considerable variation in the types of section used and correspondingly in the supers (upper stories) and fixtures made to hold them. The standardization of these appliances is often discussed and is greatly to be desired. There are two styles now in common use which differ in the method of spacing. They are now almost all made of basswood, $\frac{1}{8}$ inch thick, as this bends readily at the corners. The bee-way section (Fig. 125) is wide (usually $1\frac{7}{8}$ inches, but rarely $1\frac{5}{7}$ or 2 inches) and has passageways cut in two (sometimes three or four) sides to allow bees to enter the sections, comb building in the individual sections being limited by plain separators placed between them. The plain sections (Fig. 126) are narrow, $1\frac{3}{8}$ or $1\frac{1}{2}$ inches, and are separated one from another by "fences" on which are cleats to hold the fence away from the section to allow room for the passage of bees. The bee-way sections are usually made

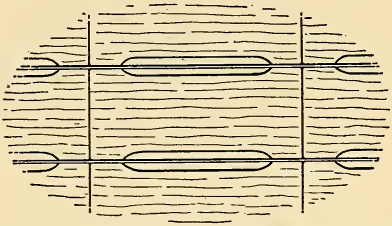


Fig. 125. — Diagram to show method of spacing bee-way sections.

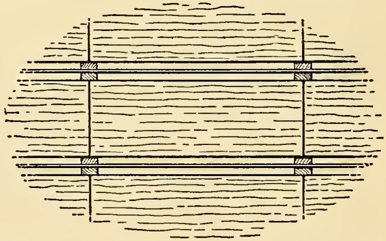


Fig. 126. — Diagram to show method of spacing plain sections.

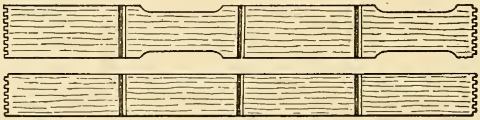


Fig. 127. — Comparison of plain and bee-way sections.

$4\frac{1}{4}$ inches square, while the plain sections are of the same dimensions, or 4 by 5, $3\frac{5}{8}$ by 5 or $4\frac{1}{4}$ by $4\frac{3}{4}$. The construction of these sections and the methods of spacing are shown by illustrations (Figs. 125, 126 and 127). The advantages of the bee-way sections are protection of the honey by the wider wood and extra strength, and some markets prefer them. The plain sections are simpler in construction, cheaper, easily cleaned of propolis and more economical of space in packing. The tall plain sections give the impression of larger size when compared with a square section of equal capacity (Fig. 128).

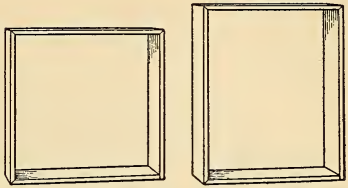


Fig. 128. — Comparison of tall and square sections of equal capacity.

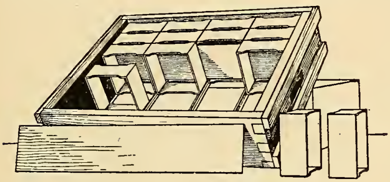


Fig. 129. — T-super.

Types of supers.

The various supers used to hold these sections differ in the method of support, the protection of the outside of the section and the degree of free communication from section to section. The types in most common use are illustrated (Figs. 129, 130, 131, 132 and 133) and little needs to be added by way of description. In the T-super (Fig. 129), the sections are supported by strips of tin (shaped like an inverted T in cross section), no protection being given to the sections on the top or bottom and, when 2-bee-way sections are used, as is customary, there is no

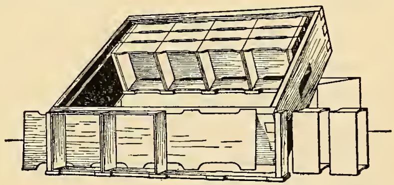


Fig. 130. — Super for square bee-way sections with section holders.

passageway horizontally in the super. The super for square bee-way sections with section holders (Fig. 130) is used perhaps more generally than any other. The sections are not protected at the top and the communication between sections is the same as in the T-super. For plain sections, the super corresponding to the one just described is shown in Fig. 131 and for tall sections (4 by 5 inches) the corresponding type is represented in Fig. 132. In the two last named, cleated fences are used to provide passage for the bees vertically and there is little opportunity for horizontal passage. To provide protection for the top of the sections a wide frame is sometimes used, and in the illustration (Fig. 133) this is shown in combination with shallow extracting combs at the sides devised for the purpose of inducing the bees to begin work in the supers quickly. The modern wide frame is a reversion to the type formerly much used, except that the older types (often for eight sections, Fig. 134) had a tin separator tacked to one side of the frame and bee-way sections were used.

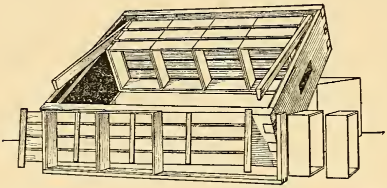


Fig. 131. — Super for square plain sections with section holders.

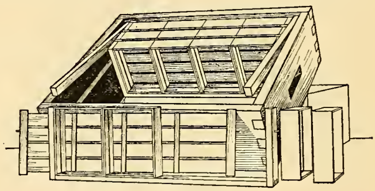


Fig. 132. — Super for tall plain sections.

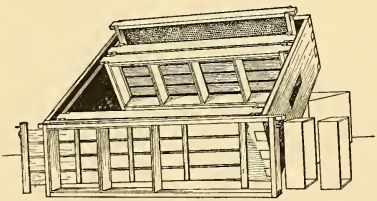


Fig. 133. — Super for tall ($4\frac{1}{4}$ by $4\frac{3}{4}$) sections in wide frames. Shallow extracting frames are shown at the sides.

Other equipment.

The other apparatus needed in extensive comb-honey production includes some of the general apiary equipment discussed in Chapter III. A supply of shallow extracting supers may often be used to advantage to induce bees to begin storing in supers, but the combination super (Fig. 133) is generally preferable. If a colony is as strong as it should be at the beginning of the honey-flow there will be little need for shallow extracting supers. The proper use of bait sections is as good as either of these methods.

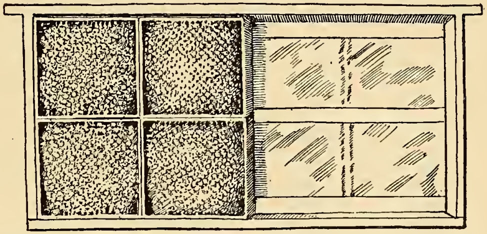


Fig. 134. — Old type of wide frame for holding sections.

Preparation of the sections.

The folding of the section and the fastening of the foundation in place are sometimes done in one machine, but in most apiaries these things are accomplished by two operations. To fold the sections (Fig. 135) without excessive breakage, they must be damp to allow the wood to bend. If they are dry they may be moistened by pouring hot water down the V-grooves while still in the crate, the stream of course being directed only on the grooves. The whole crate may be wrapped in a wet blanket for a day before the folding.

The use of foundation is necessary to insure straight combs, all of worker cells, and is essential in the production of fancy comb-honey. The foundation should be as thin as can be used without being torn by the bees and usually the grade known in the trade as "thin-super" is preferable. While only narrow strips at the top are sometimes used, it is decidedly preferable to use full sheets to insure uniformity of comb. The sheet is fastened to the top of the section, is slightly narrower than the inside of the section so that it can swing freely and extends to within $\frac{3}{4}$ to $\frac{1}{4}$ inch of the bottom. To secure better attachment of the comb to the bottom, it is becoming more commonly practiced to put a $\frac{5}{8}$ inch strip of foundation at the bottom and then make the top piece of foundation long enough to extend to within $\frac{1}{8}$ to $\frac{1}{4}$ inch of the bottom starter. The desirability of using the bottom starter is somewhat determined by the character of the flow.

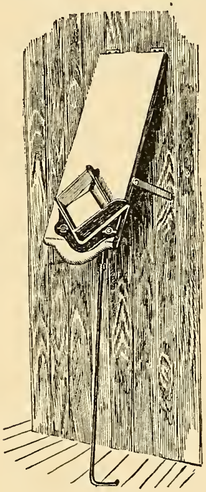


Fig. 135. — Section folder.

The pieces of foundation are usually fastened in place by a machine in which a heated metal plate is brought near or in contact with the wood at the point where the foundation is to be attached and the foundation is brought against it. The heated plate is then promptly removed and the melted wax fastens the foundation to the wood. Grooved sections which fasten a full sheet of foundation in place as they are folded are sometimes used (Fig. 132) while some beekeepers (especially in Europe) prefer a section split on top and sides in which the foundation is continuous through a row of sections.

The work of folding the sections, putting in foundation and placing them in supers should be done in advance of the honey-flow and this should usually be the winter employment of the comb-honey producer. Enough should be prepared to care for the maximum crop, for the beekeeper has no time for this work when the rush is on. Three supers for each colony should be the minimum number. The prepared supers should be carefully protected from dust.

Manipulation of the bees.

In the successful production of comb-honey, the skill of the beekeeper is more exercised than in any other branch of beekeeping. From this statement the inference should not be made that the producers of comb-honey are, as a class, better beekeepers than those who extract their honey, for there are many beekeepers who put sections on their colonies and yet fail to get the maximum returns and lose the best of the crop. It is true, however, that much of our knowledge of the best methods of handling bees has come from the work of the exceptional comb-honey producers.

It is useless to expect a weak colony to work well in sections and it is therefore first of all necessary for the comb-honey producer to see that each colony has an abundance of workers at the beginning of the honey-flow, as described in an earlier chapter. In the building up of the apiary in preparation for the honey-flow, it is often impossible to get all colonies up to the standard and it is a quite common practice to utilize the weaker colonies for extracted-honey production or to take frames of brood from the weaker colonies to build up those of nearly full strength (p. 259), thereby practically abandoning the weakest colonies for honey-production.

Keeping bees in proper condition.

If a colony is of maximum strength when the honey-flow begins, it is ready for the harvest. Every hive should be packed with brood and honey and should have an abundance of young bees. If the colony has previously occupied two stories, as many of them should if properly manipulated, they are reduced to one story and any extra frames of brood are used to build up colonies that need them. This crowding of the brood-nest, so essential to the highest success, is, however, just the condition favorable for swarming, and unless care is exercised the efforts of the beekeeper are rendered less effective. If the colony casts a swarm the working force is reduced and the two parts are not able to do as much as is possible without such a division. On the other hand, the manipulations of the beekeeper may prevent swarming, but still the bees may be put in such a condition that they do not work well. It is necessary not only that the bees be kept from swarming but that the gathering instinct shall overpower all other activities. Increase in the number of colonies during the honey-flow or just before it is therefore expensive and should be avoided.

Swarming is a far more serious problem in comb-honey production than in any other type of beekeeping. The beekeeper is therefore called upon to exercise all his skill in preventing and controlling this tendency. The manipulations used to prevent swarming are discussed in an earlier chapter. In comb-honey production the tendency to swarm is so marked that an examination of each colony once in seven to ten days is usually necessary to do the things that conditions may call for. In case swarms issue in spite of the precautionary measures, various methods are available for handling the swarm and for the disposal of the brood to best advantage, which have been previously discussed (p. 275).

Manipulation of supers.

One of the most important factors in success with comb-honey is putting the supers on in the right order and at the right time. This may not only do much toward preventing swarming, but is an important stimulus to storing the maximum amount of honey. No general rule can be laid down for the number of supers that should be put on a colony; they are simply units in the part of the hive devoted to storing which must be given to the colony as needed and not before or after. By proper management supers may be put on slightly before they are needed but they should usually not all be put on at once. Many beekeepers make their greatest mistake in this feature and wait until one super is filled and then remove it, substituting an empty one if needed. This not only cramps the colony more than necessary but, when the new super is put on, the bees go into it almost as slowly as they do into a super given at the beginning of a flow. In the meantime the brood-chamber is becoming clogged with honey at the expense of the brood. To give supers as needed necessitates careful observation of the sources of nectar. Supers should be given in time so that there is never a lack of some space for comb building. Furthermore, space for ripening nectar is needed and comb building should progress steadily so that the bees will never have honey for which there are no empty cells. If, early in the honey-flow, nectar is coming in rapidly, a new super may be added to strong colonies as

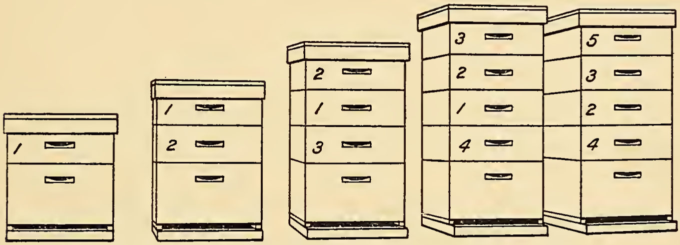


Fig. 136. — Diagram showing arrangement of the supers.

soon as work is well begun in the one put on previously. Weaker colonies should of course not be given supers so rapidly. In any event, supers should be added before the bees are in actual need of more storing space.

The position of new supers is to be determined by the probable future needs of the colony. If the prospects indicate that an additional super will be filled, it should be put below the supers already on, next to the brood-chamber, while if there is a probability that the additional super will not be used it should be placed on top, thus crowding the bees into the earlier supers. In slow honey-flows, supers may also be put on top. In a good honey-flow an empty super should be kept on top at all times so that it is available to the bees if the beekeeper is delayed in reaching the colony to give it more room. The proper order of the supers on the hive is shown in Fig. 136, it being assumed in this case that super 5 is the one which is used near the end of the flow. It will be noticed in the case of supers 1, 2 and 3, that after being placed just above the brood-chamber to be started, they are then put on the top in the next move. This carries up the wax-building bees where they are as far from the brood-chamber as possible and this is perhaps an important factor in swarm prevention.

Removal of supers.

Comb-honey intended for market should be removed as soon as possible after it is finished to prevent discoloration of the cappings, known as "travel stain." The extensive beekeeper does not have time to remove the sections individually but should give additional room just rapidly enough to make it possible to complete all the sections in a super about the same time. After the super is removed there are often some that are not completed and these may be sorted out in the shop and the unfinished ones may be put in supers and given to colonies. C. C. Miller believes that some colonies are better at this finishing work than others and so he chooses certain ones for this work. During the finishing, bees should be crowded to insure its being completed before the honey-flow ceases.

At the close of the honey-flow, the surplus space should be reduced and all supers in which no work has been done should be removed. As soon as practical, the surplus space should be reduced to one super but there should always be room for the ripening of new nectar. If desired, extracting combs may be used to receive the honey at the close of the honey-flow.

Caring for the crop.

In a heavy honey-flow most of the honey is removed before the flow ceases. In this case the bees are readily removed by smoking and brushing them out. At the close of the honey-flow, all the supers should be removed to prevent honey from being carried down to the brood-chamber and to keep the bees from propolizing the sections excessively. At this time bee-escapes (Fig. 31) greatly increase the ease of taking off supers and, while they are useful at any time, they are specially helpful after the honey-flow ceases. The honey should be taken to the shop and protected carefully from robbing bees.

Preparation of bait sections.

Before storing the supers, any unfilled sections should be sorted out and the partially filled ones may be given back to the bees to be emptied. If no disease is present in the apiary or in the neighborhood and if there are a considerable number of such sections, they may simply be exposed where the bees can get the honey from them and they should be left there until a day or two after the bees have ceased to visit them. Bees often leave sealed honey untouched under these circumstances. If there are only a few supers, they may be stacked on colonies and should be left there for a day after the bees have taken out the honey. In this way excitement is reduced to the minimum and general robbing is prevented. The emptied sections should then be saved for bait sections the following season.

Storage in supers.

The full supers are so placed in the honey-house as to permit free circulation of air, by laying them crosswise or by putting sticks between the supers. The storage room must be kept dry with the windows open (but screened) during warm weather. During damp, cool weather, the windows should be closed and the room may be heated artificially, sudden changes in temperature being avoided. If wax-moths are abundant, the honey may be fumigated with sulphur fumes or carbon bisulfide (p. 414).

Comb-honey should be prepared for market as speedily as practical after its removal from the hive. This is specially true if the honey granulates quickly. If it is necessary to store it until cold weather, the storage room must be kept continuously warm and dry.

Bulk comb-honey.

In Texas and in some other parts of the South, honey is frequently sold in the comb, being cut from large combs to any size desired. These pieces are usually put into a can, extracted-honey being poured over them to fill the spaces. This is commonly known as "chunk honey," but one German writer on beekeeping, in referring to this American product, inadvertently changed the ch to j. The advantages in producing honey in this form are: (1) it ships well; (2) crowding of the bees is not so necessary since perfect capping is not essential; (3) the bees work more readily in the larger combs, and (4) the beekeeper is not called upon to exercise so much skill in the manipulation of the colonies. The manipulations more nearly approach those incident to the production of extracted-honey. Since such honey usually sells readily locally and since beekeepers claim to receive relatively more for it than for extracted-honey, no serious objection can be raised to its production, but beekeepers should be warned that the general honey markets make no demand for honey of this type. Bulk comb-honey is produced in small quantities in all parts of the United States but, except in the regions mentioned, its production is confined to the less skilled beekeepers.

Bulk comb-honey for home use.

When all the honey produced is for home consumption, it is an excellent plan to have all the honey stored in shallow extracting frames, the length of the regular frames, but only $5\frac{3}{8}$ inches deep. Thin-super foundation may be used and the frames should not be wired. After being filled, the frames may be stored in supers and a family that consumes honey freely (as all families should) will make short work of the honey in a frame. For serving this honey, a convenient, though perhaps not artistic, method is to put the comb in a tureen. The frames may be refilled with foundation again and again. This is recommended to beekeepers with few colonies as simpler, cheaper and more profitable than comb-honey production.

Cut comb-honey for market.

Another style of package has recently been devised by the A. I. Root Co., Medina, Ohio, which is attractive and promises to have a great future. Small pieces of comb are cut, drained of the honey in the cut cells, wrapped in two thicknesses of waxed paper and finally put in an attractive carton. A number of these cartons are then packed in a box for delivery. The individual cartons are sold in dining cars, restaurants and hotels, naturally at a high price for the amount of honey served. So far the demand for this honey is limited, but beekeepers so situated that they have their winters free to put up and sell such honey may find it profitable. The comparative ease with which honey can be handled in this way suggests the desirability of a larger piece of honey, weighing perhaps a pound, wrapped in the same way. Such honey would ship better, it would all be "fancy" and should bring a high price on the market when a trade is built up. As far as the writer knows, this has not been tried in the United States.

CHAPTER XVIII

MARKETING THE HONEY CROP

The production of honey necessitates skill in the management of bees but the preparation of the crop for market and the selling of the honey are equally important to financial success and are sometimes equally difficult. In the following discussion, the procedure in getting honey into its final package ready for the consumer will first be considered, after which some general principles of honey selling, which apply to all types of honey, will be briefly given.

PREPARATION OF EXTRACTED-HONEY FOR MARKET

The beekeeping part of the work may be considered as ended when the honey reaches the tank or barrel. Honeys from different sources should so far as possible be extracted separately, for they are not of equal money value and the mixing of honeys of two colors or flavors usually reduces the wholesale price of the mixture to that of the least valuable.

Wholesale packages.

The usual wholesale package is the 5-gallon (60-pound) square tin can, such cans most often being shipped two in a crate (Fig. 137). Most of the foreign honeys that reach the United States markets come in barrels and these are also much used by southern beekeepers. In the West they are rarely used and are not considered safe. Considerable care must be exercised in their choice and in preparing them to receive the honey. Second-hand alcohol or whisky barrels are suitable, provided they have not been charred, but it is better to have them of some wood softer than oak. They must be kept in a dry place and before using must be made as dry as it is possible to get them, the hoops thoroughly tightened and the barrels tested. The inside may then be coated with paraffin as an extra precaution, but it should be remembered that the barrels must be tight first. If the wood in the barrel is wet, honey will take up this moisture, causing the wood to shrink and the barrel to leak. The usual sizes have a capacity of about thirty gallons, but those holding fifty gallons are frequently used. Unless one is producing a cheap grade of honey for which a cheap package is required, it is better and safer to use the 5-gallon tin cans.

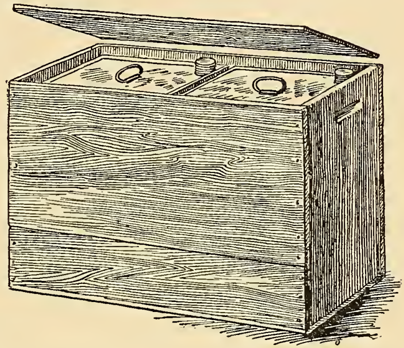


Fig. 137. — Crate holding two 5-gallon honey cans.

Retail packages for local markets.

In preparing extracted-honey for the local trade, it is customary to put it in cans or tin buckets of $2\frac{1}{2}$, 5 or 10 pounds capacity. Fruit jars and jelly glasses are also commonly used. These containers can be considered only as articles to hold honey and are entirely unsuitable for a market demanding neat attractive packages. They may often be used in less exacting markets and carry with them the advantage of being useful after the honey is eaten. To the beekeeper, they are desirable on account of their low cost in case his market will not pay a good price for his honey. Many beekeepers are, however, guilty of putting fancy honey into these unattractive receptacles, thereby stamping their product as a cheap article.

High-class retail packages.

The bottling of honey for the higher class markets requires considerable skill and the beekeeper usually leaves this work to the jobber, who has the necessary equipment and facilities for buying honey from various sources. There can be little question, however, that many beekeepers could well afford to go to the additional trouble and expense of putting honey in attractive, artistic packages for the trade that is ready to pay a good price for a high-class product.

An important consideration is the shape of the bottle. If possible this should not be a stock bottle such as is used either by other beekeepers or is obviously employed in the bottling of other commodities. An odd shape or a bottle made for the purpose on an original design will prove a good advertisement. The neck of the bottle must of course be wide. A cheap, homely label will do much to render a package unattractive. Above all, a label should not be used which obviously is used by hundreds of beekeepers and which has the name of the producer printed in a space left vacant in the making of the original design. It is possible to make labels in this way which do not tell their history too loudly, but to a bottler who sells honey in considerable quantities the expense of having a distinctive, attractive label designed and lithographed will be many times repaid. The beekeeper should note that the extensive bottlers have learned this.

Blending.

In a single apiary it is impossible to get honey of the same flavor and color year after year because of differences in the nectar secretion, due to climatic differences. It is rarely desirable to attempt to bottle honey of one source, such as white clover, because of seasonal variations which the consumer does not understand. If, however, honeys from two or more sources are blended, the seasonal variations are hidden and it is possible to give the consumer honey which looks the same and has the same taste year after year. In making up a blend, it is furthermore not desirable to use all water-white honeys, for at some time the supply of such honeys may be limited, and the consumer will not understand why honey of a certain brand has suddenly become darker. It must be remembered that the average consumer is ignorant of the facts that honey varies and that honeys from different sources are unlike in color and flavor and it is useless for one bottler to attempt to educate the entire community on these points in which the consumers have no interest. If he sells pure honey that has a good flavor and if he can duplicate it when desired no further information is asked by the average consumer. In making a blend it is a good plan to include some sage or tupelo honey as these granulate slowly and granulation injures the salability of bottled honey. An important consideration is the choice of honeys which can be obtained in quantity year after year. To bottle honey for the better markets, it is, therefore, usually necessary to buy some from various sources and the beekeeper who retails honey on a considerable scale should not depend solely on his own apiaries to supply him. In fact, even an extensive series of out-apiaries will not go far toward supplying an energetic salesman.

Argument for blending.

In the preparation of this chapter the author consulted a beekeeper of experience and the preceding paragraph was criticized on the ground that the blending of honeys hides the characteristic flavor of honey from each source and, therefore, the flavor of a blend is usually inferior to that of some of the honeys that go to make it. To a connoisseur this is true, but a comparison with another commodity may serve to show that to the average palate this is not the case. The average purchaser of tea buys a certain brand of package tea because he knows it is dependable and uniform. He does not know nor does he care what teas are mixed in this blend, but he may know enough about tea to know that an individual kind of tea varies and he does not like the variation. On the other hand, there are connoisseurs in tea who, through education and cultivation of taste, are just as particular about the teas they use as the beekeeper is about his honey. Probably we could all become educated in teas but do not consider it worth while. Similarly, the consuming public could become educated in the flavors of honeys but it is not considered worth the effort. Therefore, it is to the interest of the beekeeper to furnish a honey which is the same in color and flavor year after year, so that the variation which comes with honey from one source may be eliminated. It is almost a crime in the eyes of a northern beekeeper to mix any other honey with that from white clover but, as he is not mixing honey for himself, he should give the consuming public what it demands.

Heating honey.

In mixing honeys from various sources and in liquefying for bottling those that may be granulated, they must be heated. Direct heat must not be employed and it is a bad practice to run steam pipes through the honey tank. Heating must always be done in a double boiler and the temperature of no part of the honey should ever exceed 160° F. A higher temperature darkens it and spoils the flavor. A high temperature not only drives off the volatile substances which give honey the aroma, but a decomposition of a small part of the sugars takes place, which causes darkening. In this decomposition, products are formed which cause honey to respond positively to one of the chemical tests for invert sugar, which is a common honey adulterant. The beekeeper who overheats his honey not only injures it but he may find himself accused of adulteration. The best plan is to bring the honeys to a temperature of about 130° F. and to hold this temperature for two or three hours or until every crystal has dissolved. The temperature is then raised quickly to 160° F., at which point the honey should be put into warm bottles and hermetically sealed while hot. The bottles should be filled as full as possible so that there will not be large air spaces at the tops. The mixing and heating tank should be deep and the honey should be drawn from the bottom to avoid the scum which rises to the top and to free the honey entirely from air bubbles which not only detract from the appearance but hasten granulation.

Granulation of honey in bottles spoils the appearance but by using honeys which granulate slowly (*e.g.* sage and tupelo) in the blend and by treating in the manner just described, granulation may be prevented for a considerable time. Beekeepers often put on their labels the erroneous statement that all honeys granulate and that this is a proof of purity. Artificial invert sugars which are sometimes used in the adulteration of extracted-honey frequently granulate quickly. The adding of glucose to prevent granulation, without so indicating on the label, is of course adulteration and is not only dishonest but unlawful.

The granulation of honey after bottling is retarded (1) if the honey is free from air bubbles, (2) if the bottle is filled to the top, (3) if no scum has been poured into the bottle with the honey and (4) if not a single honey crystal is unmelted at the time of bottling. If these precautions are taken even the rapidly granulating honeys will remain liquid for a considerable period.

PREPARATION OF COMB-HONEY FOR MARKET

In comb-honey production the beekeeper must do more of the work of preparing his product for the consumer since he is producing honey in retail packages. Recently some honey jobbers have been buying honey and cleaning and grading it themselves, because so many beekeepers fail to do this work carefully, but a better price can be obtained for comb-honey if it is properly graded and cleaned before selling.

Cleaning the sections of propolis.

There is usually some propolis on the sections which should be removed. Since the removed propolis adheres to other sections if it comes in contact with them, it is best to have a bench made with a box or tray into which the propolis will fall or to raise the sections an inch or two above the table top on a block while they are being cleaned. These appliances also make it possible to reach the bottom of the section in scraping. Propolis is usually scraped by hand, a sharp steel case-knife being used. If the knife does not remove all propolis and stain, sandpaper will complete the work. The scraping of sections requires care to prevent damaging of the honey.

Grading.

In no other type of honey package is so much care needed to grade properly as in comb-honey. The grading rules which are most applicable to all conditions of comb-honey production throughout the United States are those adopted by the National Bee Keepers' Association, February 13, 1913, which are here given.

Sections of comb honey are to be graded: First, as to finish; second, as to color of honey; and third, as to weight. The sections of honey in any given case are to be so nearly alike in these three respects that any section shall be representative of the contents of the case.

I. Finish:

1. *Extra Fancy.* — Sections to be evenly filled, comb firmly attached to the four sides, the sections to be free from propolis or other pronounced stain, combs and cappings white, and not more than six unsealed cells on either side.

2. *Fancy.* — Sections to be evenly filled, comb firmly attached to the four sides, the sections free from propolis or other pronounced stain, comb and cappings white, and not more than six unsealed cells on either side exclusive of the outside row.

3. *No. 1.* — Sections to be evenly filled, comb firmly attached to the four sides, the sections free from propolis or other pronounced stain, comb and cappings white to slightly off color, and not more than forty unsealed cells, exclusive of the outside row.

4. *No. 2.* — Comb not projecting beyond the box, attached to the sides not less than two-thirds of the way around, and not more than sixty unsealed cells exclusive of the row adjacent to the box.

II. Color:

On the basis of color of the honey, comb honey is to be classified as: first, white; second, light amber; third, amber; and fourth, dark.

III. Weight:

1. *Heavy.* — No section designated as heavy to weigh less than fourteen ounces.
2. *Medium.* — No section designated as medium to weigh less than twelve ounces.
3. *Light.* — No section designated as light to weigh less than ten ounces.

In describing honey, three words or symbols are to be used, the first being descriptive of the finish, the second of color, and the third of weight. As for example: Fancy, white, heavy (F–W–H); No. 1, amber, medium (1–A–M), etc. In this way any of the possible combinations of finish, color and weight can be briefly described.

Cull honey.

Cull honey shall consist of the following: Honey packed in soiled second-hand cases or that in badly stained or propolized sections; sections containing pollen, honey-dew honey, honey showing signs of granulation, poorly ripened, sour or "weeping" honey; sections with comb projecting beyond the box or well attached to the box less than two-thirds the distance around its inner surface; sections with more than 60 unsealed cells, exclusive of the row adjacent to the box; leaking, injured, or patched-up sections; sections weighing less than ten ounces.

The Colorado Honey Producers' Association on December 13, 1911, adopted a set of grading rules which are well adapted to the market conditions which Colorado beekeepers meet. They are not suitable for grading all comb-honey because the requirements on color, weight and finish are not sufficiently separated. These rules have recently been revised.

In the grading rules of the National Bee Keepers' Association the weight is classed in three divisions, but, since the net-weight amendment is in force (since September 3, 1914) and since comb-honey in a section is considered a package of food, these divisions are no longer suitable. It is now necessary under the law that each section of honey which enters interstate commerce be marked with the net weight. This is construed to mean the weight exclusive of the wood but including the wax. Sections have quite commonly been called "one-pound sections," but unless a comb is exceptionally well filled it does not weigh a full pound. Beekeepers have usually sold these by the piece but the consuming public has known little of the actual weights. The name "one-pound section" is incorrect and should be dropped. This law will benefit the beekeepers who use full-size sections and will help to expose the few who have been using undersizes.

In grading comb-honey some beekeepers place the sections directly into shipping cases, but since the picture of each grade is a mental one only, it is perhaps preferable to make separate piles of each grade where they can be seen throughout the grading. Of course when similar sections enough to fill a case are ready they may be cased, marked and prepared for shipment. It will be found advantageous, especially to the retailer, to make smaller sub-grades to give greater uniformity to the contents of each case.

Shipping cases.

The case for shipping comb-honey which is most commonly used is one holding 24 sections in one tier (Fig. 138), but a two-tier case is preferred by many western beekeepers. Other types are used for certain local markets. It is customary also to make the shipping cases with glass fronts so that the case may be used for displaying the honey. A shipping case of corrugated paper without glass is gaining in popularity.

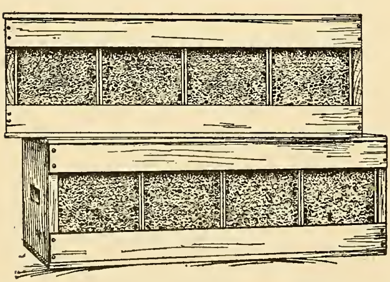


Fig. 138. — Shipping cases for comb-honey.

Glazed sections.

It is not unusual for pieces of glass to be fastened to each side of sections by means of tacks or tin triangles or by strips of paper before being offered for sale, thus protecting the honey from dust and insects. Formerly it was not uncommon to sell the package by weight, in which event the glass was sold at a considerable profit. The amendment to the Food and Drugs Act requiring that each package of food be marked with its net weight will probably injure the market for glazed sections.

Use of cartons.

The modern retail market deals chiefly in package goods and the purchaser usually sees only a carton or case and not the food that he buys. Similarly comb-honey is now frequently put in a carton and this plan commends itself because of the security from dust and insects. The cheap cartons that slip over filled sections are not so efficient neither are they so attractive as those that may be completely sealed. Most cartons are now made of thin cardboard but a sealed corrugated paper carton would be more serviceable in the delivery of the honey from the retailer. The comments made on labels for extracted-honey may well apply to the printing on the comb-honey carton. Individuality and attractiveness are essential in making an appeal to the fancy trade and the carton will appeal to the consumer as a more sanitary package than an exposed section. When cartons are used, the corrugated paper shipping case is preferable since there is no advantage in a glass front.

Shipping comb-honey.

The fragile comb in a section of honey carries considerable weight as compared with the heavier reinforced combs in the brood-chamber of the hive. In cool weather, when the wax becomes brittle, it is less capable of withstanding jars and at any time comb-honey is not capable of withstanding much hard usage. Naturally a small package like a single shipping case is easily thrown about by careless expressmen and consequently it is safer to ship in larger packages. For this reason and also to protect the wooden shipping cases from dirt and to prevent the breakage of the glass, several shipping cases are usually packed together in a crate. Comb-honey should be shipped to its final destination before cold weather. For car load shipments it is safe to pack in a car without crates since the shipping cases are not handled individually en route.

PREPARATION OF BULK COMB-HONEY FOR MARKET

The packing of bulk comb-honey does not differ essentially from that for extracted-honey except that the cans or bottles must have openings sufficiently large to admit the pieces of comb.

The packing of the small pieces of cut-out comb has been sufficiently described in the paragraph in which they were discussed.

PREPARATION OF GRANULATED HONEY FOR MARKET

As has been shown previously, some honeys granulate quickly to a semi-solid condition and some beekeepers have developed a market for it in this form. Alfalfa honey is exceptionally fine for this purpose. The honey may be poured while in a liquid condition into special paper bags or oyster pails and allowed to granulate before being sold, though such packages are somewhat crude. A better method is to allow it to granulate in larger vessels (such as 5-gallon square cans) after which it is removed and cut into bricks as butter is cut. It is then wrapped in waxed paper and put in a neat carton. Since this is a comparatively unknown article of food to the average consumer, its source and nature should be stated on the package. Granulated honey should not be allowed to remain on store shelves until warm weather, for the crystals may dissolve, causing considerable loss and inconvenience. The market for such honey is not well developed but it is worthy of considerable attention since many people after trying this honey prefer it to liquid honey.

WORDING OF LABELS

Beekeepers are often at a loss to know just what should be put on labels in order to conform with the various provisions of pure food laws. In the case of the net-weight amendment of the Federal Food and Drugs Act, the requirement is definite, that the net weight or volume shall be indicated. Since bottles vary somewhat, it is best to test a number to find the minimum and then have on the label, "Net weight not less than — oz." or "Minimum weight — oz." Aside from this there is no difficulty. If the label tells the truth about the contents, the beekeeper will not get into trouble. He should not label his honey "Pure clover honey" if it is partly sage honey, nor should he attempt to deceive the customer by labeling it "Clover brand honey" if it is not as nearly all clover honey as it is possible to get. Some beekeepers have worried over the fact that even in the purest honey there is possibly a little nectar from some other source. If this causes worry it may be entirely avoided by stating the exact facts. Furthermore it must be remembered that the officials who enforce these laws are sensible men and a slight discrepancy on the label would probably not be considered a violation of the law, provided there is evidently no intent of misrepresentation. The various pure food laws are designed to protect the purchaser against fraud and the honest producer against dishonest competition. It may perhaps be considered as ingratitude, therefore, if a beekeeper complains at the necessity of telling the exact truth on his label. Beekeepers are almost unanimously opposed to the adulteration of honey and should do everything possible to aid in the enforcement of these laws.

DEVELOPMENT OF THE HOME MARKET

Too many beekeepers ship their honey as soon as it is marketable to the chief honey markets. While there is demand in the wholesale markets under normal market conditions for all the honey that is shipped in, there are many beekeepers who could dispose of their own crops and even buy considerable honey from other beekeepers to sell in the local markets. Of course, the retail price should be considerably more than the wholesale price, and if the beekeeper does not have other work that brings him more than the retail profit he may well turn his attention to the development of his home market. He will probably find that his home town consumes little honey until he undertakes to advertise his products, but the experience of those who have tried it is that the per capita consumption of honey is easily increased to many times what it was formerly. Individual cases of success could easily be enumerated. If the beekeeper is in a small town it is probably known to many of the inhabitants that he keeps bees and in a larger town or city he can easily let this be known without much cost for advertising. The consumer will have confidence in the purity of the honey if it is bought directly from the producer, and if the beekeeper will go from house to house letting the housewives sample his honey, he will not only sell hundreds of pounds at a better price than the wholesale price but will provide a good food as a substitute for the cheap jams and syrups so much used.

To stimulate trade and create public comment, no better advertisement can be obtained than an observatory hive filled with bees. When such a hive is placed in a store window, the sidewalk is often blocked with the curious. Interest can be increased by giving an exhibition of handling bees or of extracting honey; the crowd will grow and people who have not tasted honey for years will remember that they are fond of it and will buy some. A peculiarity of honey is that it is usually easier to sell the second bottle or section than it is the first. The ingenious beekeeper will think of a dozen ways to use his bees or his commonest manipulations as advertising matter and he will probably be surprised not only at the ignorance but also at the interest of the public concerning anything pertaining to bees. Another fruitful field is found in making exhibits at fairs.

In deciding the price of his product either at wholesale or retail, the beekeeper should consult the crop reports. The bee journals give valuable information on this subject, and in 1914 the United States Department of Agriculture through the Bureau of Crop Estimates began to furnish crop reports on honey. In Ontario the Beekeepers' Association furnishes its members with this information.

CO-OPERATIVE SELLING

In discussing the sale of honey, mention should be made of co-operative selling. The best example of this to be found in the beekeeping industry in the United States is the Colorado Honey Producers' Association, which for several years has successfully looked after the interests of its members in the purchase of supplies and in the sale of honey. This organization is similar in nature to the agricultural co-operative organizations found in Europe and parts of the United States. Beekeepers who have similar honey and who are so situated as to be unable to develop home markets should consider the possibilities of this method of selling at wholesale.

CHAPTER XIX

THE PRODUCTION AND CARE OF BEESWAX

Beeswax was formerly an important part of the products of the beekeeper for, at the close of the season, certain colonies were chosen to be killed after which the honey and wax were removed. With the introduction of modern methods, honey-production increased, but there was less beeswax since the combs are not destroyed, except as they are accidentally broken. In spite of this entire change of policy on the part of the beekeeper, beeswax is a part of the product of the apiary which should not be neglected. Cappings from extracting, pieces of comb built in parts of the hive where frames have accidentally not been supplied, burr and brace combs and combs accidentally broken in extracting may be mentioned as sources which in the aggregate furnish the beekeeper with a considerable amount of wax, while occasionally the combs of diseased colonies still further increase the supply. The preparation of this wax for market often involves considerable labor and the beekeeper too often neglects it on that account. However, if pieces of comb are carefully preserved from wax-moth larvæ, they may be kept until there is an accumulation sufficient to justify the necessary expenditure of time or combs may now be sent to central stations or dealers for rendering.

Rendering the wax.

Beeswax is ordinarily removed from the combs by heat. Cappings from extracting and new combs may be melted up and the wax allowed to harden in a cake since these contain little or no foreign matter. If any dirt is present, it will settle at the bottom in cooling and may be cut from the cake. A common method for melting combs and pieces of wax is by the use of the solar wax extractor, the combs being put in a box covered with glass and the heat of the sun, being confined by the glass, melts the wax, which runs into a lower compartment where it hardens. In Hawaii, the beekeepers have unusually large solar extractors to melt their cappings as well as other pieces of comb. A more rapid method is to place the combs in a double boiler (Fig. 139), the combs being either hung on cross supports or thrown on a screen (like that in an uncapping tank) and as the wax melts it runs out a gate provided for the purpose. A less efficient method is to boil combs in water and skim off the wax. Doctor Miller finds a dripping pan in the oven of the kitchen stove a good substitute for a solar extractor in the winter.

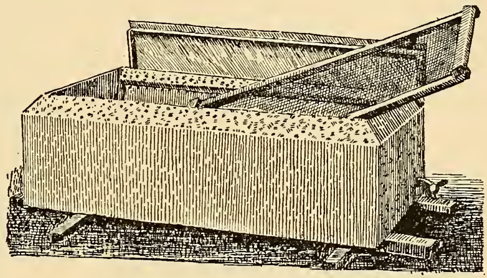


Fig. 139. — Double boiler for melting combs.

Wax presses.

These methods are satisfactory for clean combs, free from pollen, cocoons and other substances, but in the case of old combs much of the wax adheres to the cocoons and is not liberated. To render old combs they should (if the weather is cold) be broken up and then soaked in water after which they should be put into a sack, heated and pressed under strong pressure while hot. In this way most of the wax is removed from the cocoons. There are three types of press in common use. In the steam heated press the mass of comb is kept hot by steam generated below during the process of pressing out the wax, which drops down and is drained off. In the hot water press (Fig. 140), the whole process takes place under hot water, the liberated wax rising to the top where it is removed. A method in common use is to melt up the combs in a boiler and dip off the melted mass into a burlap bag which is then subjected to pressure, no additional heat being supplied. Small presses of these types may be purchased from dealers in supplies but if there is much wax to be rendered, larger machines of the hot water type should be made to which more pressure may be applied. In any type of press it is desirable to press the bag of comb thoroughly and then loosen it to allow the combs to be filled with water before pressing again. This may be repeated several times until no more wax is liberated. It is advised that soft water be used in rendering combs.

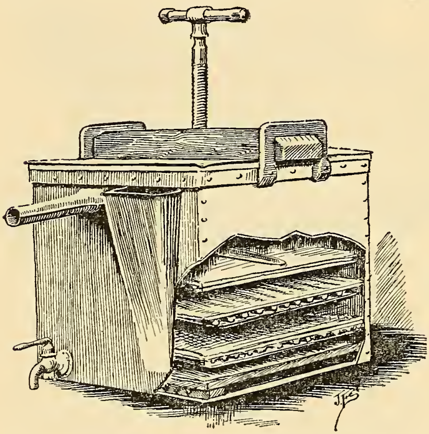


Fig. 140. — Hot water (Hershiser) wax press.

The residue after the removal of the wax is commonly known among beekeepers as "slumgum" and since beekeepers seem to have a vocabulary of their own and since there is no other name for this substance we must perforce accept it. In most cases, slumgum contains a considerable amount of beeswax, some samples supposed to be practically free being found on analysis to contain forty per cent beeswax. Cocoons entirely free from beeswax are brownish-gray and cannot be pressed into a hard cake. If then the slumgum after removal from the press forms a black hard mass, the beekeeper may rest assured that it still contains wax. This may be shown quickly by putting some in the fire, where it burns briskly. It is almost permissible to believe that every man who makes a wax press thinks that no other wax press could ever equal it and some of the most powerful and elaborate ones that have been demonstrated to the author were the least efficient.

Removing wax by dissolving.

In Europe, the wax in slumgum is sometimes dissolved out with turpentine or some other light oil and the solvent is then regained by distillation, but there is no record of this being done on a commercial scale in America. By no other means can all the wax be removed, but it is claimed that this "extracted wax" differs slightly both physically and chemically from wax removed by melting. If a solvent is used carbon tetrachloride would probably be the most satisfactory.

Cleaning wax.

After the wax is extracted, it usually contains many foreign particles. While still in a liquid condition the wax should be placed over an inch or more of water in a vessel which will conserve the heat so that the wax can remain liquid for a considerable time. If a heavy wooden box is available this is good, but even better results may be accomplished by packing a thinner vessel in a box filled with sawdust. If it can remain liquid for twenty-four hours or more the results are best. Just before hardening (when the temperature is just above the melting point of wax) it should be carefully dipped off from the top into vessels to cool. These vessels should either have the top wider than the bottom or have smooth straight sides which are covered with a thin layer of honey just before the cooling wax is poured in. Every beekeeper should know that wax and honey never mix. The particles of dirt will have settled to the bottom and when the wax appears discolored the remainder may be left to harden in the insulated vessel. The dirt may then be scraped away from this cake, and if there is much wax still in the dirt it may be kept to put in the next melting and the dirt will gradually be eliminated.

Extensive dealers in wax use a little sulfuric acid to assist in cleaning the wax. Manufacturers of comb-foundation usually advise against this practice because beekeepers often use too much acid. A proportion of not more than one pint to forty gallons of water should be used, this water being sufficient for the melting of 750 pounds of wax.

Granulation of wax.

In rendering, wax may be formed into an emulsion due to the presence of gums in the honey which adheres to the combs and on hardening this resembles a thick paste of corn meal. Many beekeepers believe that this is pollen from the combs and throw it away. It is, however, almost solid wax. In melting up combs which had contained honey-dew on one occasion the author found the whole mass of wax in this condition after cooling. Such granulated wax (as it is usually called) should be melted slowly by dry heat (not in water) and with care the wax may be saved. It is claimed that this emulsion is less common when sulfuric acid is used in clearing and Dadant claims that it is increased by excessive heat. The important fact for the beekeeper is that this is not pollen and should be saved.

Bleaching wax.

The bleaching of wax is rarely done by the beekeeper and requires little mention in a book on beekeeping. It is interesting to note, however, that waxes from various regions vary greatly in bleaching, some of the darker waxes being easily bleached while some lighter waxes do not respond to this treatment. Presumably this is due to the kind of honey and pollen available to the bees when the wax was secreted. Wax dealers claim that wax from some of the southern States is the best obtainable in the United States for bleaching. Usually wax is cut into thin ribbons and exposed to sunlight, but chemicals are sometimes used in bleaching.

White (bleached) wax differs physically and chemically from yellow wax.

Adulteration of wax.

Fortunately this also is a subject in which beekeepers take no interest, but nevertheless beeswax is frequently adulterated by the addition of mineral waxes, wax from other insects or tallow or by cruder methods, such as the addition of gypsum, starch or flour. The detection of these adulterations (except the cruder ones) must usually be left to the chemist, but beekeepers rely on what is known as the "break test." If a cake of pure wax is cracked it presents a granular surface which is not seen in wax with even a small percentage of paraffin. The determination of the specific gravity is also useful to the beekeeper in confirming his suspicions of a lot of wax.

Preparation of wax for market.

Usually the beekeeper ships his cakes of wax in bags or barrels to the wax dealer and most commonly to the manufacturer of comb-foundation. To see a great pile of these cakes as they come in is sufficient to convince one that beekeepers are not as a rule sufficiently careful in cleaning their wax. One large company of beekeepers puts up wax in cakes just large enough to go into a shipping case such as is used in shipping two 5-gallon square cans of extracted-honey. Each cake is wrapped in paper and there is not a particle of dirt on the bottom of the cake. This firm receives an equivalent of about two cents a pound more than beekeepers similarly located and in fact has received over five cents a pound more than beekeepers through whose territory the wax passes on its way to market. The fact that they produce several thousand pounds of wax a year makes this a considerable item and it may not be so well worth while for a beekeeper with only a little wax to ship at one time.

Special production of wax.

In the previous discussion it is assumed that beeswax is always a by-product of the apiary, but the manipulation of bees for the production of wax is a phase of beekeeping which might well be tried in some tropical or sub-tropical regions. If the honey is of low grade and the cost of transportation is excessive, this should be tried. In Hawaii the author advised [1] that by special manipulations the honey-dew honey be converted into wax and this has been tried. While the manipulation is reported not materially to have reduced the output of honey-dew honey it did increase the wax considerably. In Porto Rico and in other tropical countries there are good locations from which the transportation of honey is almost impossible and the author advised [2] that this be tested out in Porto Rico. There are records in bee journals of this being done with success in such localities but details are lacking so that to the present the subject is one chiefly of speculation. It is usually believed that from seven to twenty pounds of honey are consumed in the building of one pound of comb and in the literature the preference is given to the higher estimates. However, bees appear to build comb much more quickly than usual under some conditions, and this suggests that because of some physiological condition the building of comb is more economical. Careful work as to the cost of wax in terms of honey is greatly needed, as well as tests as to the possibility of producing wax where honey is worth only about three cents a pound at the apiary.

Uses of beeswax.

The only way in which the beekeeper utilizes beeswax to any extent in his work is in the form of comb-foundation. This is made of thin sheets of pure beeswax embossed with

[1] Phillips, E. F., 1909. A brief survey of Hawaiian beekeeping, U. S. Dept. of Agric. Bureau of Entomology, Bul. 75, Pt. V.

[2] Phillips, E. F., 1914. Porto Rican beekeeping. Bul. 15, P. R. Agric. Exp. Station.

the bases of cells of the comb. It is supposed that Mehring in 1857 made the first comb-foundation and during the next twenty years some progress was made, but not until Root (1876) made a machine by means of which foundation is made between rollers was much advance made. Repeated and continuous efforts to improve the product have led to great advance in the reliability of the manufactured foundation and comb-foundation is now used by all progressive beekeepers. Better results are obtained if the wax is sheeted and then put between the rollers under considerable pressure, and as a result the home-made article is less dependable than that made in well-equipped factories. Over 500,000 pounds of beeswax is annually made into comb-foundation in the United States. The Rietsche press is used in Europe but rarely in America. Two concrete or plaster of Paris molds are made so that if hot wax is poured on one and the other applied the wax is molded to foundation. This foundation is soft, breaks easily and is more wasteful of wax than that made on rolls.

As was stated earlier, comb-foundation is made of pure wax. It is reported that in Europe it is sometimes adulterated by adding paraffin or cerasin, but it is claimed that when this is done the foundation is not easily accepted by the bees and sags badly after the comb is built. It may be stated that the manufacturers of comb-foundation in this country do not practice this deception and the author has personal knowledge of several cases in which these manufacturers have rejected shipments of adulterated wax even when offered at a very low price. This should give the American beekeeper confidence in the marketed product.

In addition to the use of beeswax in beekeeping it has many uses in the arts, sciences and industries. It is extensively used in making candles, which are not molded as are tallow candles but are made by pouring, drawing or dipping. Beeswax candles are used chiefly in church ceremonies. It is also used for making furniture and leather polishes, sealing and grafting waxes and in making certain varnishes. It is also used in electrical work as an insulation and to wax threads, especially in sewing leathers. Numerous salves and cosmetics in which beeswax is an ingredient are recommended in books on beekeeping, but it is surely safer to take the advice of a physician on these matters.

In view of the fact that American beekeepers produce relatively little beeswax in proportion to the extent of the beekeeping industry, it is necessary to import a considerable amount from other countries to supply the heavy demands. This amounts to about 700,000 pounds annually.

CHAPTER XX

THE CARE OF BEES IN WINTER

For honeybees to survive the winter season in cold climates it is necessary that they be able to generate considerable heat. They cannot hibernate as do solitary insects and they cannot migrate to warmer climates. The only method open to them is, therefore, the storage of food and the production and conservation of heat when the outer temperature falls below the critical temperature, 57° F. The behavior of the cluster during the winter season has been discussed in an earlier chapter (p. 88).

Losses in winter.

That the winter problem warrants considerable investigation and study is shown by the fact that American beekeepers annually experience an average loss of probably ten per cent of their colonies. The value of these amounts to several million dollars and this loss and the weakening of colonies serve further to discourage the beekeeper and to reduce his income the following year. In certain years the losses have been excessive. The season of 1884–85 stands out in the history of American beekeeping as one of terrible devastation. During the winter of 1903–04 probably seventy per cent of the bees in New England died while in 1909–10 the loss was probably fifty per cent in the northeastern United States. The winter of 1911–12 was also one of heavy mortality, the actual death of colonies costing the beekeepers in the eastern United States millions of dollars. The problem is therefore one of vital interest to the beekeeper and is one of the most important in the development of the industry.

Object of winter protection.

In providing extra protection to the colonies outdoors or in placing them in special cellars, the object of the beekeeper is to reduce the expenditure of energy on the part of the bees. As was shown earlier (p. 128), a worker bee may for all practical considerations be considered as capable of only a certain amount of work and when this work is performed the bee dies. Consequently if too much energy is expended during the winter the entire colony may die, or if some bees still live they are unable to do the work required of them in the spring. To conserve the energy to the fullest extent there are numerous external factors which must be considered by the beekeeper in planning for the winter.

Requirements for successful wintering.

Before discussing the methods advocated for the care of bees in winter, it will be well to name the factors which are essential to the activities of bees during this season. First of all, to winter well, a colony must be large enough to generate heat and to conserve it economically. It should also contain a great number of young bees, full of vitality and capable of prolonged heat production should this become necessary. To accomplish these requirements breeding should be prolonged in the fall. The colony should also have a good queen capable of keeping up egg-laying rather late and then able to permit the colony to build up rapidly to full strength the following spring.

Winter stores.

The colony should be provided with an abundance of food of good quality. No food better than good honey has ever been found for bees and the safest plan is to leave enough in the hives to supply the bees without feeding. Not all honeys are equally good and in general it is safe to consider the lighter honeys preferable. The fall honeys are not considered as good as those obtained earlier. There are exceptions to these statements, however, since buckwheat honey is satisfactory. Most honeys from tree sources are not so good as those from smaller plants because of the higher gum content. Honey-dew honey should not be left in the hives for winter stores, but if some is present the danger may be reduced by feeding ten pounds or more of sugar syrup after brood-rearing ceases. In case the colony is found to be short of stores a syrup made of granulated sugar may be fed. If the feeding is done early, one part of sugar to one part of water (by measure) is a proper proportion, but for later feeding one part of water to two and one-half parts of sugar is preferable. To the latter syrup, add one teaspoonful of tartaric acid to fifteen or twenty pounds of sugar while it is being heated to change the cane sugar to invert sugar. Heating should be continued until every crystal is dissolved. Late feeding should be done rapidly. The use of candy for colonies which exhaust their stores in winter should be considered as an emergency treatment and nothing but granulated sugar should be used in making the candy. Before cold weather arrives each colony to be wintered out of doors should have in the combs thirty pounds of honey and preferably more.

Cause and effects of humidity in the hive.

In winter, especially in a cold or poorly ventilated cellar, the atmosphere in the hive may become so laden with water vapor that water will condense on the cover, combs and sides of the hive, drop to the bottom board and even run out the entrance. The source of this moisture is, of course, the food of the bees. Honey is a carbohydrate, and when consumed ultimately becomes carbon dioxid and water, one gallon of honey producing approximately one gallon of water. Unless the moisture is carried off in the form of vapor by convection currents in the atmosphere, it will be condensed in the hive, for bees do not ventilate the hive by fanning when clustered.

The condensation of water may be prevented by raising the temperature, by abundant ventilation or by artificial drying, as by the use of unslaked lime. These methods may be applied in the bee cellar. It should be recalled that an increase in the temperature of the atmosphere increases the capacity of the atmosphere for water vapor and thereby decreases the relative humidity.[1]

Bees need water in winter but they get enough in their food provided the temperature does not get so high that the relative humidity of the outer air is too low. The optimum relative humidity has not been determined and, in fact, virtually no observations have been made on the relative humidity of the atmosphere of the hive or bee cellar. Probably the great diversity of opinion as to the best temperature for the bee cellar is due to the unrecorded differences in the relative humidity of the various cellars observed.

Effects of ventilation.

Ventilation of the hive and of the bee cellar depends upon the currents of air caused by the differences in temperature in two points, since bees do not mechanically ventilate the hive in winter. The movements of air serve not only to remove carbon dioxid and bring in oxygen but, probably more important, they carry out the surplus water vapor. Abundant ventilation is beneficial and becomes harmful only if the temperature is too greatly reduced thereby. It has been determined that bees survive in an atmosphere which contains an unusually high percentage of carbon dioxid but it is not wise to err on that side.

Source of heat and effects of changes of temperature.

It has been determined by Demuth and the author [2] that bees generate heat in winter by muscular activity and that

[1] The beekeeper interested in cellar wintering will do well to consult Marvin, 1912, Psychrometric tables, Weather Bureau Publication 235 and other works dealing with the relation of relative humidity to temperature.

[2] Phillips and Demuth, 1914. The temperature of the honey bee cluster in winter. U. S. Dept. of Agric., Bulletin 93.

undisturbed broodless bees generate virtually no heat between 57° and 69° F. (Fig. 141). When the temperature of the air about the bees falls below 57° the bees form a cluster and raise the temperature, often almost to blood heat. It follows that when the temperature of the bees is above 57° and below 69° F. they do less work than at other temperatures and their energies are thereby conserved. However, to raise the outer temperature to 57° F. often so reduces the relative humidity of the surrounding air as to create excitement in the cluster and thereby to destroy the desirable condition. Other factors not yet worked out probably have a bearing on this problem. The majority of beekeepers consider 40° to 45° F. as the best cellar temperature, but it is clear that the temperature can usually be raised to at least 50° F. with beneficial results. Humidity and ventilation are so intimately connected with temperature that one cannot be investigated separate from the others.

Disturbance.

Any factor which induces undue activity in the winter must be considered as a disturbing factor. For example, low temperature, improper humidity, poor food or insufficient ventilation create an undue excitement which should be avoided. Disturbance is usually considered, however, as applying to manipulation of the colony or to jarring while the colony is clustered. Any such circumstance causes the colony to raise the temperature, which may not again become normal for many hours. All manipulation or handling is to be avoided, therefore, especially in cold weather or in the cellar. Colonies sometimes begin brood-rearing in winter, usually induced by some improper outside condition. The care of the brood then causes a high temperature and corresponding excessive activity which decimates the colony. Brood-rearing should so far as possible be avoided until the bees can fly freely.

In this connection it will be recalled that breeding often

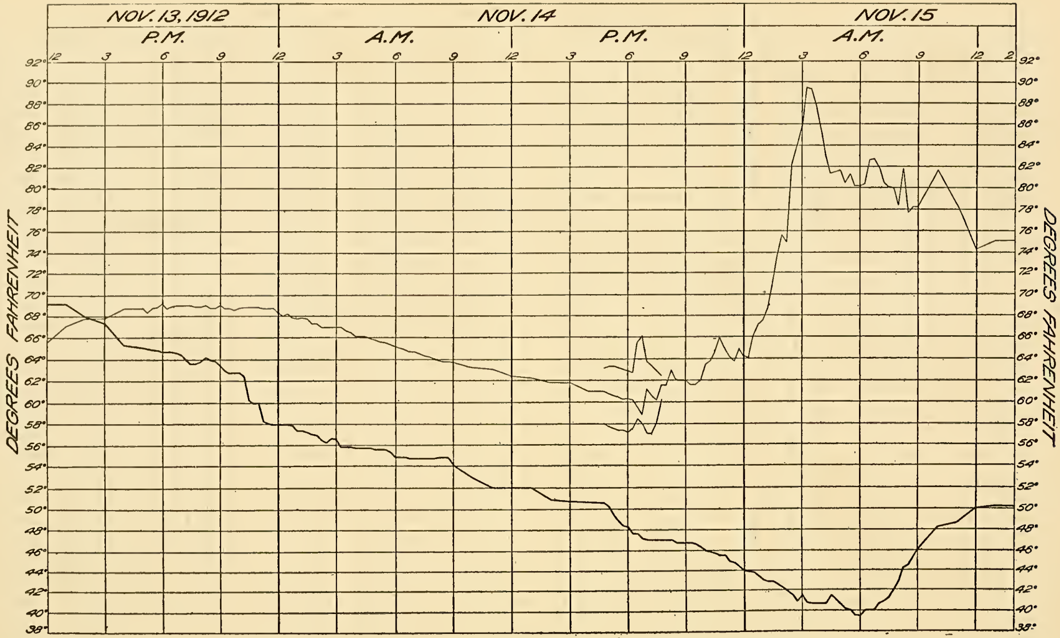


FIG. 141. — Diagram showing the response of a colony of bees to changes in outside temperature-record of Nov. 13–15, 1912. The heavy line represents the outer temperature and the lighter line that within the cluster. The two short lines represent temperatures on the edge of the cluster where activity was first observed.

begins in colonies wintered out of doors during the coldest weather. The previously mentioned results on colony temperatures lend support to the theory that excessive outside cold causes the raising of the temperature of the cluster to the point where egg-laying is possible and that the beginning of breeding is a response to the stimulus of external cold. Similarly, colonies wintered in the cellar may have their temperature raised by reason of an undue accumulation of feces and breeding may be begun. If these theories are tenable, winter breeding is to be considered as indicative of poor wintering and there is abundant evidence that the best results are obtained where no breeding takes place until the bees fly freely.

METHODS OF WINTERING BEES

There are two main plans of wintering bees and it is often difficult for the beekeeper to decide which he should adopt. They may be left on their summer stands (Fig. 142) where they are free to fly on warm days or they may be placed in a cellar or special repository as a protection against extremes of temperature, in which event they normally have no opportunity to fly and to void their feces until placed again in their summer locations. C. C. Miller, in an excellent article [1] on cellar wintering, concludes that in general up to 40° latitude it is better to winter outside, and north of that it is questionable. However, he also points out the fact that latitude or even isothermal lines cannot alone determine this. Wind velocity and constancy and the facilities of the beekeeper are important considerations. There seems to be a growing sentiment among the beekeepers to prefer to winter outdoors, but this should probably be considered chiefly as indicating a lack of information concerning the methods of getting optimum conditions in the cellar.

[1] Miller, C. C., 1913. Some things about cellar-wintering. American Bee Journal, LIII, pp. 271–273, 310–312.

Outdoor wintering.

In warm situations, bees may be left outside all winter with no added protection, for they are often able to withstand great hardship and may even survive zero weather in a single-walled hive. However, if the energy of the colony is to be properly conserved, they should not be called upon to endure this. Beekeepers are coming to the view that abundant packing is desirable and the tendency seems to be

Fig. 142. — An apiary in winter.

to use more than was formerly thought necessary. Packing serves to prevent the loss of heat generated by the bees and thereby materially lessens the muscular activity necessary. Just as it is practically impossible to leave too much honey in a hive for winter, so it has never been observed that a colony is too thoroughly packed.

A commendable plan, which has been in use for many years, is to place four colonies close together in a box, two facing east and two facing west, leaving room for four to six inches of planer shavings or dry leaves on all sides and perhaps a foot on top. Sawdust is less desirable than fine shavings because it holds water and thereby becomes a poorer non-conductor. Tunnels through the packing provide entrances to the hives and the roof should be water tight to prevent the packing from becoming wet from rain or snow. This method of packing is used with excellent results in many northern apiaries in the United States and Canada. Packing may also be applied to each colony (Fig. 142) or to a row of hives in a variety of ways to suit the convenience of the beekeeper.

To secure the most favorable conditions, each strong colony may be given two hive-bodies well supplied with stores and then if four colonies are packed together in a large box as described above we have as nearly ideal conditions as may be obtained in the open. The beekeeper may rest assured that the labor involved in thoroughly packing his colonies and in furnishing abundant stores will be repaid many fold.

Colonies wintered outdoors should be provided with packing early. While the temperatures of autumn nights are not so low as to endanger the bees, still the heat which must be generated in an unpacked hive is an unnecessary drain on the vitality and stores of the colony and for the average northern apiary it is desirable that the colonies be packed early in October. Similarly, the packing should not be removed too early. When frequent examinations of the colony become necessary, the temporary packing around the hives becomes bothersome, but it is best to leave it on so long as it does not interfere with the work of the apiary. Where heavy outside packing is needed, the packing may usually be kept on until some time in May.

To reduce convection currents a tall hive is to be preferred in winter. For summer manipulations the majority of American beekeepers prefer a hive not deeper than the Langstroth, which is rather shallow for best results in winter. This may be overcome by giving each strong colony two hive-bodies, the top one being well filled with stores. If such a hive is well packed it is highly satisfactory.

Hives of various types are made in which insulation is provided permanently, and were it not for the difficulty of moving such hives they would probably be more in favor among commercial beekeepers. Top packing is the most beneficial and may profitably be retained throughout the summer if practical.

Insulation for the conservation of heat is of the greatest importance, but even a well insulated hive or group of hives may not offer adequate protection unless sheltered from strong winds. The enormous loss of heat due to wind is usually not appreciated. A high fence or a heavy evergreen hedge is the means of a great saving of bee vitality.

The weakest place in the protection of the colony is the entrance. It is not safe to contract the entrance too much for it may then become entirely closed by dead bees. Neither is it safe to close the entrance entirely and provide indirect ventilation for the bees become restless when confined. The entrance should be closed as much as possible and yet provide room for dead bees. An entrance $\frac{3}{8}$ by 8 inches is perhaps the largest ever needed in wintering outside and this is often too large, especially for relatively weak colonies.

The wrapping of hives in black tar paper and leaving unprotected the fronts of the hives which face south are often advocated on the theory that the heat of the sun will more rapidly warm up the hive on bright days. Since the sun shines on the hive only a small fraction of the time in the average apiary in the winter season, the benefits of heat from the sun should not be overestimated. Any arrangement for absorbing heat from without is equally effective in dissipating heat from within and consequently a heavy packing on all sides is advisable. If possible it is best to have the packing cases painted white to reduce loss of heat.

To summarize: for outside wintering, leave abundant stores, pack early and heavily, protect from wind and unpack late.

Cellar wintering.

It is much more difficult to give definite advice to the beekeeper who wishes to winter his colonies in a cellar, although there is theoretically every reason to consider this the better method. If good food is given the colony (and this is more important in the cellar than outdoors in most climates) and if the cellar temperature and ventilation are controlled properly, excellent results may be obtained and a considerable saving made in the stores consumed, although the saving of stores is a minor consideration. The optimum cellar temperature, as stated above, is usually believed to be between 40° and 45° F. It has been shown that at such a cellar temperature the production of heat is constantly necessary during the winter and this may be reduced by raising the cellar temperature. Great care must, however, be exercised that the bees do not become excited and crawl out of the hives. In general a cellar temperature of 50° F. or higher results in a saving of the vitality of the bees. Sufficient ventilation should be provided to prevent condensation of water, which will, however, be rare at the higher cellar temperature. Light should be excluded and the colonies should be absolutely undisturbed from the time they are put in place until they are removed. Most beekeepers use the cellars under their residences, but special cellars are often constructed under the honey-house or in the apiary (Fig. 143). Since low temperatures are to be avoided it is usually preferable to use a

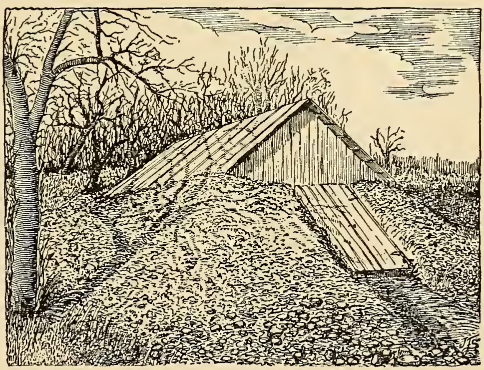


Fig. 143. — Roof of a bee cellar away from a house.

cellar under the residence, especially if the house is heated by a furnace. If separate cellars are built they should be exceptionally well insulated on all sides, top and bottom, so that the heat generated by the bees will be sufficient to raise the temperature of the cellar to at least 50° F. Honey is expensive fuel and bees are costly furnaces, consequently artificial

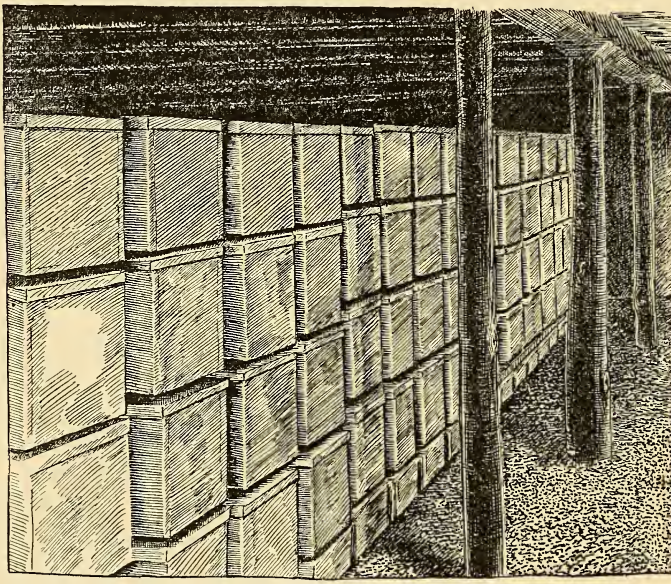


Fig. 144. — Arrangement of hives in a cellar.

heat combined with insulation will be found to result in better wintering in most cases. Few of the special cellars built away from the house are satisfactory and furthermore if the bees are not near by there is danger that the beekeeper will not give them the attention which they often need during the confinement.

In the construction of the cellar, care should be exercised to provide good drainage and ventilation should be adequate to remove the moisture so that condensed moisture will never be observed on the bottom boards. If moisture condenses on the covers only it does no harm. Since adequate ventilation without too great a reduction in temperature is difficult without artificial heat, this is an additional argument in favor of using the cellar under the residence for the bees.

Colonies should not be put into the cellar until all brood has emerged and until all the young bees have had a chance to fly to void their feces. There is a growing tendency at present to put the colonies in early and this is to be commended. After a good flight and after the bees are clustered, the hives should be carried in with the least possible disturbance. They may be piled one above the other as high as convenient for lifting (Fig. 144) and the tiers should be separated by alleys wide enough for convenient passage.

During the winter, dead bees should be removed from the floor as well as from the bottom boards (with the minimum disturbance) and a careful watch should be kept that the bees do not become excited by too low or too high a temperature. A reliable thermometer is practically necessary in good cellar wintering and the use of a sling psychrometer (wet and dry bulb thermometer) to determine the relative humidity of the air in the cellar is recommended. If the bees remain in proper condition they may profitably be left in the cellar until rather favorable weather arrives in the spring. If dysentery develops they may require earlier removal.

It is obviously impossible to give definite dates for putting bees in the cellar or for taking them out. This the beekeeper must determine according to the climatic conditions and, of course, the dates may vary from year to year. Perhaps the best advice is to put bees in the cellar immediately after the last good flight in November. Naturally one cannot be sure that bees will get a flight late in the month. It is also not desirable to leave the bees outside waiting for a flight which may not come, for feces accumulate rapidly in such cool weather, and if bees go into the cellar after being without a flight for a couple of weeks they are poorly prepared for the winter confinement. With improved cellar conditions and with the proper food, bees may be put in earlier without detriment.

It is often equally difficult to decide when bees should be put back on their summer stands. They should not be taken out until fresh pollen and nectar are available, unless they show pronounced signs of dysentery, as indicated by spotting of the hive or by undue excitement. If the cellar temperature and humidity are right, they may profitably be left in until danger of severe cold is practically past.

After colonies are removed from the cellar, they may profitably be given protection to aid in the conservation of heat. The elaborate packing used on colonies wintered outdoors is not practical for the spring, but the more colonies are protected from the wind and the more insulation that is given to conserve heat, the better the bees are able to build up rapidly to full strength.

Effects of confinement.

Bees normally do not eject their feces in the hive, and if confined there for a time, either outdoors or in the bee cellar, feces may so accumulate that the bees are unable to hold them. The hive and combs are then spotted and this condition the beekeeper knows as dysentery. The feces are composed of the parts of the food which cannot be digested and assimilated and of the excreted products. Therefore, a food which contains an unusual amount of indigestible material is ill suited for food during a period of confinement. Honey-dew honey is specially bad, since it contains a relatively large percentage of gums, and sugar syrup is ideal in so far as the prevention of dysentery is concerned.

It has been shown in the paper previously mentioned that the accumulation of feces causes the bees to become more active, and this in turn causes an increase in the temperature of the cluster (Fig. 145). The temperature may finally reach a point where brood-rearing may begin, and this with the increased activity causes excessive feeding and still greater accumulation of feces. It is therefore quite plain that a good food free from gums is of primary importance

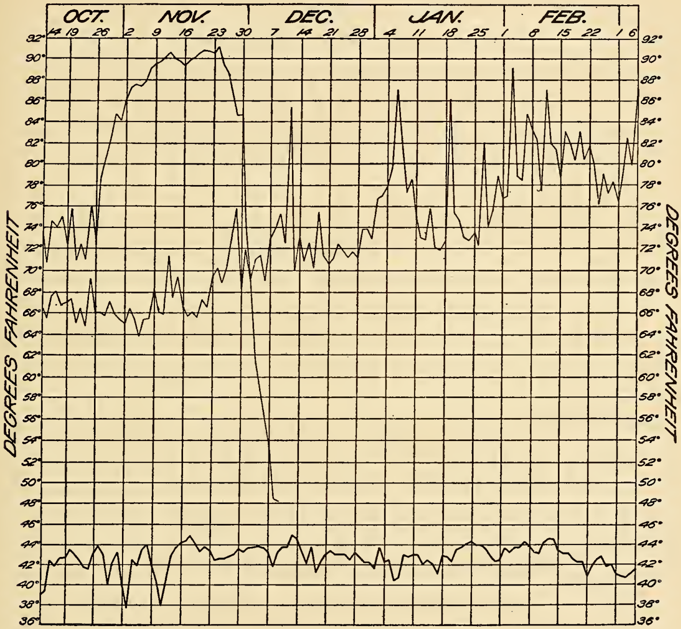


Fig. 145. — Diagram showing the effects of an accumulation of feces. The heavy line represents the temperature of the cellar, the lighter ones those inside the clusters. The colony which died in December was on honey-dew stores and the one which lived through the winter was on honey stores. Brood-rearing occurred in the honey-dew colony during November and it also suffered from dysentery.

in successful wintering. If the bees are free to fly at frequent intervals the inferior food will do less harm and bees may even winter on honey-dew honey if there are no long periods of confinement. It is, however, doubtful whether they are as vigorous later on if the food is inferior.

Years ago it was asserted [1] that the presence of pollen in the hive where the bees could eat it is responsible for dysentery, but later work and the experience of beekeepers do not warrant this conclusion. A suggestion made by Holterman is worthy of consideration in this connection. He advocates giving each colony ten pounds of sugar in the form of syrup late in the fall to be sure they have enough food. This serves another purpose, perhaps not fully appreciated. The syrup will be stored next to the cluster, the bees will then use it first and, since it contains no gums, the accumulation of feces cannot occur until the syrup is exhausted.

Spring dwindling.

If the colony goes into winter quarters with few young bees or if by excessive activity during the winter because of poor care they age rapidly, the adult bees are often unable to do the work required of them when brood-rearing begins. Then they may die more rapidly than they are replaced by the emerging bees. To this condition the name spring dwindling is applied. Obviously the proper course is to prevent the condition. The prolonging of brood-rearing in the fall and especially the giving of proper care in winter, including good food and protection from cold, will prevent this condition. If it should occur, it may be reduced somewhat by abundant protection from cold and wind in the spring.

A final word of qualification should be inserted here at the close of the discussion of the care of bees in winter. An effort has been made to give the best advice possible in the light of our present limited knowledge of this subject. As the investigations proceed, some of the statements here made may need qualification, and indeed with the facts at hand some of them could be limited more than they now are.

[1] Heddon, Jas., 1885. Success in bee culture. Dowagiac, Mich.

CHAPTER XXI

THE SOURCES OF NECTAR AND POLLEN

To the beekeeper who properly studies his locality, one of the most important as well as often one of the most difficult tasks is to determine the sources from which his bees gather nectar and pollen. The books and journals devoted to beekeeping give considerable information concerning honey-plants, but to learn which ones are to be considered as of primary importance and to identify properly those on which bees are seen working is sometimes difficult. In localities where only one or two plants yield surplus, this problem is relatively easy. For example, in part of the irrigated regions of the West, alfalfa and sweet clover are almost the only plants which the beekeeper need consider, while in the northern part of the United States there are localities where white clover is virtually the only surplus-yielding species which need influence the apiary management.

Reason for knowledge of nectar sources.

Since the beekeeper does not cultivate anything especially for his bees, it may not be evident why he should study the honey-plants. While it is true to a large extent that the beekeeper must take whatever the plants in the region furnish, he must, to be successful, know when the dependable plants will bloom so that he may have his colonies strong and ready to gather the harvest. In the establishment of out-apiaries he should also study the country to decide on the best locations, those nearest to the most valuable and abundant sources.

Difficulties of identification.

At times this work calls for considerable knowledge of botany, which most beekeepers cannot be expected to possess. Because of errors in identification and failure to keep in touch with recent advances in the science of botany, the scientific names of the honey-plants in the books and journals on beekeeping often do not agree with those of the leading botanical works.

Study of neighboring locations.

It frequently happens that a beekeeper maintains his apiary for years in one locality, sometimes experiencing a total failure of his crop, when within a few miles of him there are nectar resources on which he might draw, but of which he is in ignorance. Many beekeepers have come to see this only after they have established out-apiaries. A beekeeper who is depending on his bees for a considerable amount of his income should make a study of the regions about him, perhaps for a distance of several miles, and when he finds a locality which looks promising, but concerning which he can get no definite information, it will pay to place one or two colonies there and to inspect them at intervals during the season. In this way, it is possible at times to find locations favorable for migratory beekeeping. Any swamps within moving distance should be investigated, as these regions are more dependable than drier locations. In view of the fact that many beekeepers by staying at home are losing nectar that is abundant only a few miles away, it is evident that scouting should be more generally practiced. The increasing use of automobile trucks by beekeepers will probably lead to more migratory beekeeping than has existed in the past.

Function of nectar.

The nectar which is secreted in the flowers of numerous species of plants is not a mere by-product of plant activity but serves a definite function in the plant's life-cycle. There are numerous adaptations of plant structure and physiology which serve to bring about cross-fertilization, by which the ovule of one flower is fertilized by pollen from another flower, often from another plant of the same species. Pollen of certain species is carried from flower to flower by the wind but one of the most common methods is through the agency of insects. The insects which perform this mission are usually attracted by the nectar which the flowers secrete and, in going from flower to flower to get this nectar for food, they act as unconscious agents of cross-fertilization by carrying pollen from the stamen of one flower to the pistil of another. The nectar is therefore the attractive object in this process.

Many insects do this work; some flowers are visited most frequently by flies, others by small wild bees, but a honeybee not only goes for nectar for its own food but also carries it to the hive for food for the brood and for the adults in adverse seasons. It therefore makes many visits. The honeybee is unique in many ways, not the least wonderful of which is its hoarding instinct. That the honeybees gather at times more than they need makes it profitable for the beekeeper to care for them so that he may take this surplus.

In the adaptations of Nature, nectar is first of all to attract insects, then when honeybees gather it, they do so to feed themselves and their brood. The surplus honey is therefore simply a by-product, an over-production due to the prodigality of Nature, by which the beekeeper profits. Unless gathered by the bees and appropriated in part by the beekeeper, much of this nectar would simply dry up, consequently honey-production is the conservation of a natural resource, which if not taken immediately is lost.

Variations in nectar.

Nectar varies with each individual species of plant. Since plants vary in the color of flowers, shape of leaves and in innumerable other characters, it should not be a matter of surprise that they also show marked differences in color, water content and flavor of nectar. Not only do flowers of different species of plants secrete nectar of various types but nectar of any one species may differ according to soil, climatic conditions and other environmental factors influencing the growth of the plant, just as may the leaves and other parts of the plants. For example, in Colorado alfalfa honey is a beautiful white product but farther south it is more amber in color. This may sometimes be due to an admixture of other nectars.

Variation in secretion.

Nectar-secretion may, in a sense, be taken as an indication as to the most favorable conditions for growth of any species and most species which furnish nectar are highly susceptible in this respect to outside influences. Within the limits of the geographical distribution of a nectar-secreting species there may be a more restricted area in which the flowers secrete nectar. The species may be rather prevalent outside its usual nectar-secreting boundaries, but there is probably some factor in the environment not best suited to the plant if it fails to produce nectar. For example, alfalfa is now grown in all sections of the United States but the Mississippi River may be taken roughly as the eastern boundary of its secreting area. White clover produces in the northern part of the United States a superb honey, often in exceedingly heavy honey-flows, but farther south it becomes a honey-plant of secondary importance.

Effects of climatic conditions on secretion.

Any species of nectar-secreting plant is often rendered non-productive by unfavorable weather conditions. The smaller plants usually cease nectar-secretion at once in dry weather, while the tree sources are less quickly affected. Basswood seems to be an exception, however. Hot, sultry weather with rains at night during the blooming period of white clover usually brings a heavy honey-flow. The sages of southern California secrete nectar in abundance only if there is sufficient rainfall while the plants are growing, preparatory to flowering. Because of this fact, the beekeepers of that region carefully watch the records of rainfall during the winter to judge as to their prospects for a heavy honey-flow in the summer. The physiology of nectar-secretion is so little understood, by beekeepers at any rate, that we do not know the relative importance of temperature, humidity, barometric pressure and other environmental factors in bringing about abundant secretion. If these influences were more carefully studied, the beekeeper could better forecast his crop and plan his work day by day during the season. As it is, he relies on his unbounded hope of success to carry him through.

Advantages of swamp sources.

Since plants which grow in swamps are less subject to changes in available moisture and usually get an abundance, the swamp honey-plants are usually more dependable than those growing in dry soils. In swamp lands, too, the honey-plants are less liable to destruction through agricultural operations and conditions are more likely to remain the same year after year. These facts should be more generally recognized by beekeepers seeking new locations for the establishment of apiaries. The tree sources are usually more dependable than smaller plants.

Cultivation of plants for nectar.

It was stated earlier in this chapter that the beekeeper does not cultivate anything especially for his bees. This has been tried several times without profit. However, plants which are nectar-producers and which also have a value in some other respect may often be cultivated with profit to the beekeeper. Alsike clover is an excellent honey-plant and many beekeepers have materially improved their ranges, either by planting this clover as a forage plant or by encouraging neighboring farmers to do so. Buckwheat, alfalfa and cotton may also be mentioned among the cultivated plants of value to the beekeeper. In seeking to improve a range by changing the flora, it is often profitable to scatter seed of some plant which will occupy waste land. Although the appreciation of the value of sweet clover as a forage plant and soil renovator is increasing among farmers, it is still valuable to the beekeeper chiefly as occupying waste land, crowding out less valuable plants. The scattering of sweet clover seed along embankments and over waste land has proved so profitable to beekeepers that the seed is now offered for sale annually in the bee journals.

Value of the minor sources.

Those plants which, because of scarcity or limited secretion of nectar, fail to give the beekeeper a surplus are, nevertheless, of marked value and are worthy of more consideration than they usually receive. The amount of honey consumed by an average colony of bees in a year has been variously estimated as from 200 to 600 pounds.[1] This will, of course, vary according to the locality, strength of colony and other factors. Accepting even the lowest figure, it is evident that a moderate sized apiary obtains tons of sugar from the flowers in the surrounding territory. While nectar comes in abundantly enough at times to produce a surplus, the beekeeper does not leave in the hives at the close of a surplus honey-flow enough to feed the bees until another major honey-flow, except possibly at the close of the season. The bees are almost constantly gathering nectar from the minor sources during the summer and the aggregate gathered from these plants is enormous. If, for example, nectar were obtained in the North from white clover only, at the close of the flow the beekeeper would be compelled to leave about

[1] A recent estimate is one made by Hommell (1913, [Consumption of a hive of bees during the year] La Vie agricole et rurale, II, No. 22, pp. 653–655) in which it is concluded that an average of 480 pounds is needed, divided as follows: maintenance of bees, 400 lbs., feeding of brood, 70 lbs., wax production, 10 lbs.

200 pounds for the bees, and there is rarely enough honey from white clover to permit this. This indicates that the beekeeper is debtor to the minor sources for much more than he is accustomed to believe.

Gathering of pollen.

The amount of pollen consumed by a colony annually is also considerable. Estimates of the averages in this phase of bee feeding are not available, but there is, nevertheless, some basis for judging the consumption. If during the active season a colony becomes queenless and has no brood to feed, the stores of pollen increase rapidly and several combs are often filled in a short time. It can scarcely be claimed that queenless bees gather more pollen than normal ones and, in fact, it is sometimes stated that the gathering is then reduced, so that it is safe to conclude that had brood been present these extra stores of pollen would have been consumed almost as fast as gathered. It must be true, therefore, that a colony uses many frames of pollen in a season, so that pollen sources are important to the beekeeper. In gathering pollen a bee is less uniformly beneficial to plants than when gathering nectar. They may cross-pollinate the flowers when so engaged but they are, at the same time, appropriating a part of the pollen on which fertilization depends. In some species of plants, an abundance of pollen seems to serve as an attractive agent, just as does nectar in those species provided with nectaries.

Value of bees in cross-pollination.

In discussing the plants from which bees gather nectar, further mention should be made of the beneficial results which arise from the visits of bees to the flowers of certain fruits. As was explained earlier in this chapter, nectar is serviceable to the plant in acting as an attraction to insect visitors, which act as agents in cross-pollination. Because of the mutual adaptations of the insects and plants, they often become mutually indispensable. Some varieties of fruit trees are incapable of self-fertilization, in other cases fertilization is more abundant with cross-pollination and in no case is cross-pollination detrimental. It is therefore evident that successful fruit-growing is dependent on insect visitation. Of all the insects which serve the fruit-grower, there is none more efficient than the honeybee. Furthermore, in one important respect the honeybee becomes the most dependable of all. At the season when the fruit trees blossom, insects of the wild species may be scarce, having been decimated by severe winter conditions, and we have no way of increasing their number. While honeybees also suffer, sometimes severely, from winter conditions, it is relatively easy not only to build up the colonies in the early spring but to bring in additional colonies as agents of fertilization. It therefore is a simple matter for the fruit-grower to provide insects to fertilize his blossoms, if the weather is suitable for flights during the blooming period. Progressive fruit-growers in all parts of the country are coming more and more to realize this and many of them now keep bees solely for the benefits to the fruit crops.

Since it unfortunately sometimes happens that ignorant or incorrectly informed fruit-growers do considerable injury to colonies of bees in their neighborhood by spraying their trees with poisonous chemicals while in full bloom, it may be well to examine the facts to determine who receives the greatest benefits from the presence of bees in the average farming community. If one examines a fruit tree in full bloom, many species of insects will be found at work on the blossoms, gathering or eating nectar and pollen. These numerous species vary greatly in their efficiency in bringing about cross-pollination, and no species is better fitted by structure or behavior for this work than the honeybee. Furthermore, if colonies of bees are to be found near by, as there generally are, there are usually as many honeybees on the trees as there are insects of all other species combined. Insects of many of the visiting species stay only long enough to get sufficient to eat to satisfy their own immediate needs, but the honeybees hurry back and forth from the hive, making repeated visits and cross-fertilizing innumerable blossoms, in their efforts to increase the colony stores. The honey obtained from fruit blossoms is usually small in quantity and serves only to stimulate brood-rearing, but in getting it the bees benefit the fruit-grower to an extent which can scarcely be over-estimated. One peculiarity of behavior is worthy of special mention in this connection. Honeybees rarely go from one species of flower (p. 119) to another (unless the flowers are virtually identical) while on one trip from the hive. There is also evidence worthy of belief that an individual honeybee confines its visits to one species of plant, sometimes for several days. For example, a bee will not be seen flying from an apple blossom to a dandelion flower growing beneath the tree and then perhaps back to an apple blossom. Consequently, on visiting an apple blossom it does not present dandelion pollen or, in fact, any pollen other than that from the apple and, by virtue of this constancy, the benefits of the visits of honeybees are increased many fold.

In view of these facts, it is not difficult to believe that in many orchards over half of the fruit set is to be attributed to the visits of the honeybees. Were this estimate reduced to ten per cent, which even an avowed enemy of the bee would consider too low, it appears that the fruit-growers receive more actual financial benefit from the presence of bees in the average farming community than do the beekeepers who own them. It therefore appears quite obvious that it is to the interest of fruit-growers to encourage beekeeping in every way in their immediate localities.

Damaging effects of incorrect spraying.

Since the spraying of fruit trees while in bloom is highly injurious, not only to honeybees but to all of the insect visitors, it is evident that such spraying is to that extent detrimental to the interests of the fruit-grower himself. Since spraying in full bloom is not necessary to control the codling moth and is not advised by entomologists and since it is injurious to bees, several States, at the instigation of the beekeepers, have enacted laws prohibiting such spraying. However, it is difficult to enforce such a law and, through ignorance, carelessness or neglect, serious damage is done to beekeepers at times. It may also be added that spraying in full bloom not only is unnecessary and detrimental to bees but it directly injures the fruit blossoms.[1] It is therefore evident that in the light of our present knowledge, spraying fruit trees while in full bloom is unwarranted and unwise.

Bees do not puncture ripe fruit.

In discussing the relationship existing between beekeeping and fruit-growing, there still remains one source of misunderstanding between men engaged in these branches of agriculture which should be mentioned. Fruit-growers often make the statement that honeybees puncture ripe fruit to suck the juices, thereby causing considerable financial loss, as well as hindering the picking of the fruit. This claim has been the cause of ill-feeling in certain localities. It has, however, been abundantly demonstrated that honeybees do not puncture the skin of any fruit. To show this, if a colony of bees is confined in a hive without honey and is given specimens of sound fruit, the bees will die of starvation without puncturing a single fruit. On the other hand, if an apple, plum or grape is punctured, even slightly, and given to bees in this way they will suck all the juice. If it is maintained that confined bees may act differently from those free to fly, it may be replied that no one has ever seen honeybees puncture fruit either by stinging or biting. Furthermore, if there is any nectar available, honeybees will always take that in preference to the juice of injured fruits. If then a fruit-grower sees honeybees sucking his fruit, he may be sure

[1] *Cf.* Beach, S. A., and Bailey, L. H., 1900. Bul. 196, N. Y. Agric. Exp. Sta., Geneva.

that the fruit was first damaged by some bird, by some other insect (*e.g.* hornet), by a bruise or by some form of decay and he may further be certain that the bees are sucking the juices of only damaged, unmarketable fruit. It may also be added that fruit juices are most undesirable stores for bees and, if used exclusively in winter, the colony will probably die. The beekeeper is therefore often being injured as much as the fruit-grower when the bees suck overripe or injured fruits.

Beekeepers naturally appear biased in seeking to prove the bee a harmless and solely beneficial insect. They even minimize the annoyance of the stings in their loyalty to the bee. In pointing out the benefits of bees and denying injuries so often laid at their door, the present writer may also be accused of this bias. The investigations that have been made, however, uniformly support the contentions of the bee enthusiasts and the supposedly harmed fruit-grower should be led to suspect that his judgment is in error. The ranks of the bee advocates are year by year being materially augmented by fruit-growers who have become convinced of the correctness of the attitude that the beekeeper maintains toward his bees.

Supposedly poisonous honeys.

Frequent mention is made in the literature on bees of supposedly poisonous honeys. It is of course true that the juices of many plants are poisonous to man and this may be the foundation for the belief that nectar of such species also contains the poisonous principles. Among the plants sometimes reported to produce poisonous nectar from which poisonous honeys are made by the bees, are mountain laurel (*Kalmia latifolia*), tobacco (*Nicotiana tabacum*), yellow jessamine (*Gelsemium sempervirens*), sweet pepper bush (*Clethra alnifolia*) and rhododendrons (one species of which is supposed to be the source of honey reported by Xenophon as having poisoned his soldiers). It would be unsafe to deny that the nectar of any plant produces a poisonous honey, but it is certain that not all of the plants named above produce such honey. Mountain laurel, yellow jessamine and rhododendrons are abundant in the lower Appalachian Mountains and there are more bees to a square mile in this section than anywhere else in the United States. Assuredly much nectar is gathered by bees from these plants, and if all the honey from these sources were poisonous there would be an epidemic of poisoning annually in this region. Clethra is the source of much honey, eaten widely with immunity. If any plant is ever the source of poisonous honey, this fact should be determined and made known, but the vague rumors now current are valueless. It should be remembered in this connection that certain individuals have idiosyncrasies toward certain foods and this may account for some of the recorded cases of honey poisoning. In some rare individuals the eating of honey from any source or thick sugar syrup causes violent pains in the stomach. Until physiologists agree as to the cause of this phenomenon it is unsafe to speculate, but assuredly honeys should not be ranked as poisonous because they cause distress in eccentric individuals.

Plant honey-dew.

By all odds, the main source of the sugars that bees get is nectar from flowers. There are other sources which should be mentioned, however, which occur more frequently than is recognized by beekeepers. In the absence of floral nectar, bees gather sugars from any available source, giving preference to those which have attractive odors. Many species of plants are provided with glands which secrete sweet liquids and which are located outside the flowers (extra-floral nectaries). Examples of this are found on the leaves of cotton (*Gossypium hirsutum*) and Hawaiian hau (*Hibiscus* or *Paritium tiliaceum*, on outside of flower bracts also). Various acacias have glands on the stems. Other examples are found on castor beans (Ricinus) and partridge-pea (*Chamæcrista fasciculata*) and other cases are mentioned in the list of honey-plants at the close of this chapter. To the product which the bee makes from sugar from these sources the name plant honey-dew honey is given.

Insect honey-dew.

The main source of honey-dew is, however, not plant secretion but insect excretion. Certain plant-sucking insects, belonging to the order Hemiptera, such as plant-lice (Aphidæ), scale insects (Coccidæ), leaf hoppers (Jassidæ), white flies (Aleyrodidæ) and tree hoppers (Membracidæ), all belonging to the Homoptera, suck the juices of the various plants on which they are specifically parasitic and the portion of the sap not utilized by the sucking insect is ejected, falling on the leaves and stems of the plant and even running off to the ground below. Many of these juices are sweet and are gathered by bees exactly as they gather nectar, except that if nectar is available honey-dew is abandoned. This is carried to the hive, ripened and sealed, making what is known as honey-dew honey. This substance is high in its content of gums and is a poor food for bees in winter. It was formerly believed that the honey-dew of some aphids was secreted from the tubular processes on the dorsal side of the abdomen but it is now established that it is an intestinal excretion, just as in the other families. Honey-dew is gathered by ants perhaps more than by bees.

The sugars in honey-dew honey are the same as those in honey and the chief chemical difference is in the higher percentage of gums. The flavor is usually poor, and most honey-dew honeys are dark in color and granulate quickly, often before sealing. An exception is that from the sugar-cane leaf-hopper (*Perkinsiella saccharicida*) of Hawaii which rarely granulates. Honey-dew honey is probably much more common than is appreciated by beekeepers, for the excreting insects are present in millions every summer and probably many of our honeys contain small amounts of this substance. It is not unlikely that the variation in gum content of honeys and the variation in color from a supposedly uniform floral source may in part be due to varying admixtures of honey-dew.

In the summer of 1909, honey-dew honey was exceptionally abundant throughout the eastern United States. This was due not only to the shortage of nectar but to an exceptionally large number of aphids. The prevalence of these insects is determined largely by immediate climatic conditions and they are destroyed by millions by heavy rains. Dry seasons may therefore dry up the nectaries and at the same time allow plant-lice to propagate excessively, giving us our honey-dew seasons.

ANNOTATED LIST OF HONEY-PLANTS

In the following list an effort is made to give the plants of value to the beekeeper, as sources of nectar and pollen, with brief notes which will be helpful in determining the relative importance of the various species. While this list is chiefly for plants in the United States, mention is made of some important plants of tropical America, especially of Hawaii and Porto Rico. The list will also apply to Canada.

The arrangement of these notes in alphabetical order is adopted as placing the notes where they will first be sought by the majority of readers, under the common name of the species. The following of the natural order, by families and genera, would show relationships which can only be suggested here by naming under each family the species of that family that are mentioned in the notes.

This list is unavoidably incomplete because so little systematic work has been done on honey-plants. There are hundreds of valuable notes on these plants in the bee journals but they are hard to find and often it is impossible to tell what species is being discussed since the scientific name is not given or is given incorrectly and since the same common name is sometimes given to two or more species in various parts of the United States.

Acacias, wattles, Acacia spp. Shrubs or trees, flowers small, in heads. Catclaw, *A. Greggii*, May and July. Honey white, fine flavor. Catclaw, *A. Greggii* and *A. Wrightii*, semi-arid regions of Texas and Arizona. Catclaw and the closely related huajilla, *Havardia* (*Xygia*) *brevifolia*, are of first rank among honey-plants. The various wattles are listed as important honey sources in Australia, Africa and tropical America. Black wattle, *A. decurrens mollis*, and other species are of value in California and in Hawaii. Huisache, *A.* (*Vachellia*) *Farnesiana*, is also present along the Rio Grande. *A. constricta*, June, Arizona. Various species in subtropical regions, probably all valuable.

Aceraceæ; see Maple family.

Æsculaceæ; see Buckeye family.

Ailanthus, tree of heaven, *Ailanthus glandulosa*. Native of China, reported in eastern United States and as valuable in California. Honey ill-tasting. Extra-floral nectaries present.

Ailanthus family, Simarubaceæ; see Ailanthus and Manchineel.

Alder, Alnus spp. Pollen.

Fig. 146. — Alfalfa.

Alfalfa, *Medicago sativa* (Fig. 146). Perennial, 12–18 inches, excessively branched after cutting, short raceme of blue or violet flowers. Blooms several times during summer, depending on number of cuttings. Honey light in color, granulates quickly, especially after extraction, flavor excellent. Grown throughout United States but valuable as a honey-plant only west of Mississippi River (except in rare cases). Native of old world. The main source of honey in the irrigated regions of Colorado, Utah and other western states. The honey from this source is reported as amber from more southern localities, but this may be due to an admixture of other honeys. Alfalfa honey is produced extensively as comb-honey, but in this form it suffers in comparison with that of the clovers because of rapid granulation. The flavor is described as mint-like. Also called Spanish trefoil, lucerne and purple medic. An excellent forage plant yielding several crops a season. Frequently cut before or during blooming period. *M. denticulata* and *M. lupulina* reported from California.

Alfileria, pin clover, *Erodium cicutarium*. Annual, April–September, throughout United States, especially California. Native of old world; honey of good quality, pollen abundant. *E. moschatum*, good in California.

Algaroba; see Mesquite and also Saman.

Alsike clover, *Trifolium hybridum*. Perennial, erect, 1–2 feet, quite similar to white clover except in size. Cultivated extensively (usually with timothy) for hay. Flowers white tipped with pink, to pink. May–October, but especially June–July. Honey only slightly darker than that from white clover. This clover is rapidly increasing in importance to the beekeeper. Called also Swedish clover. Not a hybrid between white and red clovers as name indicates.

Amaryllidaceæ; see Amaryllis family.

Amaryllis family, Amaryllidaceæ; see Century Plant and Lophiola.

Ambrosiaceæ; see Ragweed family.

American bee balm; see Horsemint.

American holly; see Gallberry.

Ampelopsis, Ampelopsis spp. Nectar, pollen.

Anacardiaceæ; see Sumac family.

Anemone, *Anemone quinquefolia*. Pollen.

Antigonon (Corculum). Listed by Root, 1910, Florida, California, tropics.

Apple, *Pyrus Malus* (Fig. 2). Honey light amber, superb; pollen.

Apple family, Malaceæ (a subfamily of Rosaceæ); see Pear, Apple, Juneberry and Haws.

Aquifoliaceæ; see Holly family.

Asclepiadaceæ; see Milkweed family.

Ash, Fraxinus spp. Pollen.

Asparagus, *Asparagus officinalis*. Honey amber, pollen.

Asters, Aster spp. Perennial (rarely annual), 1–4 feet or more, ray flowers white or purple, sometimes pink or blue, July to frost. Honey amber in color, flavor often pronounced. Throughout the United States, especially in North, different species being adapted to differences in soils and moisture. *A. ericoides* and *A. novæ-angliæ* are said to be the most valuable to the beekeeper. The goldenrods which bloom at the same time and which are more conspicuous get much of the credit for nectar-secretion which belongs rightly to the asters. Valuable especially in providing winter stores, although the so-called fall honeys are not so good for this purpose as the purer types of honey (see Wintering). Britton and Brown mention 142 species of this genus in the United States and 250 species in all. Plants of related genera are also sometimes known as asters. The species blooming early are rarely valuable as honey-plants.

Azalea, wild honeysuckle, Azalea spp. Some nectar, pollen.

Ball or button sage; see Sage.

Banana, Musa spp. Cultivated in Florida and extensively in tropical America. Pollen.

Banana family, Musaceæ; see Banana.

Barberry, *Berberis vulgaris*. Pollen, nectar.

Barberry family, Berberidaceæ; see Barberry, *Berberis pinnata* and *B. trifoliolata*.

Basswood, linden, whitewood, *Tilia americana* (Fig. 147). In forests and in moist soils, tree to 125 feet, leaves oblique, flowers borne on bracts 2–4 inches, June–July (usually at end of white clover honey-flow). Honey light amber to white, flavor when unmixed is pronounced (especially if extracted when unripe) and not especially pleasant, but when mixed with white clover honey is exceptionally fine. In rich woods in northeastern United States and in mountains south to Georgia, west to Nebraska. Formerly much more abundant. The cultivated species, *T. europæa*, is equally valuable when present. The wood is used in making the one-piece sections used almost universally for comb-honey. Nectar secretion quickly affected by adverse weather conditions. A heavy yielder when weather preceding the honey-flow is favorable. The heavy cutting of these trees has greatly decreased the importance of this tree to the beekeeper. The name linn (or lin) or lime tree is given to the European species, *T. europæa*. *T. heterophylla* is also common (called bee-tree). *T. pubescens* has a more southern distribution. The other species of Tiliaceæ are mainly tropical.

Fig. 147. — Basswood.

Bayberry; see Sweet-Gale.

Bayberry family, Myricaceae; see Sweet-Gale.

Bearberry; see Manzanita.

Bee balm, *Melissa officinalis.* Nectar.
Beech, Fagus spp. Pollen.
Beech family, Fagaceæ; see Beech, Chinquapin, Chestnut and Oak.
Bee-tree; see Basswood.
Beggar's tick; see Spanish Needle.
Bell-flower, campanula, campanilla, Ipomœa spp. Of primary importance in Cuba, honey white of finest flavor. Other species in this family furnish nectar.
Bell-flower family, Campanulaceæ; see Bell-flower.
Berberidaceæ; see Barberry family.
Berberis pinnata. California. Honey amber.
Berberis trifoliolata. Texas, January–February, nectar and abundant pollen.
Betulaceæ; see Birch family.
Bignoniaceæ; see Trumpet-creeper family.
Birch, Betula spp. Pollen.
Birch family, Betulaceæ; see Hornbeam, Hazelnut, Birch and Alder.
Blackberry; see Raspberry.
Black mangrove, *Avicennia nitida.* Perhaps the most abundant source of nectar ever observed. Killed by frost in Florida in 1894 and is returning abundantly. Found in Porto Rico.
Black sage; see Sage.
Black ti-ti; see Ti-ti.
Black walnut, *Juglans nigra.* Pollen.
Black wattle; see Acacia.
Bloodroot, *Sanguinaria canadensis.* Pollen.
Bloodwort family. Hæmodoraceæ; see Morong.
Blueberry, Vaccinium spp. Nectar, pollen.
Blue-curls, *Trichostema lanceolatum.* Honey white, granulates quickly, August–November.
Blue gum; see Eucalyptus.
Blue-thistle; see Viper's Bugloss.
Blueweed; see Viper's Bugloss.
Bokhara clover; see Sweet Clover.
Boneset, thoroughwort, *Eupatorium perfoliatum.* Nectar. Autumn.
Borage family, Boraginaceæ; see Viper's Bugloss.
Boraginaceæ; see Borage family.
Buckeye, *Æsculus glabra.* Pollen, nectar.
Buckeye family, Æsculaceæ; see Horsechestnut, Buckeye and California Buckeye.
Buckthorn, coffee berry, *Rhamnus cathartica.*
Buckthorn family, Rhamnaceæ; see Buckthorn, Cascara Sagrada, Coffee Berry, White Lilac and Rattan Vine.
Buckwheat, *Fagopyrum esculentum* (Fig. 148). Annual, 1–3 feet,

blooms June–September, depending on time of planting. Honey dark purple in color, flavor strong and rank, of use mainly in baking, body usually heavy although in rapid flows it may be thin. In New York, Pennsylvania, Michigan, especially, but found in almost all parts of northern United States. Native of old world. Sometimes escapes from cultivation. Reliable as a nectar plant especially in more northern localities. Nectar secreted most abundantly in the morning.

Fig. 148. — Buckwheat.

Buckwheat family, Polygonaceæ; see Wild Buckwheat, Antigonon, Buckwheat, Heartsease and *Polygonum lapathifolium*.

Bur-marigold; see Spanish Needle.

Bush clovers, Lespedeza spp.

Butterfly-weed; see Milkweed.

Button-bush, honey-balls, *Cephalanthus occidentalis*. In swamps, honey mild, light color.

Cabbage palmetto, *Sabal palmetto*. To 30 feet, July–August, honey white, mild, Florida.

Cabbage tree; see Moca.

Cactaceæ; see Cactus family.

Cactus, prickly pear, Opuntia spp. Locally in deserts and semi-arid regions, honey heavy of poor flavor.

Cactus family, Cactaceæ; see Cactus.

Cæsalpinaceæ; see Senna family.

California buckeye, *Æsculus californica*. Considerable nectar. Reported that the honey poisons the bees (California); more than doubtful.

California laurel, *Umbellularia californica*. December–March.

California poppy, *Eschscholtzia californica*. March–July, pollen, some nectar, California.

Campanilla; see Bell-flower.

Campanula; see Bell-flower.

Campanulaceæ; see Bell-flower family.

Canada thistle, *Carduus arvensis*. Honey of good quality.

Caper family, Capparidaceæ; see Cleome and Jackass Clover.

Capparidaceæ; see Caper family.

Caprifoliaceæ; see Honeysuckle family.

Carpet-grass, *Lippia nodiflora*. Of value in California.

Carrot family, Umbelliferæ. Various species are of minor importance as sources of nectar and pollen.

Cascara Sagrada, *Rhamnus Purshiana.* Honey dark, does not granulate. California.

Catalpa, catawba, *Catalpa speciosa.* Of little value.

Catawba; see Catalpa.

Catnip, *Nepeta Cataria.* Nectar. Unimportant.

Century plant, *Agave americana.* Heavy yielder in semi-arid tropical localities, July–August. Also other species of Agave.

Chestnut, *Castanea dentata.* Some nectar, pollen.

Chicory, *Cichorium Intybus.* July–October, eastern United States.

Chicory subfamily; see Chicory, Dandelion and Sow Thistle.

China-tree, Pride of India, *Melia azedarach.* Spring, of value in early brood-rearing, Texas.

Chinquapin, *Castanea pumila.* Honey dark amber of most unpleasant flavor, Georgia and other southern States.

Fig. 149. — Spider-flower (Cleome).

Cichoriaceæ; see Chicory.

Cistaceæ; see Rock-rose family.

Citrus fruits, lime, orange, grape fruit, lemon, Citrus spp. Cultivated, Florida, California, Texas, some species wild in Florida. Trees. Honey white, heavy body, delicious flavor. The value of these trees to the beekeeper is probably overestimated and honey from other sources is probably sold as "orange honey," under which name the citrus honeys are usually all sold.

Clematis, Clematis sp. Superb honey when sufficiently abundant, New England. Pollen.

Clematis ligusticifolia. In hills of California, June–July. Pollen abundant.

Cleome, spider-flower, *Cleome serrulata* and *C. spinosa* (Fig. 149). Herbs 2–3 feet, erect, flowers pink or white in *C. serrulata*, purple in *C. spinosa*. *C. serrulata* in prairies Illinois west to Rocky Mountains; *C. spinosa*, from tropical America, sometimes cultivated, Illinois to Louisiana. *C. serrulata* is called Rocky Mountain Bee-plant by Colorado beekeepers. Under favorable conditions both species are heavy yielders, but they are, nevertheless, not of primary importance.

Clethraceæ; see White Alder family.

Clover; see Sweet Clover, White Clover, Alsike Clover, Crimson Clover, Bush Clovers and Alfileria.

Cocklebur, *Xanthium pennsylvanicum.* Pollen in Autumn.

Cocoanut palm, *Cocos nucifera.* Honey amber, of secondary importance, West Indies.

Coffee berry, *Rhamnus californica.* Honey amber, April–May. Foothills of Sierra Nevada Mountains.

Coffee berry; see also Buckthorn.

Compositæ; see Thistle family.

Coral-berry; see Indian Currant.

Corculum; see *Antigonon leptopus.*

Coreopsis; see Spanish Needle.

Corn, *Zea mays.* Pollen. Reported as sometimes yielding nectar from the tassels.

Cornaceæ; see Dogwood family.

Cotton, *Gossypium hirsutum* (Fig. 150). Cultivated, southern States. June–August. Increasing in importance. Extra-floral nectaries on leaves and bracts.

Fig. 150. — Cotton.

Cowpea, *Vigna sinensis.* Honey light, of poor flavor. Bees get nectar from extra-floral nectaries.

Creeping thyme, *Thymus Serpyllum.* Perennial herb, branched, creeping, forming dense mats, flowers in clusters. Honey probably amber, flavor not as good as that of many other honeys. In thickets and waste places south to Pennsylvania. June–September. Native of Europe. From a plant of this genus the celebrated honey of the ancient Greeks was produced, especially on Mount Hymettus.

Crimson clover, *Trifolium incarnatum.* Annual erect, 6–30 inches, flowers crimson in long heads. Honey quite like that of white clover. Cultivated for hay and in waste places. Native of Europe. Blooms somewhat earlier than the other clovers.

Crowfoot family. Ranunculaceæ; see Anemone, Liverwort, Clematis and Meadow-rue.
Cruciferæ; see Mustard family.
Cucumber; see Gourd family.
Cucumber tree; see Tulip Poplar.
Cucurbitaceæ; see Gourd family.
Currant, Ribes spp. Pollen, nectar.
Cyperaceæ; see Sedge family.
Cyrilla family, Cyrillaceæ; see Ti-ti.
Cyrillaceæ; see Cyrilla family.

Dandelion, *Taraxacum officinale*, or *Leontodon Taraxacum* (Fig. 151). Perennial herb growing close to ground. Flowers yellow, blooms throughout year but most abundantly in early spring (with or following fruit bloom in North). Honey amber. In waste places and a weed in lawns and fields throughout the United States. Not valuable as a source of surplus honey, but especially helpful in building up colonies in early spring.

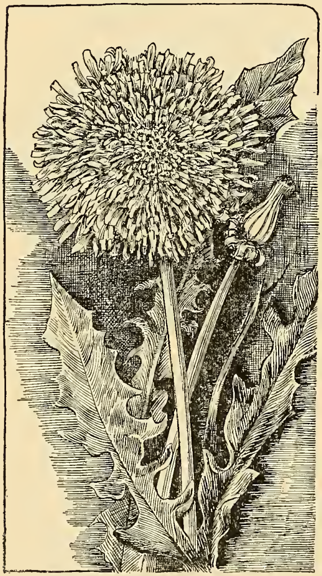


Fig. 151. — Dandelion.

Date palm, *Phœnix dactylifera.* Abundant nectar, California, Arizona.
Desert willow, *Chilopsis linearis.* New Mexico.
Dogwood family, Cornaceæ; see Tupelo.
Dutch clover; see White Clover.

Ebenaceæ; see Ebony family.
Ebony family, Ebenaceæ; see Persimmon.
Elder, Sambucus spp. Pollen, nectar.
Elm, Ulmus spp. Pollen.
Elm family, Ulmaceæ; see Elm, Granjeno and Hackberry.
English walnut, *Juglans regia.* Nectar, pollen.
Ericaceæ; see Heath family.
Eucalyptus, Eucalyptus spp. Numerous species of value introduced into California. The species vary greatly in nectar

secretion. Honey-scented gum, *E. melliodora*, swamp mahogany gum, *E. robusta*, white iron wood, *E. leucoxylon*, and blue gum, *E. globulus*, are those most valued. Primary honey plants in Australia. Honey sometimes strong flavored.

Eucalyptus family, Myrtaceæ; see Eucalyptus and Rose Apple.

Evening primrose family, Onagraceæ; see Willow-herb.

Eysenhardtia, rock brush, *Viborquia orthocarpa*. Important in southwest Texas.

Fagaceæ; see Beech family.

Figwort family, Scrophulariaceæ; see Mullen and Simpson's Honey Plant.

Fireweed, *Erechtites hieracifolia*. Eastern United States, July–September.

Fireweed; see also Willow-herb.

Frostweed; see Rockrose.

Gallberry, inkberry, *Ilex glabra*. Shrub, 2–6 feet, leaves evergreen, few teeth at apex or entire. May–July. Honey light color and of fine quality. Sandy soils, Massachusetts to Florida, west to Louisiana, mainly along coast, abundant in North Carolina, South Carolina, Georgia and Alabama, especially in cut-over forest lands. An important and increasingly valuable source of nectar in the southern States where considerable honey is produced (chiefly for local consumption). A reliable yielder. Other species of holly are also valuable, as American holly, *I. opaca*, April–June.

Geraniaceæ; see Geranium family.

Geranium family, Geraniaceæ; see Alfileria.

Goldenrod, Solidago spp. Perennial herbs, 1–5 feet, flowers generally yellow in panicles or heads, August to frost. Honey golden yellow, not of finest flavor, heavy body. Various species are adapted to all types of soil, but those growing in moist soils are the only ones of value to the beekeeper. The value of the goldenrods is probably exaggerated. In many places they are the most conspicuous flowers in the fall and get credit for honey which probably comes mainly from the asters. Eighty-five species, mostly in North America. The species which bloom early are usually valueless. The odor of the fall honeys is so pronounced that it can be detected some distance from the hive when freshly gathered.

Gooseberry, Grossularia spp. Pollen, nectar.

Gooseberry family, Grossulariaceæ; see Gooseberry and Currant.

Gourd family, Cucurbitaceæ. Various species furnish pollen and nectar, especially the genera Cucurbita, Cucumis and Citrullus, pumpkin, squash, cucumber and watermelon.

Gramineæ; see Grass family.
Granjeno, *Celtis pallida.* Southwest Texas, of value.
Grape family, Vitaceæ; see Grapes, Ampelopsis and Virginia Creeper.
Grape fruit; see Citrus Fruit.
Grapes, Vitis spp. Pollen, some nectar.
Grass family, Gramineæ; see Sorghum and Corn. Wind pollinated, some species visited for pollen.
Greasewood, *Adenostema fasciculatum.* April–July. California.
Grossulariaceæ; see Gooseberry family.
Guamá; see Guava.
Guava, *Inga vera*, and **guamá**, *I. laurina.* Of primary importance in Porto Rico, found elsewhere in West Indies and Central America.
Gum; see Eucalyptus.

Fig. 152. — Heartsease.

Hackberry, Celtis spp. Nectar, abundant pollen.
Hæmodoraceæ; see Bloodwort family.
Hamamelidaceæ; see Witch-hazel family.
Haws, Cratægus spp. Nectar, pollen.
Hazelnut, Corylus spp. Pollen.
Heartsease, lady's thumb, smartweed, *Persicaria persicaria* (Fig. 152). Annual herb, 6–24 inches or more (especially in middle west). Flowers in dense racemes, pink and purple, June–October, especially August–October. Honey light amber to dark, flavor good but easily lost by heating, granulates. On waste land throughout the United States, often abundant. An important source in middle west. Native to old world. The common name heartsease is given to this plant by most beekeepers. There are about 200 species of this genus, 71 occurring in North America, probably most of them contributing nectar.
Heath family, Ericaceæ; see Azalea, Rhododendron, Mountain Laurel, Sourwood and Manzanita. The heather, *Calluna vulgaris*, of Europe is a member of this family.

Heather; see Heath family.
Hemp, *Cannabis sativa.* Pollen, eastern United States.
Hickory, Carya sp. Pollen.
Hog plum, jobo, *Spondias lutea.* Valuable in Porto Rico.
Holly; see Gallberry.
Holly family, Aquifoliaceæ; see Gallberry.
Honey-balls; see Button-bush.
Honey-locust, *Gleditsia triacanthos.* Nectar. Much less important than black locust.
Honey-scented gum; see Eucalyptus.
Honeysuckle; see Tartarian Honeysuckle.
Honeysuckle, wild; see Azalea.
Honeysuckle family, Caprifoliaceæ; see Elder, Indian Currant and Tartarian Honeysuckle.
Hop, *Humulus lupulus.* Pollen, general in the United States.
Horehound, *Marrubium vulgare.* Common throughout most of United States, native of old world. Honey dark amber, strong flavor, surplus locally in California.
Hornbeam, *Carpinus caroliniana.* Tree to 40 feet, pollen, eastern United States.
Horsechestnut, *Æsculus Hippocastanum.* Some pollen and nectar.
Horsemint, *Monarda punctata* (Fig. 153). Perennial herb, 2–3 feet, flowers in whorls on stem and terminal, April–June in Texas, later farther north. Honey amber, flavor somewhat strong. Southern New York to Florida, west to Wisconsin and Texas, especially valuable in eastern Texas where it is of major importance. In the genus Monarda there are ten species, probably all valuable to the beekeeper. Wild bergamot, *M. fistulosa*, and American bee balm, *M. didyma*, should be especially mentioned. *M. clinopodioides* is also listed for Texas as important.

Fig. 153. — Horsemint.

Huajilla; see Acacias.
Huckleberry, Gaylussacia spp. New England, of importance along coast.
Huckleberry family, Vacciniaceæ; see Huckleberry and Blueberry.
Huisache; see Acacia.
Hydrophyllaceæ; see Water-leaf family.
Hypericaceæ; see St. John's-wort family.

Indian currant, coral-berry, *Symphoricarpos racemosus.* Nectar, July.
Inkberry; see Gallberry.
Iron-weed, Vernonia spp. Nectar, late summer.
Iron-wood; see Ti-ti.

Jackass clover, *Wislizenia refracta.* August–October. Honey white. San Joaquin valley, California, increasing.
Jerusalem artichoke; see Sunflower.
Jobo; see Hog plum.
Judas tree, red bud, *Cercis canadensis.* Nectar, pollen.
Juglandaceæ; see Walnut family.
Juneberry, service berry, *Amelanchier canadensis.* March–May, tree to 60 feet.

Keawe; see Mesquite.

Lady's thumb; see Heartsease.
Lantana, Lantana sp. Valuable in Hawaii.
Lauraceæ; see Laurel family.
Laurel family, Lauraceæ; see Red Bay and California Laurel.
Leatherwood; see Ti-ti.
Leguminosæ; see Pea family.
Lemon; see Citrus Fruits.
Lilac; see White Lilac.
Liliaceæ; see Lily family.
Lilies, Lilium spp. Pollen.
Lily family, Liliaceæ; see Onion, Lilies, Asparagus and Yucca.
Lima bean, Phaseolus sp. Important locally in California, where grown extensively.

Fig. 154. — Locust.

Lime; see Citrus Fruits.
Lime tree; see Basswood.
Lin; see Basswood.

Linden; see Basswood.
Linden family, Tiliaceæ; see Basswood.
Linn; see Basswood.
Liverwort, *Hepatica triloba.* Pollen.
Locust, *Robinia Pseudacacia* (Fig. 154). Tree to 80 feet, flowers white, fragrant, in drooping racemes. May–June. Honey white, fine flavor, heavy body. Pennsylvania south to Georgia and west to Iowa. There are six species of Robinia native to America, of special value as honey-plants where white clover is not dependable, usually furnishes nectar for about ten days only.
Locust; see also Honey Locust.
Logwood, *Hæmatoxylum campechianum.* In Jamaica this produces a honey of superb quality and color. Native of tropical America and West Indies.
Loosestrife, *Lysimachia vulgaris.* Pollen.
Lophiola, *Lophiola americana.* Pine barren bogs, eastern United States, June–August.
Loranthaceæ; see Mistletoe family.
Lucern; see Alfalfa.
Lupine, Lupinus spp. Nectarless, visited for pollen.
Lupinus affinis. Reported from California as a nectar plant.

Madder family, Rubiaceæ; see Button-bush.
Magnolia, Magnolia spp. Not important.
Magnolia family, Magnoliaceæ; see Magnolia and Tulip Poplar.
Magnoliaceæ; see Magnolia family.
Malaceæ; see Apple family.
Mallow, Malva spp. Some nectar, pollen.
Mallow family, Malvaceæ; see Marshmallow, Mallow, Cotton and Sida spp.
Malvaceæ; see Mallow family.
Manazanillo; see Manchineel.
Manchineel, manazanillo, *Hippomane Mancinella.* Important in southern Florida.
Manzanita, bearberry, Arctostaphylos sp. Shrub or small tree, November–February. Foothills of western slope (2000–9000 feet), California. Honey amber (or white) of excellent flavor.
Maple family, Aceraceæ; see Maples.
Maples, Acer spp. Nectar, especially pollen.
Marshmallow, Althæa spp. Nectar, unimportant.
Meadow-rue, Thalictrum spp. Pollen.
Meadow sweet, *Spiræa latifolia.* Some nectar.
Melia family, Meliaceæ; see China-tree.
Meliaceæ; see Melia family.

Menthaceæ; see Mint family.

Mesquite, *Prosopis glandulosa.* Shrub and tree, flowers in dense spikes, seed in constricted pods. April and June–July. Honey light amber, of good flavor. Fifteen species in tropical regions. *P. glandulosa* is of value as a honey-plant in the semi-arid regions of Texas, New Mexico and Arizona, extending into Mexico. *P. juliflora*, introduced from Mexico, is the chief floral nectar source in Hawaii (called algaroba, keawe), honey white, granulates quickly. This species is also found in Peru and has recently been introduced to Porto Rico. *P. velutina* and *P. pubescens*, April–July reported from Arizona.

Milkweed, Asclepias spp. Various species of value, especially those in swamps. Pollen masses adhere to bees, sometimes making them incapable of flight. Butterfly weed, pleurisy-root, *A. tuberosa*, especially valuable.

Milkweed family. Asclepiadaceæ; see Milkweed.

Mimosa spp. Tropical and subtropical. Probably of value.

Mimosa family, Mimosaceæ; see Acacia, Mesquite, Guava, Saman and Mimosa spp.

Mimosaceæ; see Mimosa family.

Mint, Mentha spp. Honey amber, of value locally.

Mint family, Menthaceæ; see Blue-curls, Horehound, Catnip, Sages, Horsemint, Pennyroyal, Bee Balm, Creeping Thyme and Mint. An important family.

Mistletoe, Phoradendron spp. Parasitic, December–January, Texas, California, earliest source of nectar in Texas.

Mistletoe family, Loranthaceae; see Mistletoe.

Moca, cabbage tree, *Geoffrœa jamaicensis.* Of marked value, West Indies, tropical America.

Moraceæ; see Mulberry family.

Morong, red-root, *Gyrotheca capitata.* Pine barrens.

Mountain laurel, Kalmia spp. Valuable locally, Allegheny Mountains.

Mulberry, Morus spp. Pollen.

Mulberry family, Moraceæ; see Mulberry, Hop and Hemp.

Mullen, Verbascum spp. Pollen, nectar in some species.

Musaceæ; see Banana family.

Mustard; see Rape.

Mustard family, Cruciferæ; see Rape and Radish. Numerous species of this family are valuable but are not of primary importance.

Myricaceæ; see Bayberry family.

Myrtaceæ; see Eucalyptus family.

Oak, Quercus spp. Pollen, some nectar.

Oleaceæ; see Olive family.
Olive, *Olea europœa.* April–May, California, value doubtful.
Olive family, Oleaceæ; see Ash, Privet and Olive.
Onagraceæ; see Evening Primrose family.
Onion, *Allium Cepa.* Nectar. Valuable where abundant.
Orange; see Citrus Fruits.
Orchid family, Orchidaceæ. Usually adapted to larger insects. Some pollen.
Orchidaceæ; see Orchid family.

Palm family, Palmaceæ; see Cabbage Palmetto, Saw Palmetto, Date Palm, Royal Palm and Cocoanut Palm.
Palmaceæ; see Palm family.
Paloverde, *Cercidium torreyanum.* Reported as valuable in Arizona, May.
Papaveraceæ; see Poppy family.
Partridge pea, *Chamœcrista fasciculata* (Fig. 155). Annual herb, 1–2½ feet, leaves sensitive, flowers yellow, solitary or in small clusters. Nectaries on petioles. July–September. Honey light amber, body thin, flavor not good, of value only for baking. Maine to Florida, west to Kansas and Texas, but valuable as a producer of surplus only in Georgia and Florida. The species of this genus are not nectar yielders, except such as have extra-floral nectaries, from which nectar is quickly washed out in rainy weather.

Fig. 155. — Partridge pea.

Pea family, Leguminosæ. This family contains many species of the highest importance to beekeepers. The honeys are usually white. See Lupines, *Lupinus affinis*, Alfalfa, Sweet Clover, White Clover, Alsike Clover, Crimson Clover, Wild Alfalfa, Locust, Moca, Bush Clover, Vetches, Lima Bean and Cowpea.
Peach, *Prunus persica.* Nectar, pollen.
Pear, Pyrus spp. Nectar, pollen.
Pecan, Carya sp. Pollen.
Pennyroyal, *Hedeoma pulegioides.* Annual, eastern United States, July–September. Four species in Florida of value locally, January–February.

Pepper tree, *Schinus Molle*. Southern California, introduced. Regular producer of nectar. Honey amber, strong flavor.
Persimmon, *Diospyros virginiana*. Tree to 100 feet, May–June, eastern United States.
Phacelia hispida and P. tanacetifolia. Of value in California. Honey of *P. hispida* granulates quickly. Species of *Phacelia* valued by beekeepers in Europe.
Plantaginaceæ; see Plantain family.
Plantain, Plantago spp. Pollen.
Plantain family, Plantaginaceæ; see Plantain.
Pleurisy-root; see Milkweed.
Plums, Prunus spp. Cultivated and various wild species. Spring.
Polygonaceæ; see Buckwheat family.
Polygonum lapathifolium and P. punctatum are of value in California.
Poma rosa; see Rose Apple.
Poplar; see Tulip Poplar.
Poplars, Populus spp. Pollen.
Poppy, Papaver spp. Pollen.
Poppy family, Papaveraceæ; see Poppy, Prickly Poppy, Bloodroot and California Poppy.
Potato family, Solanaceæ; see Tobacco.
Prickly pear; see Cactus.
Prickly poppy, *Argemone platyceras*. Texas, pollen, May–July.
Pride of India; see China-tree.
Primrose family, Primulaceæ; see Loosestrife.
Primulaceæ; see Primrose family.
Privet, Ligustrum spp. Not important.
Pumpkin; see Gourd family.
Purple medic; see Alfalfa.
Purple sage; see Sage.

Radish, *Raphanus sativus*. Pollen, nectar.
Ragweed, *Ambrosia elatior*. Annual herb, 1–6 feet, July to frost, flowers in racemes, green. Throughout United States, a troublesome weed. An important source of pollen, yields no nectar.
Ragweed family, Ambrosiaceæ; see Ragweed and Cocklebur.
Ranunculaceæ; see Crowfoot family.
Rape, mustard, Brassica spp. Pollen and nectar. Especially valuable in California (*B. nigra*). Honey granulates rapidly.
Raspberry, blackberry, Rubus spp. Various species of value.
Raspberry; see also Wild Raspberry.
Rattan vine, *Berchemia scandens*. Some surplus. Honey dark amber, April, Texas.

Red bay, *Persea borbonia.* Southeastern United States, April–June.
Redbud; see Judas Tree.
Red clover; see White Clover.
Red-root; see Morong.
Rhamnaceæ; see Buckthorn family.
Rhododendron, Rhododendron spp. Valuable locally, Allegheny Mountains.
Rock brush; see Eysenhardtia.
Rockrose, frostweed, Helianthemum spp. Pollen.
Rockrose family, Cistaceæ; see Rockrose.
Rocky Mountain bee-plant; see Cleome.
Rosaceæ; see Rose family.
Rose apple, poma rosa, *Caryophyllus jambos.* Tropical, of value.
Rose family, Rosaceæ; see Meadow Sweet, Raspberry, Blackberry, Wild Raspberry, Greasewood, Strawberry, Roses, Plum and Peach.
Roses, Rosa spp. Pollen only.
Royal palm, Roystonea spp. Honey amber, West Indies. Secretes heavily.
Rubiaceæ; see Madder family.
Rue family, Rutaceæ; see Citrus Fruits.
Rutaceæ; see Rue family.

Sage brush, *Artemisia californica.* Valuable for pollen, southern California.
Sages, Ramona spp. (Also classified as Audibertia spp. and Salvia spp.) Plants of California species vary in size up to 10 feet. April–July. Honey "water-white," granulating least quickly of any American honeys, flavor mild and delicious. The semi-arid regions of southern California in cañons to 5000 feet (Richter). The black, ball or button sage, *R. stachyoides* (Fig. 156), is perhaps the most important, although white sage, *R. polystachya* (Fig. 157), and purple sage, *R. nivea*, are valuable. These plants require about twenty inches of rainfall in late winter followed by warm spring, free from fogs, to produce

Fig. 156. — Button sage.

best results. When at their best these plants equal any other species in nectar secretion, but failures in crop are common. The sage worm (*Platyptilia marmarodactyla*) does considerable damage to the button sage, destroying the nectaries, especially in cloudy weather. Britton and Brown list seven species of Salvia for the eastern United States and state that there are twenty-five other species in the United States. Richter lists seven other species as California honey-plants.

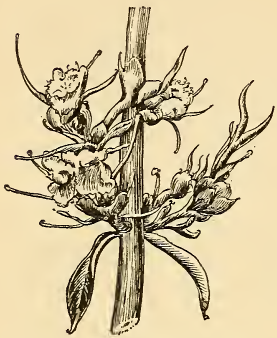


Fig. 157. — White sage.

St. John's-wort, Hypericum spp. Pollen.

St. John's-wort family, Hypericaceæ; see St. John's-wort.

Salicaceæ; see Willow family.

Saman, algaroba, *Pithecolobium Saman*. West Indies, Central and South America.

Saw palmetto, *Sabal megacarpa*. To 7 feet, May, honey amber, thick. Florida.

Scrophulariaceæ; see Figwort family.

Sedge family, Cyperaceæ; see Tule.

Senna family, Cæsalpinaceæ; see Judas Tree, Partridge Pea, Honey Locust, Eysenhardtia, Paloverde and Logwood.

Service berry; see Juneberry.

Sida spp. Tropical, listed for Hawaii.

Simarubaceæ; see Ailanthus family.

Simpson's honey-plant, *Scrophularia vernalis*. This common name is used only among American beekeepers. The species is native of southern Europe and was formerly cultivated for bees in parts of the United States, but without profit. Nectar abundant. Other species of Scrophularia are good honey-plants.

Smartweed; see Heartsease.

Solanaceæ; see Potato family.

Sorghum, *Holcus halepensis*. Pollen.

Sorrel-tree; see Sourwood.

Fig. 158. — Sourwood.

Sour clover; see White Clover.
Sour gum; see Tupelo.
Sourwood, sorrel-tree, *Oxydendrum arboreum* (Fig. 158). Tree to 60 feet, flowers white in numerous racemes, June–July. Honey light in color, granulates slowly. In dry woods, Pennsylvania to Florida, especially in Piedmont region and lower mountains. An exceptionally heavy yielder, little affected by changes in climatic conditions, nor is nectar washed out by rains.
Sow thistle, *Sonchus oleraceus*. Some nectar.
Spanish needle, Bidens spp., Coreopsis spp. The numerous species of these genera are variously adapted to all conditions of soil and moisture, but the swamp species are most important to the beekeeper. Annual or perennial herbs to several feet, ray flowers yellow. Autumn. Honey amber, body heavy, flavor somewhat pronounced, granulates slowly. *Bidens involucrata*, native of middle west, is abundant (introduced) in the Delaware River bottoms south of Philadelphia, where it yields excessively. *B. aristosa* is the species reported as so valuable in the Illinois and Mississippi River bottoms. The Kankakee Swamps (northern Indiana and Illinois) contain Spanish needle in abundance. There seems to be considerable confusion as to the identification of the various species, and a careful study should be made of these valuable fall flowers.
The common name Spanish needle is the one usually adopted by beekeepers. Tickseed, sunflower, beggar's tick and bur-marigold are also applied to various species.
Spanish trefoil; see Alfalfa.
Spider-flower; see Cleome.
Spikeweed, *Centromadia pungens*. Central California, formerly a leading source of honey, now being superseded by other plants.
Squash; see Gourd family.
Strawberry, Fragaria sp. Nectar in some localities.
Sumac, *Rhus glabra*. Shrub to 20 feet, flowers yellowish green in dense conical panicles. June–August. Honey amber of fine flavor when well ripened. Distributed widely in moist regions of United States, yielding a surplus in New England. There are several species of Rhus of value to the beekeeper. Poison ivy, *R. radicans*, yields nectar.
Sumac family, Anacardiaceæ; see Sumac, Pepper Tree and Hog Plum.
Sunflower, Helianthus spp. Nectar often abundant. Jerusalem artichoke, *H. tuberosus*, cultivated for edible tubers is of value in moist soil. *H. annuus*, common in West.
Sunflower; see also Spanish Needle.
Swamp mahogany gum; see Eucalyptus.

Swedish clover; see Alsike Clover.

Sweet clover, *Melilotus alba* (Fig. 159), *M. officinalis*, *M. indica*. Biennial herbs (*M. indica*, annual), 3–10 feet. Flowers white in *M. alba* and yellow in other two species, in slender racemes. June–September, or even later, usually in July. Honey slightly green in color, flavor described as like cinnamon. Throughout United States, usually in waste places but becoming more common as a forage plant. Secretes nectar wherever grown. Native of old world. In some sections (Kentucky, Utah) this plant is valued as a soil renovator (see Farmers' Bulletin No. 485, U. S. Department of Agriculture). White sweet clover, *M. alba* (Fig. 159), is the most common species. Seed is now offered for sale annually in the bee journals. It has been sown extensively by beekeepers in waste places and along embankments. Called also Bokhara clover and has numerous other common names. Twenty species, all native of old world. *M. indica* more abundant in far west.

Fig. 159. — Sweet clover.

Sweet-gale, bayberry, Myrica spp. Wind pollinated, some pollen.

Sweet gum, *Liquidambar Styraciflua*. A source of abundant propolis.

Sweet pepper bush, *Clethra alnifolia*. Shrub, 3–10 feet. Honey light amber, good body. In swampy woods, Maine to Florida, especially near coast, July–August. Of special value in New England and New Jersey.

Tartarian honeysuckle, *Lonicera tatarica*. Nectar, important locally, other species valuable in which flowers are not too long for bees to reach. Bumble-bees sometimes pierce tubes of the honeysuckle, *L. Periclymenum*, to obtain nectar, after which honeybees work on the pierced flowers.

Thistle, Carduus spp. Considerable nectar.

Thistle family, Compositæ; see Iron-weed, Boneset, Goldenrod, Asters, Sunflower, Spanish Needle, Sage Brush, Fireweed, Thistle, Canada Thistle and Spikeweed. This is a most important family from the standpoint of the beekeeper.

Thoroughwort; see Boneset.

Tickseed; see Spanish Needle.

Tiliaceæ; see Linden family.

Ti-ti, leatherwood, iron-wood, *Cyrilla racemiflora.* Evergreen shrub to 35 feet, flowers small, white in narrow racemes. May–July, February–March in Florida. Honey red, flavor strong, good only for baking. Virginia to Florida to Texas, of value chiefly in Georgia and Florida. Not a reliable source, as the nectar is washed out by rains, which are frequent during blooming period in Florida. Precedes tupelo in Appalachicola region. Black ti-ti, Cliftonia sp., blooms later and is more reliable.

Tobacco, *Nicotina Tabacum.* Nectar locally, especially in Connecticut, honey fair.

Tree of heaven; see Ailanthus.

Trumpet-creeper family, Bignoniaceæ; see Catalpa and Desert Willow.

Tule, Scirpus sp. Reported as a honey-plant from interior valleys of California; probably incorrect.

Tulip or yellow poplar, poplar, white wood, cucumber tree, tulip tree, *Liriodendron Tulipifera* (Fig. 160). Tree to 175 feet, flowers 2 inches wide, resembling tulips, greenish yellow, orange inside. May–June. Honey dark amber, of pronounced flavor. In woods, eastern half of United States. Especially abundant in Ohio Valley and southern Appalachian mountains. An unusually heavy and reliable yielder.

Fig. 160. — Tulip poplar.

Tulip tree; see Tulip Poplar.

Tupelo, sour gum, Nyssa spp. Trees to 100 feet, leaves oval or acute or slightly toothed (*N. aquatica*). April–June. Honey of fine quality, light amber, rarely granulating, flavor mild but characteristic. Swamps of eastern United States, west to Missouri and Texas, especially abundant in Florida, Alabama and Georgia. The honey from tupelos is of especial value in blending extracted-honeys for table trade because of its slowness in granulating. There are four species of Nyssa of value to the beekeeper. Tupelo, *N. aquatica*, is found abundantly in southern swamps, especially along the Appalachicola River. Secretes so abundantly that it will support thousands of colonies. Sour gum, *N. sylvatica*, is found farther north and with *N. biflora* furnishes abundant nectar. In abundance of nectar these trees equal the basswood.

Ulmaceæ; see Elm family.

Umbelliferæ; see Carrot family.

Vacciniaceæ; see Huckleberry family.

Verbenaceæ; see Vervain family.

Vervain family, Verbenaceæ; see Carpet Grass, Lantana and Black Mangrove.

Vetches, Vicia spp. Nectar, pollen.

Viper's bugloss, blueweed, blue-thistle, *Echium vulgare*. Biennial herbs, 1–2½ feet, stem erect bearing numerous blue to purple flowers, stem hairy, July–September and later. In fields and waste land, native of Europe, especially abundant in Virginia, Maryland and Pennsylvania. The common name blue-thistle is the one by which beekeepers usually know this plant. An important source in the Shenandoah Valley.

Fig. 161. — White clover.

Virginia creeper, *Parthenocissus quinquefolia*. Nectar, pollen.

Vitaceæ; see Grape family.

Walnut family, Juglandaceæ; see Black Walnut, English Walnut, Hickory and Pecan.

Water-leaf family, Hydrophyllaceæ; see Phacelia.

Watermelon; see Gourd family.

Wattles; see Acacias.

White alder family, Clethraceæ; see Sweet Pepper Bush.

White clover, *Trifolium repens* (Fig. 161). Perennial, creeping branches often taking root at nodes. Blooms from May on, but especially in June–July, when it is especially valuable. Honey light in color, granulates slowly, flavor superb. In pasture lands and waste places in moist regions of United States and Canada. Valuable as honey source chiefly in North and East. Not cultivated, thrives in limestone regions. Native of Europe and introduced into United States. One of the most important sources. May be considered as a "standard" for comb-honey, being equaled by no other source for this type of honey. Nectar-secretion quickly affected by adverse weather conditions. Honey often mixed with basswood in Michigan, Wisconsin and adjoining States. Also called Dutch clover, under which name seed is often sold. Other species of *Trifolium* are also valuable, *e.g.* sour clover, *T. fucatum*, California. Red clover, *T. pratense*, usually has a corolla tube too long for the honeybee to reach the nectar. At times bees get considerable nectar from this source. See also Crimson Clover and Alsike Clover.

Fig. 162. — Willow-herb.

White ironwood; see Eucalyptus.

White lilac and others, Ceanothus spp. California, February–May. Nectar and abundant pollen.

White sage; see Sage.

Whitewood; see Basswood and also Tulip Poplar.

Wild alfalfa, *Lotus glaber*. June–September, California.

Wild bergamot; see Horsemint.

Wild buckwheat, *Eriogonum fasciculatum*. Honey light amber, granulates quickly. April–November, southern California.

Wild honeysuckle; see Azalea.

Wild raspberry, *Rubus strigosus*. Shrubs, 3–6 feet, stems with small prickles. May–July or later. Honey white, flavor unsurpassed by that of any other honey. In dry lands, Canada south in mountains to North Carolina and in west to New Mexico, to 5500 feet in North Carolina. Especially valuable in cut or burned over lands in northern Michigan and noted in parts of New York. This is said to be the original of the Cuthbert red raspberry so widely cultivated. Reliable where abundant.

Willow family, Salicaceæ; see Poplars and Willows.

Willow-herb, fireweed, *Chamænerion angustifolium* (Fig. 162). Perennial herbs, 2–8 feet, flowers pink to purple (rarely white), in spike-like racemes. Honey white, flavor excellent, not pronounced. In dry soil, especially in burned-over forest lands. Labrador south to North Carolina, Kansas and California, but especially in Michigan, Wisconsin, Minnesota, Canada and Washington. This species continues in bloom from July to frost, the flowers maturing in series upward on the stem. A heavy reliable yielder.

Willows, Salix spp. Extraordinary value for pollen, some nectar. Early spring.

Witchhazel family, Hamamelidaceæ; see Sweet Gum.

Yellow poplar; see Tulip Poplar.

Yucca, *Hesperoyucca Whipplei*. Semi-desert, California.

CHAPTER XXII

BEE DISEASES AND ENEMIES

THE honeybee is subject to several diseases which are at times a serious handicap to the industry. Several years ago these diseases were working insidiously, destroying the industry in some localities and constituting a serious handicap elsewhere. The recent agitation on this subject has, however, brought about a wider knowledge of these diseases and they are losing their destructiveness just so fast as the beekeepers learn how to recognize them and how to treat diseased colonies.

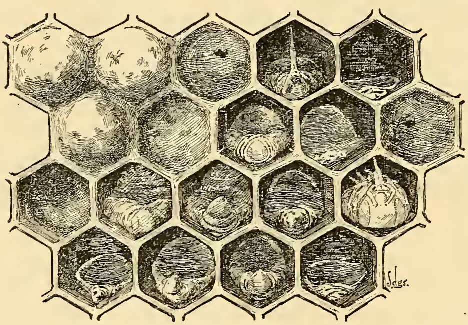
The diseases of bees may be divided into two classes, those affecting the brood and those to which the adult bees are subject. The diseases of the brood are the more destructive and more is known concerning their causes, distribution, symptoms and treatment.

BROOD DISEASES

There are three recognized diseases of the brood, known as American foul brood, European foul brood and sacbrood or

NOTE. Various phases of the investigation of the brood diseases are reported in publications of the United States Department of Agriculture to which the reader is referred for additional information. These publications deal with the symptoms, treatment, geographical distribution and causes of the diseases as well as the control measures provided by various States in the form of apiary inspection. The present discussion of brood diseases is largely drawn from the author's bulletin "The Treatment of Bee Diseases," Farmers' Bulletin 442, since it seems useless to attempt a rearrangement of the material in this bulletin.

pickled brood. These diseases weaken colonies by reducing the number of emerging bees needed to replace the adult bees which die from natural causes. The adult bees are not known to be affected. The larvæ dead of these diseases show certain differences in appearance which are useful in determining which disease is present. These diseases are entirely distinct, as shown by these differences in appearance, by differences in response to treatment, by differences in the age of the larvæ affected and by bacteriological examination. There is no evidence that chilled or starved brood develops into an infectious disease or that dead brood favors the development of an infectious disease.



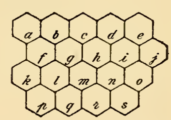


FIG. 163. — American foul brood: *a*, *b*, *f*, normal sealed cells; *c*, *j*, sunken cappings, showing perforation; *g*, sunken capping not perforated; *h*, *l*, *m*, *n*, *q*, *r*, larvæ affected by disease; *e*, *i*, *p*, *s*, scales formed from dried-down larvæ; *d*, *o*, pupæ affected by disease. Twice natural size.

American foul brood.

This disease (Fig. 163) is frequently called simply "foul brood." It usually shows itself in the larvæ just about the time that they fill the cells and after they have ceased feeding and have begun pupation. At this time the larva is sealed over in the comb (Fig. 163, *a*, *b*, *f*). The first outward indication of the infection is a slight brownish discoloration and the loss of the well-rounded appearance of the normal larva (Fig. 163, *l*). The larva gradually sinks down in the cell and becomes darker in color (Fig. 163, *h*, *m*) and the posterior end lies against the bottom of the cell. Frequently the segmentation of the larva is clearly marked. By the time it has partially dried down and has become quite dark brown (coffee colored) the most typical characteristic of this disease manifests itself. If a match stick or tooth-pick is inserted into the decaying mass and withdrawn, the larval remains adhere to it and are drawn out in a thread (Fig. 164), which sometimes extends for several inches before breaking. This ropiness is the chief characteristic used by the beekeeper in diagnosing this disease. The larva continues to dry down

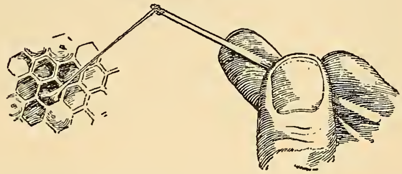


Fig. 164. — The ropiness of American foul brood.

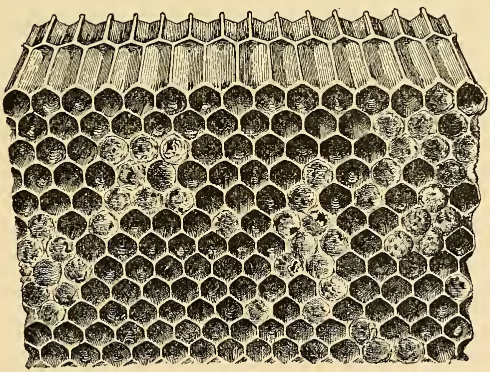


Fig. 165. — American foul brood comb, showing irregular patches of sunken cappings and scales. The position of the comb indicates the best way to view the scales.

and gradually loses its ropiness until it finally becomes merely a scale on the lower side wall and base of the cell (Fig. 163, *e*, *p*, *s*). The scale formed by the dried-down larva adheres tightly to the cell and can be removed with difficulty from the cell wall. The scales can best be observed when the comb is held with the top inclined toward the observer so that a bright light strikes the lower side wall (Fig. 165). A characteristic and usually penetrating odor is often noticeable in the decaying larvæ. This can best be likened to the odor of heated glue.

The larger part of the larvæ which die of this disease are attacked after being sealed in the cells. The cappings are

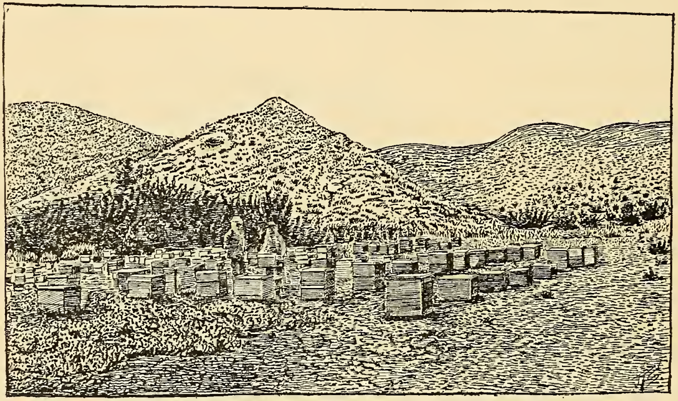
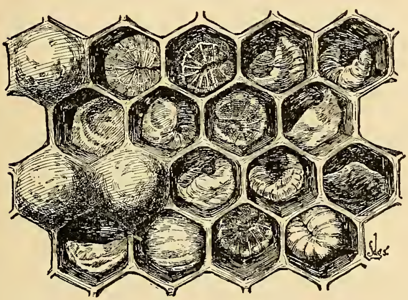


Fig. 166. — Apiary in southern California which was practically destroyed by disease. When this apiary was visited by the author in 1908, only 15 colonies were seemingly free from American foul brood in the 151 hives. After treatment only 14 colonies were saved. This devastation had occurred in two seasons.

often entirely removed by the bees, but when they are left they usually become sunken (Fig. 163, *g*, *c*, *j*) and frequently perforated (Fig. 163, *c*, *j*). As the healthy brood emerges the comb shows the scattered sunken cappings covering dead larvæ (Fig. 165), giving it a characteristic appearance. Pupæ also may die of this disease, in which case they too dry down (Fig. 163, *o*, *d*), become ropy and have the characteristic odor and color. The tongue frequently adheres to the upper side wall and often remains there even after the pupa has dried down to a scale. Younger unsealed larvæ are sometimes affected. Usually the disease attacks only worker brood, but occasional cases are found in which queen and drone brood are diseased. It is not certain that race of bees, season, or climate have any effect on the virulence of this disease, except that in warmer climates, where the breeding season is prolonged, the rapidity of devastation (Fig. 166) is more marked. Cause, *Bacillus larvæ.*

European foul brood.

This disease (Fig. 167) was formerly called "black brood." It usually attacks the larva at an earlier stage of its development than American foul brood and while it is still curled up at the base of the cell (Fig. 167, *r*). A small percentage of larvæ dies



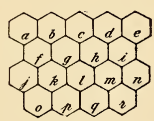


FIG. 167. — European foul brood: *a, j, k,* normal sealed cells; *b, c, d, e, g, i, l, m, p, q,* larvæ affected by disease; *r,* normal larva at age attacked by disease; *f, h, n, o,* dried-down larvæ or scales. Twice natural size.

after capping, but sometimes quite young larvæ are attacked (Fig. 167, *e, m*). Sunken and perforated cappings are sometimes observed just as in American foul brood (Fig. 163, *c, g, j*). The earliest indication of the disease is a slight yellow or gray discoloration and uneasy movement of the larva in the cell. The larva loses its well-rounded, opaque appearance and becomes slightly translucent, so that the tracheæ may become prominent (Fig. 167, *b*), giving the larvæ a clearly segmented appearance. The larva is usually flattened against the base of the cell but may turn so that the ends of the larva are to the rear of the cell (Fig. 167, *p*) or may fall away from the base (Fig. 167, *e*, *g*, *l*). Later the color changes to a decided yellow or gray and the translucency is lost (Fig. 167, *q*, *h*). The yellow color may be taken as the chief characteristic of this disease. The dead larva appears as a moist, somewhat collapsed mass, giving the appearance of being melted. When the remains have become almost dry (Fig. 167, *c*) the tracheæ sometimes become conspicuous again, this time by retaining their shape, while the rest of the body content dries around them. Finally all that is left of the larva is a grayish-brown scale against the base of the cell (Fig. 167, *f*, *h*) or a shapeless mass on the lower side wall if the larva did not retain its normal position (Fig. 167, *n*, *o*). Very few scales are black. The scales are not adhesive but are easily removed and the bees carry out a great many in their efforts to clean house.

Decaying larvæ which have died of this disease are usually not ropy as in American foul brood but a slight ropiness is sometimes observed. There is usually little odor in European foul brood, but sometimes in bad cases a sour odor is present, which reminds one of yeast fermentation. This disease attacks drone and queen larvæ almost as quickly as those of the workers.

European foul brood is more destructive during the spring and early summer than at other times, often entirely disappearing during late summer and autumn or during a heavy honey-flow. Italian bees seem to be better able to resist the ravages of this disease than any other race. The disease at times spreads with startling rapidity and is most destructive. Where it is prevalent a considerably larger percentage of colonies is affected than is usual for American foul brood. This disease is variable in its symptoms and other manifestations and is often a puzzle to the beekeeper. Cause, *Bacillus pluton*.

Sacbrood or pickled brood.

In this disease the larva dies about the time of sealing. It usually lies on its back with the head turned upward.

The color varies, but is frequently light yellow or brown and the head is often almost black. The body is swollen and the contents watery and the head may be quite hard. There is no ropiness. This disease is usually not the cause of any serious loss in the apiary and as a rule no treatment is necessary. The most serious aspect of this disease is that it is often mistaken for European foul brood or American foul brood and the colony is treated accordingly. The cause is a filterable virus.

Methods of spread.

Since all three of these diseases are infectious they are spread in much the same way. It has long been recognized that it is unsafe to feed honey from a diseased colony and probably most cases are due to the carrying of the virus in honey, as in robbing or feeding. It is well, therefore, to practice the following precautionary measures:

(1) Do not allow weak colonies to be robbed out.

(2) Never feed honey purchased on the open market.

(3) If possible keep all honey from diseased apiaries out of the neighborhood.

(4) In introducing purchased queens, transfer them to clean cages and destroy the old cage, candy and accompanying workers.

(5) Colonies of bees should never be purchased unless it is certain that they are free from disease.

(6) The purchase of old combs and second-hand supplies is dangerous unless it is certain that they come from healthy apiaries.

Treatment.

The treatment of an infectious bee disease consists primarily in the elimination or removal of the cause of the disease. In treating a disease, therefore, the aim of the manipulation is to remove or destroy all the virus causing the disease. It should be remembered that the effort is not to save the larvæ that are already dead or dying but to stop the further devastation of the disease by removing all material capable of transmitting the cause of the trouble. In all of the operations great pains should be taken not to spread the disease through carelessness. After handling a diseased colony, the hands of the operator should be washed with water to remove any honey that may be on them. It does not pay to treat colonies that are considerably weakened by disease. In case there are several such colonies they should be united to form strong, vigorous colonies before or during treatment.

Shaking treatment.

The treatment consists essentially in the removal of all infected material from the colony and in compelling the colony to take a fresh start by building new combs and by gathering fresh stores. This is done by shaking the adult bees from the old combs into a clean hive on clean frames.

The shaking treatment should be given during a flow of honey, so that other bees in the apiary will not be inclined to rob. If this is not possible the operation may be performed under a tent made of mosquito netting or a wire-cloth cage. The best time is during the middle of a clear day when a large number of bees are in the field.

All implements that will be needed, such as queen and drone trap, hive tool and lighted smoker, should be in readiness before the operation is begun. A complete clean hive with frames is provided, as well as a tightly closed hive-body in which to put the contaminated combs after shaking. An extra hive cover or some similar apparatus should be provided to serve as a runway for the bees as they enter the new hive. The new frames should contain strips of comb-foundation from one-fourth to one inch wide. Full sheets are not desirable and if combs built on full sheets of foundation are desired they may be built later.

The old hive containing the diseased colony (Fig. 168, *A*) is now lifted to one side out of the flight of returning field bees and the clean hive (*B*) set exactly in its place. The cover

(*G*) is now taken off and a few frames (*E*) removed from the center of the hive. If unspaced frames are used, those remaining in the hive should be pushed tightly to either side of the hive, thus making a barrier beyond which the bees cannot crawl as they move to the top of the hive after shaking. This largely prevents them from getting on the outside of the hive. If self-spacing frames are used, a couple of thin boards laid on the top-bars on either side will accomplish the same result. The runway (*D*) is put in place in front of the entrance. The old hive is now opened for the first time. The frames are removed one at a time, lowered part way into the

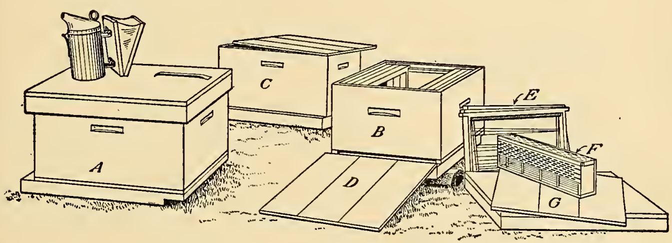


FIG. 168. — Apparatus for the shaking treatment: *A*, hive containing diseased colony (formerly in position of *B*); *B*, clean hive; *C*, empty hive to receive combs after shaking; *D*, hive cover used as runway; *E*, frames removed from *B* to give room for shaking; *F*, queen and drone trap; *G*, cover for clean hive, *B*.

new hive and, with a quick downward shake, the bees are dislodged. The frames are then put into the extra hive-body (*C*) and immediately covered to prevent robbing. After all the frames are shaken the bees remaining on the sides of the old hive (*A*) are shaken out.

If honey is coming in freely, so that thin honey is shaken out of the combs, cover the runway (*D*) with newspapers and shake the bees in front of the new hive (*B*), leaving all frames in place and the cover on. After the operation the soiled newspapers should be destroyed. In shaking in front of the entrance the first one or two frames should be so shaken that the bees are thrown against the entrance, where they can locate the hive quickly. They then fan their wings and the others follow them into the hive. If this is not done the bees may wander about and get under the hive or in some other undesirable place.

After the bees are mostly in the new hive a queen and drone trap (*F*) or a strip of perforated zinc is placed over the entrance to prevent the colony from deserting the hive. The old combs are now quickly removed. If several colonies are being treated at one time it may pay to stack several hive-bodies containing contaminated combs over a weak diseased colony to allow most of the healthy brood to emerge, thereby strengthening the weak colony. After ten or twelve days this colony is treated in turn and all the combs are rendered into wax.

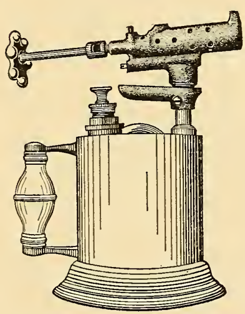


Fig. 169. — Gasoline torch.

An apiary of any size should have included in its equipment a wax press (p. 335) for removing wax from old combs. After the contaminated frames are taken to the honey-house the combs should be kept carefully covered, so that no bees can reach them until the wax can be rendered. This should not be delayed very long or the combs may be ruined by wax-moths. The slumgum or refuse remaining after the wax is removed should be burned as it is usually not sterilized in the rendering of the wax. Contaminated combs should not be put into a solar wax extractor for fear of spreading the disease. The wax from contaminated combs may safely be used in the manufacture of comb-foundation.

The hive which has contained the diseased colony should be thoroughly cleaned of all wax and honey, and it is desirable that it be carefully disinfected by burning out the inside with a gasoline blue-flame torch (Fig. 169). If this piece of apparatus is not available, several hive-bodies may be piled together on a hive bottom and some gasoline or kerosene poured on the sides and on some straw or excelsior placed at the bottom of the pile. This is then ignited and after burning for a few seconds a close-fitting hive cover is placed on top of the pile to extinguish the flames. The inside of the hive-bodies should be charred to a light brown. The careful cleaning and disinfection of frames always costs considerably more in labor than new frames would cost, but these also may be carefully cleaned and used again. Frames may be cleaned by boiling in water for about half an hour, but this frequently causes them to warp badly. The disinfection of hives and frames with chemicals is not recommended.

If there is a considerable quantity of honey in the contaminated combs it may be extracted. This honey is not safe to feed to bees without boiling, but it is absolutely safe for human consumption. If there is a comparatively small quantity it may be consumed in the beekeeper's family, care being taken that none of it is placed so that the bees can ever get it.

To put such honey on the market is contrary to law in some states. There is always danger that an emptied receptacle will be thrown out where bees can have access to it, thus causing a new outbreak of disease. It can be safely used for feeding to bees in summer, provided it is diluted with at least an equal volume of water to prevent burning and boiled in a closed vessel for not less than one-half hour, counting from the time that the diluted honey first boils vigorously. The honey will not be sterilized if it is heated in a vessel set inside of another containing water. Boiled honey should not be sold as honey. It is good only as a food for bees and even then should never be used for winter stores, as it would probably cause dysentery.

Some beekeepers prefer to shake the bees first on to frames containing strips of foundation as above described and in four days to shake the colony a second time on to full sheets of foundation, destroying all comb built after the first treatment. This insures better combs than the use of strips of foundation, but it is a severe drain on the strength of the colony. Since it is desirable to have combs built on full sheets, the best policy is to replace any irregular combs with full sheets of foundation or good combs later in the season.

If the treatment just described is given at the beginning of a good honey-flow, it is practically equivalent to artificial swarming (p. 283) and may result in an actual increase in the surplus honey, especially in the case of comb-honey production. The wax rendered from the combs will sell for enough to pay for the foundation used if full sheets of foundation are employed. If treatment must be given at some other time, so that the colony must be fed, the cost is materially increased. In feeding, it is best to use sugar syrup or honey that is known to have come from healthy colonies.

Fall treatment.

If it is necessary to treat a colony so late in the fall that it would be impossible for the bees to prepare for winter without assistance, the treatment may be modified by shaking the bees on to combs entirely full of honey so that there is no place for any brood to be reared. This will usually be satisfactory only after brood-rearing has entirely ceased. Unless a colony is quite strong it does not pay to treat in the fall, but it should be destroyed or united with another colony. In case a diseased colony dies outdoors in the winter, there is danger that other bees may have opportunity to rob the hive before the beekeeper can close the entrance. In case bees are wintered in the cellar it is more advisable to risk wintering before treatment, for if the colony does die the hive will not be robbed.

Additional treatment for European foul brood.

Since, as stated previously, Italian bees seem to be better able to withstand European foul brood than are other races, it is recommended that apiaries in regions where this disease is prevalent be requeened with young, vigorous Italian queens of good stock. This should be done whether or not the shaking treatment is given.

It has been found that the removal of the queen and the keeping of the colony queenless for a period often results in the disappearance of European foul brood. E. W. Alexander, who advocated this method,[1] recommended that the colony be kept queenless (by cutting out all queen cells at the end of nine days) for a period of twenty days, at which time a cell containing a queen of Italian stock ready to emerge is to be given to the colony. The young queen will thus begin to lay in about twenty-seven days after the old queen has been removed, or in at least three days after the last of the drone brood has emerged. Other writers have advocated a shorter time.

The dequeening treatment is not always successful and it is therefore recommended that care be exercised in trying it. Since there is a considerable percentage of successful results, this would indicate that there is an important principle involved. It should not be forgotten, however, that European foul brood often disappears in the late summer of its own accord if the case is not severe, and it is probable that in many of the cases of dequeening reported as successful the disease would have disappeared without the treatment. This treatment is suggested only for the experienced beekeeper.

DISEASES OF ADULT BEES

These diseases are but imperfectly known and there is much need of further investigation. In view of this condition it is virtually impossible to give much help in treatment.

Dysentery.

This condition is one which is manifest chiefly in late winter and is caused by improper food. It is therefore discussed in the chapter on wintering.

[1] Alexander, E. W., 1905. How to rid your apiary of black brood. Gleanings in bee culture, XXXIII, pp. 1125–1127.

Nosema disease.

In 1909 Zander[1] showed that a protozoon, named by him *Nosema apis*, is found abundantly in the mid-intestine of adult bees and he associated this organism in a causal relationship with the death of many thousands of colonies annually. Since this announcement other investigators have taken up work on this organism. It has been determined that heating the organism to 57° C. (134.6° F.) for ten minutes kills it. In England it is now claimed[2] that this organism is the cause of the so-called Isle of Wight disease or Microsporidiosus which is reported to have decimated the bees on that island and to have caused heavy losses in England. Numerous facts concerning this organism have been brought out, especially notable being the wide geographical distribution of the parasite. In spite of the work done by the various investigators there is a paucity of authentically proven facts which leaves much to be desired. No treatment has been suggested in England except destruction of the colony to prevent the spread of the disease. American beekeepers will do well to await reliable investigation before following such advice.

Paralysis.

Under this name beekeepers seemingly place practically all the diseases of adult bees which they observe. Symptoms attributed to paralysis are also given for poisoning and the more one reads of the symptoms and treatments suggested, the more hopeless it appears when one is asked to recommend treatment. Until more is known it is unsafe to give advice.

Spring dwindling.

This name has also apparently been given to various conditions. To avoid confusion it should be applied only

[1] Zander, Enoch, 1909. Tierische Parasiten als Krankheitserreger bei der Biene. München.

[2] Graham-Smith and others, 1912. Report on the Isle of Wight bee disease. Supplement Jr. Board of Agric., XIX, No. 2, 143 pp.

——, 1913, *ibid.*, 47 pp.

to the loss of bees in the spring due to the fact that the adults have been weakened by poor wintering and die faster than they can be replaced by emerging brood. This is therefore discussed in the chapter on wintering.

ENEMIES OF BEES

Most books on beekeeping devote considerable attention to the enemies of bees, of which there are several. Since they are relatively unimportant, however, the discussion will here be confined to the two species of wax-moth. These do no damage to strong healthy colonies of bees properly cared for, and if seen in the hive they indicate weakness. This weakness may be due to queenlessness or lack of stores, but the most common cause is probably a brood disease. Beekeepers frequently attribute the loss from disease to some other cause and wax-moths are most frequently blamed for the losses observed.

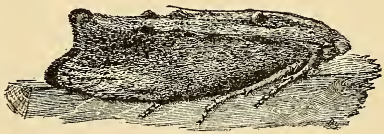


Fig. 170. — Wax-moth in natural position at rest.

The wax-moth (*Galleria mellonella*).

The larvæ of this moth (Figs. 170, 171 and 172) destroy combs by burrowing through them, constructing tunnels of silk

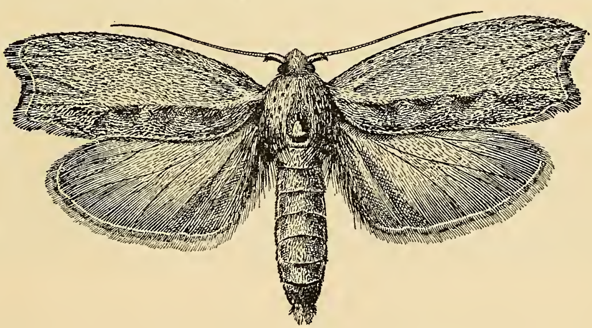


Fig. 171. — Wax-moth, male. Enlarged.

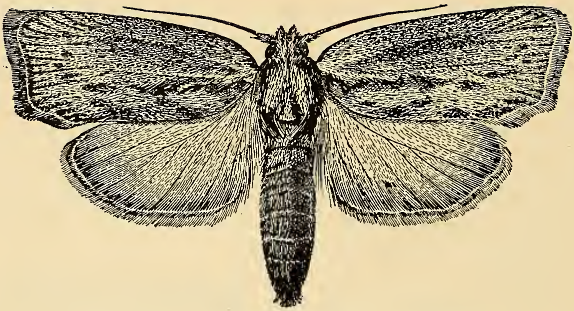


Fig. 172. — Wax-moth, female. Enlarged.

as they go (Fig. 173). These tunnels are spotted with excreta. The larvæ (Fig. 174) feed on pollen, cocoons and other materials in the combs. The eggs are laid in crevices in the hive or in any narrow space (Fig. 175) and seemingly in most localities there are probably few hives that do not harbor some

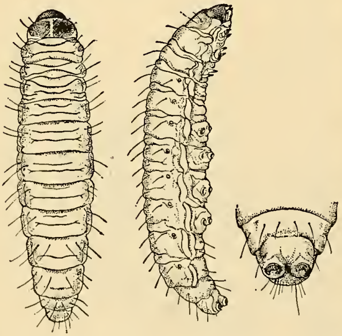


Fig. 174. — Larva of wax-moth.

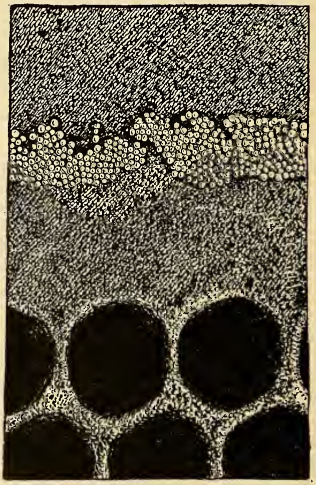


Fig. 175. — Eggs of wax-moth laid on top-bar of frame.

eggs. If combs are removed from the bees and sealed up, it will frequently be found that they become riddled by

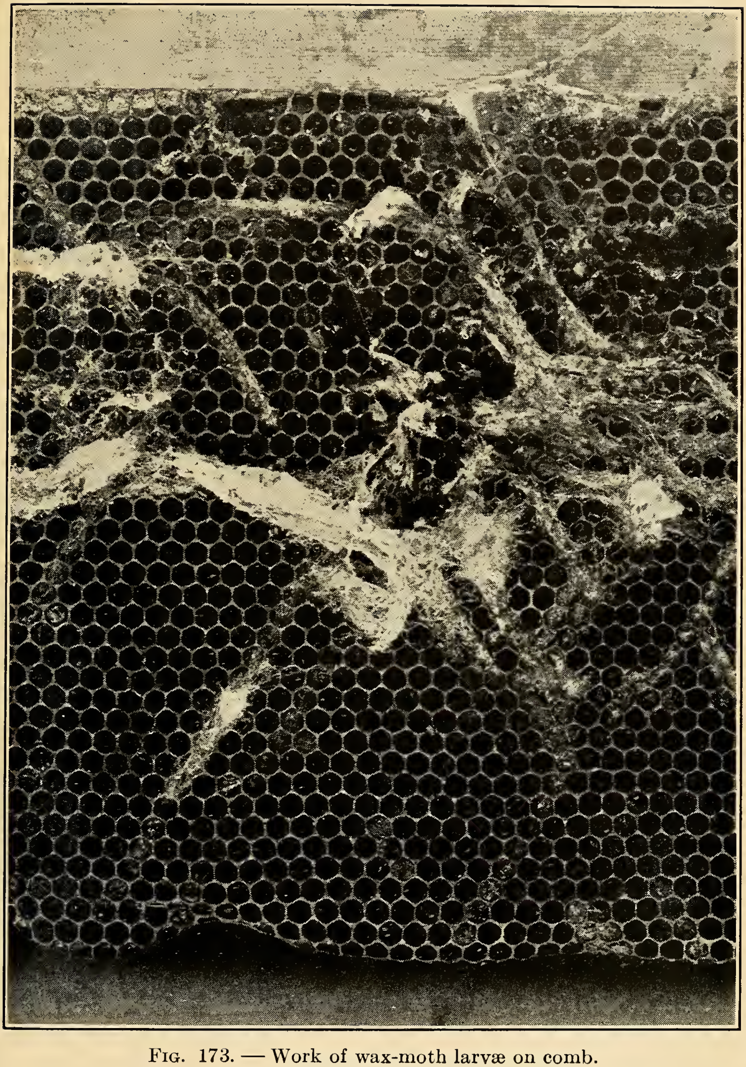


Fig. 173. — Work of wax-moth larvæ on comb.

the tunnels of these larvæ, presumably developed from eggs already present on the combs or frames. After feeding, the larvæ pupate, first spinning silken webs around themselves. Previous to pupation (Figs. 176 and 177) they sometimes burrow a little way into the hive wall, this being specially noticeable in the redwood hives in the West. The life history of this moth has recently been described by Paddock.[1] Although repeatedly introduced, the wax-moth is not found in Colorado. Except for special regions, as the one just mentioned, this moth is found wherever bees are kept and is also destructive to the combs of the giant bee (*Apis dorsata*). The female moths can

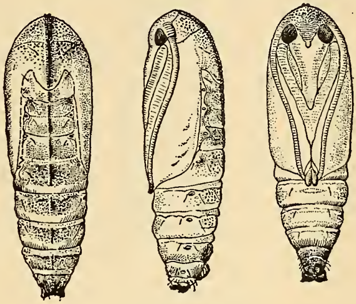


Fig. 176. — Pupa of wax-moth.

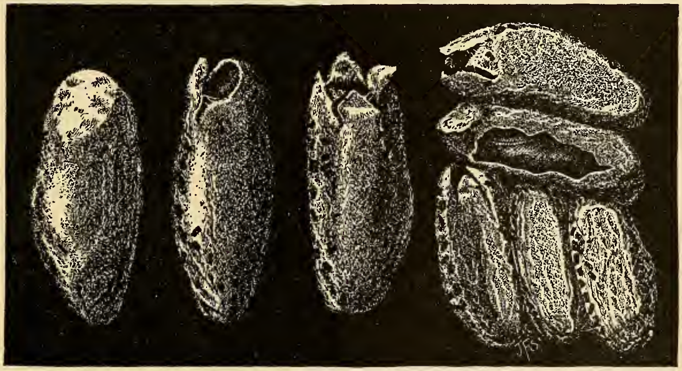


Fig. 177. — Cocoons of wax-moth.

[1] Paddock, F. B., 1913. The life history and control of the bee-moth or wax-moth. In Bulletin 158 "Investigations pertaining to Texas beekeeping." Texas Agric. Exp. Station.

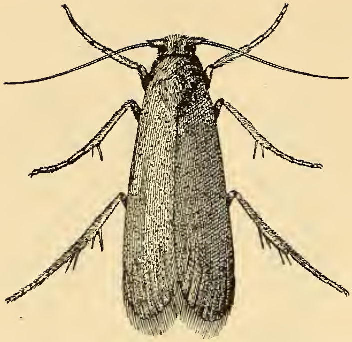


Fig. 178. — Lesser wax-moth in natural position.

often be seen flying in the apiary in early evening and attempting to enter the hives.

The lesser wax-moth (*Achroia grissella*).

This moth (Figs. 178, 179, 180, 181 and 182) is less widely distributed in the United States than the previous species. The larvæ tunnel through combs in much the same way as those of the larger species. The eggs are laid singly on the side wall of cells.

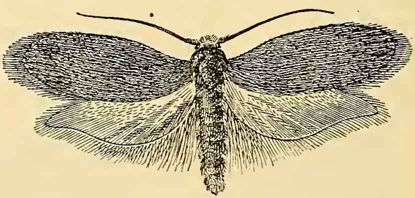


Fig. 179. — Lesser wax-moth, male.

Remedies.

To destroy the moth larvæ and pupæ in combs not in use, place them in hives tiered one above the other and on top place an empty hive or super. On the top-bars of the uppermost frames place a saucer into which pour bisulfid of carbon. The gas caused by the evaporation of the liquid

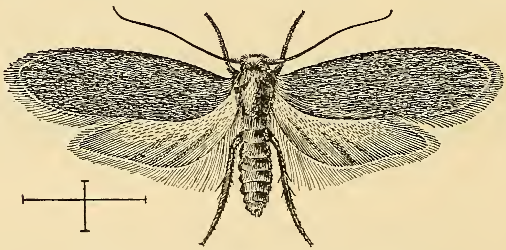


Fig. 180. — Lesser wax-moth, female.

is heavier than air and settles down through the combs. Care should be exercised not to allow the fumes to reach a flame, as the gas is highly inflammable. The eggs of the wax-moth are usually not destroyed by fumigation, so the operation should be repeated at intervals of two or three weeks until all the eggs have hatched. Sulphur fumes may also be used.

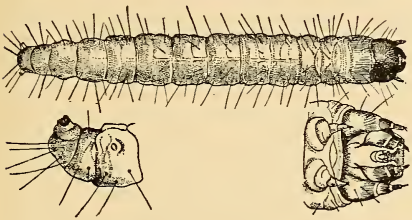


Fig. 181. — Lesser wax-moth, larva.

Other enemies.

Among other animals which may be mentioned as enemies of bees there are several that are parasitic or predaceous, or which destroy the combs. Toads, various species of birds, mice, rats and other small mammals (especially in winter), certain spiders and mites, dragon-

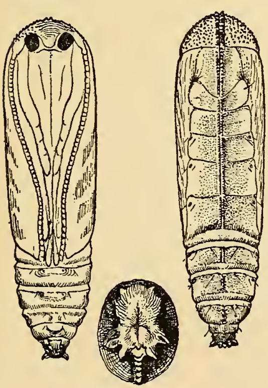


Fig. 182. — Lesser wax-moth, pupa.

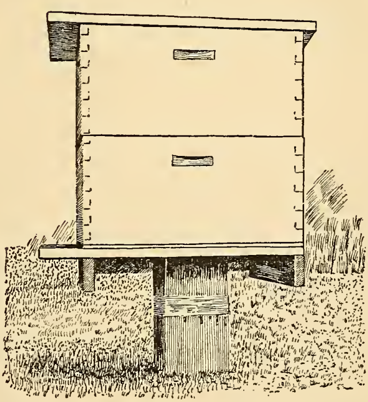


Fig. 183. — Hive stand to keep off ants. The band around the post is tree tanglefoot.

flies (especially in Florida where they destroy queens while mating), various Hemiptera which suck the blood of adult bees, the death's head moth (repeatedly mentioned in Europe), Mediterranean flour moth (eating pollen in stored combs), a dipterous parasite (*Braula cæca*) sometimes found on imported queens, blister beetle (Melœ) and other beetles feeding on pollen or combs, wasps and hornets (Vespa) and ants, especially in tropics and semitropics, are the chief offenders. Dragonflies are so destructive to queens as to make queen-rearing unprofitable in some places. Various devices have been suggested for circumventing ants, among which is the hive stand shown in Fig. 183, used in Hawaii. Around the post which serves as a base, a strip of tree tanglefoot is painted and this is renewed at intervals. The bee louse seemingly does not thrive in America. There are several plants which trap bees and destroy them and, as mentioned under honey plants, the pollen masses of certain milkweeds adhere to bees, sometimes making them incapable of flight.

CHAPTER XXIII

THE REARING OF QUEENS

UNLESS the queen at the head of a colony is a good one it is useless to expect that colony to be productive. It therefore becomes necessary for the progressive beekeeper to pay considerable attention to the rearing of queens which fulfill the requirements for commercial success. The chief requirements are prolificness, vigor of offspring and purity of race. While ability in egg-laying is a character which is inherited, it is also influenced by the age of the queen and by the care she received during her development. Quietness in winter, reduction in swarming and gentleness are other desirable characters.

Commerical queen-rearing.

Queen-rearing has become a prominent specialty in American beekeeping and there are numerous beekeepers who devote almost their entire energies to rearing queens of various races for sale. To these specialists, beekeepers have in the past looked for the greatest advancement in the breeding of better stock, but it is becoming more and more evident that this work should not be left entirely to commercial breeders. In any event it is usually not economical for the extensive beekeeper to purchase all of his queens. Queens that have been shipped through the mails, especially those that have previously been laying heavily, are frequently injured to the extent that they never again fully show their former prolificness. Even if this were not the case, the cost of queens is almost always greater than is warranted by the time saved the honey-producer in not rearing them. This should not be interpreted as an intimation that American queen breeders charge excessive prices, for such is emphatically not the case, as is shown by the fact that so many queen breeders are compelled to abandon the work in a year or two as financially unprofitable. From data furnished the author by numerous commercial breeders, it is evident that many of them would make more money if they devoted their time to honey-production. However, each queen costs relatively much less in time and honey in requeening perhaps half the colonies in an apiary in a season than it does when one rears a large number of queens in making a business of rearing queens for sale.

Systematic requeening.

The giving of a young queen to each colony at stated times is coming to be the approved practice of some of the best commercial honey-producers. After two seasons in a large colony in temperate regions (about one year in the tropics), the majority of queens are incapable of laying the large number of eggs per day that were laid earlier. There are many individual exceptions, and if a beekeeper can give each colony considerable attention he may get good results from a large per cent of his older queens. The extensive commercial honey-producer cannot spend much time on each colony and he must work by averages. If, therefore, older queens are less prolific and if the cost of requeening does not exceed the increased profits due to the giving of young queens, he is prudent to requeen. Before deciding this he should count the cost and should especially see to it that he is reducing his queen-rearing to a system so that no time is wasted in this work. As honey-production becomes more intensive and as queen-rearing methods become more economical of time, an increasing number of extensive beekeepers are finding it profitable to requeen each colony once in two years systematically and, of course, to replace queens earlier if any prove defective.

Conditions under which queens are reared.

There are three circumstances under which bees build queen cells naturally and in artificial queen-rearing it is necessary to bring about or to utilize some one of these conditions. (1) The most common condition is that found in the preparation for swarming (p. 62). (2) If a colony becomes queenless and if suitable larvæ are present, queens will be reared. (3) If a queen becomes inefficient the workers will rear young queens to supersede her. It is believed that the best queens are those reared under the swarming impulse and in supersedure.

Saving natural queen cells.

During the swarming season the beekeeper can often obtain a number of fine queen cells without any cost in time by taking queen cells from colonies preparing to swarm, provided the parent queens are of satisfactory stock. By placing these in colonies to be requeened, after the removal of the condemned queens, requeening takes place naturally and without further manipulation. Making a colony queenless early in a honey-flow, like that from clover in the North, costs less perhaps than a period of queenlessness at any other time, in that the eggs laid then are not of value as future honey gatherers. Furthermore, this may often be done in connection with dequeening to treat swarming. By keeping a watch for opportunities to utilize good natural queen cells, time may be saved by reducing the amount of artificial queen-rearing.

Having natural cells built.

The Miller method.— C. C. Miller advocates the following method: The breeding queen is kept in a two-frame nucleus so that all comb built will be of worker cells. Beginning at about the time queen cells are being built for swarming, on the same day each week a frame is inserted in place of one of the combs in the nucleus containing the breeding queen. This new frame contains two small starters of foundation about 4 by 1 inches, placed 4 inches from each end. If the nucleus is fairly populous, in a week this frame will contain considerable comb and the cells will contain eggs and young larvæ. It is now taken away and another frame with starters substituted. The new comb is now trimmed so that the cells at the edge containing eggs are cut away, leaving young larvæ on the border of the comb. It is then inserted in the middle of a strong colony which has begun to build queen cells in preparation for swarming, all former queen cells being destroyed and the queen being removed. In ten days the comb containing queen cells from eggs of the breeding queen is removed and the cells given to nuclei from which the queens are mated. They may if desired be left in a nursery cage to emerge.

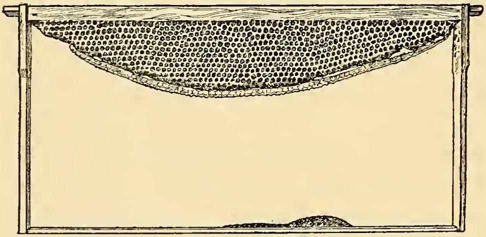


Fig. 184. — Comb cut for starting queen cells by the Alley method. A strip of partly drawn comb-foundation is here used to hold the eggs chosen for queen-rearing.

The Alley method. — For convenience, a method described by Alley has much to commend it. A strip of comb is cut out, just wide enough to contain one complete row of cells containing eggs. This is then cut down by removing about two-thirds of the side walls on one side. With a match or small stick, one in every two or two in every three eggs are destroyed, leaving the cells empty. The strip of comb is now fastened to the lower edge of a comb cut as represented in Fig. 184, the eggs remaining now being pointed downward. This prepared frame is now given to a queenless colony from which all young unsealed brood has been removed. The workers remodel the cells which contain the eggs, making them into queen cells.

The Hopkins method. — Another method has recently been recommended by Hopkins [1] for getting queen cells in quantity. A new comb is given to a breeding queen to be filled with eggs, after which it is removed, and with a sharp knife three out of every four rows of cells across the comb are cut away to the midrib, leaving every fourth row intact. Two of every three eggs are then destroyed as described previously, as well as any eggs accidentally left between the rows. This comb is now laid face down over the brood-chamber of a queenless colony, being raised above the top-bars of the hive by means of an empty frame or a specially constructed collar.

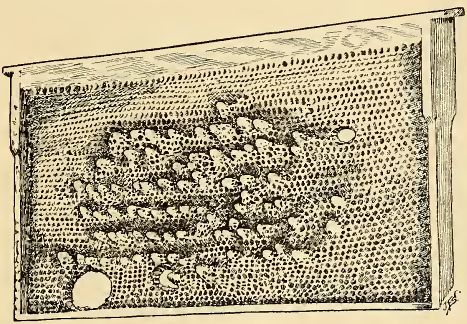


Fig. 185. — Queen cells reared by the Hopkins method.

The sealed queen cells are shown in the accompanying illustration (Fig. 185). To protect the developing queens from cold, the horizontal frame should be covered with a light mat. To prevent sagging, the comb may be supported by wires wound around the frame between the rows of cells. It is possible that when so many cells are built some queens are not good.

With any of these methods the queen cells may be cut out and protected with a West spiral wire cell protector and given to a colony or small nucleus, or they may be placed in a nursery cage for the queens to emerge.

[1] Hopkins, I., 1911. The illustrated Australasian bee manual. Wellington, N. Z. See also various journal articles by this author.

Queen cells on artificial bases.

To have the queen cells in more convenient shape for handling, artificial cell cups have been devised. Doolittle [1] made cups by dipping a smooth stick with rounded end into melted wax and removing the adhering wax. Now the usual method is to use wooden cell bases. A short cylinder of wood is hollowed out on one end and lined with wax, the cavity being the size of a queen cell base. The opposite end of the cylinder has a nail point in it so that the cell cup may be readily attached to a wooden strip or, better, the cylinder is flanged and hangs through a hole in the supporting bar (Fig. 187).[2]

Transferring larvæ.

Having made the necessary cups they are inverted, and the usual practice is to wipe the inside of the cell with a little royal jelly procured from another queen cell. Young larvæ are now carefully lifted from the worker cells and placed in the artificial cell cups, being taken of course from the colony of the queen selected as best for breeding. The supplied cells are now hung in a colony prepared for cell building. The larvæ chosen should be as young as they can be obtained, preferably not more than one day from the egg. Older larvæ may be used but the resulting queens will probably be less valuable.

Swarm box.

A method for getting queen cells started which is in some respects preferable to putting them in a queenless colony is the use of the swarm box (Fig. 186). A special box, with wire screen bottom to provide adequate ventilation, is made large enough to hold five full frames, but only three are used, there being left alternating spaces the width of a frame. The frames used should be abundantly supplied with pollen

[1] Doolittle, G. M., 1889. Scientific queen rearing. Chicago: also later editions.

[2] See the various booklets by E. L. Pratt (pseudonym Swarthmore).

and honey and it is best to have one an empty comb into which water is poured. The top of the box is removable and has two slots cut in it into which are fitted two cell bars which allow the queen cells to hang over the spaces between the frames. When the box is prepared with the frames fastened in place and the slots filled with the empty cell bars (or plain strips of wood), bees are shaken into the box sufficient to fill it more completely than bees are usually found in a hive, care being taken that a queen is not put into the swarm box. This should usually be done about ten o'clock in the morning when the field bees are mostly away from the hive, thus providing a surplus of young bees. In about six hours the empty artificial cell bases are removed one at a time and a worker larva transferred to each one, the hole meanwhile being closed by an extra cup. When this is completed the top of the box is covered snugly to keep the cells warm and the swarm box is put away in a dark cool place. Usually by the next morning most of the cell cups will have been built down and queen development will have begun. Considerable variation in the success of this method has been reported and there are numerous phases of this question on which more light is needed. Some strains of bees seem to be poor for this purpose. On the whole, however, when directions are carefully followed, a good number of fine queen cells will usually be obtained. The

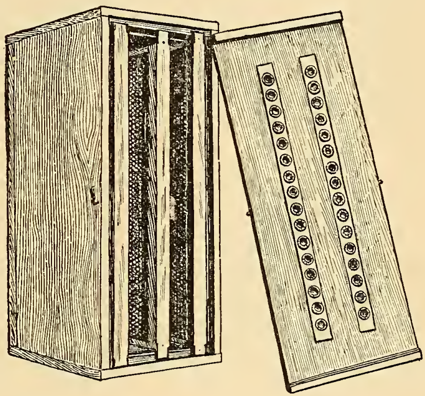


Fig. 186. — Swarm box for starting queen cells, showing position of frames and inner side of lid, with wooden cells in place, ready for bees.

method commends itself because of the saving of time and it is used by many commercial queen breeders.

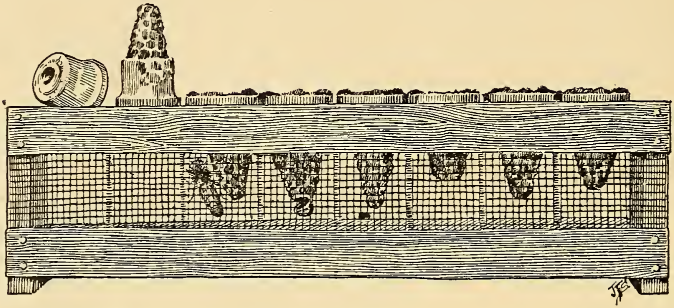


Fig. 187. — Pratt nursery. Two cells are removed to show construction. Six such nursery cages fit in a Langstroth frame.

Having cells built out.

After cells have been started by any of the methods given, they may be put in the upper story of a normal colony, protected by perforated zinc to keep the queen from destroying the cells. During the time that the queen larvæ are

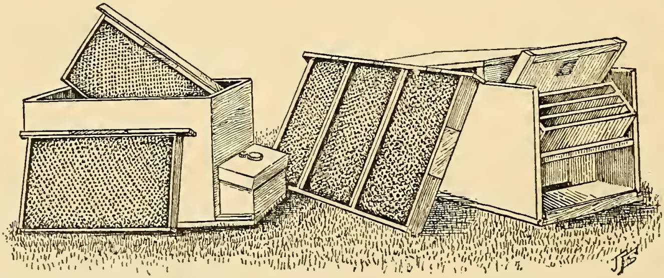


Fig. 188. — Queen mating hives. This type is used in the apiary of the Bureau of Entomology. The frames are supported by tins which may be removed and used to fasten three frames together to form a large frame of Langstroth dimensions. A feeder is provided either at the front (right) or back (left) of the hive. These small hives are unnecessarily complex.

taking food they should be kept in a strong colony so that they will be abundantly fed. If there is no honey-flow, it is necessary to give the colony some sugar syrup or honey daily to keep it in prime condition. The cells will be well cared for in strong queenless colonies, but to keep colonies queenless so long is expensive. It is a well recognized fact that if a colony is divided by perforated zinc, the portion away from the queen is in condition to build and care for queen cells and may be considered as virtually queenless.

Nursery cages.

Before the queens are ready to emerge, about ten days from the time of transferring the larvæ, each cell may be put in some sort of nursery cage (Fig. 187), so that as the queens emerge they will not kill each other or destroy other cells. As a rule individual cages for each queen cell are best. If colonies are ready to receive them the best method is to put each queen cell in a colony so that there will be no necessity for introducing adult queens.

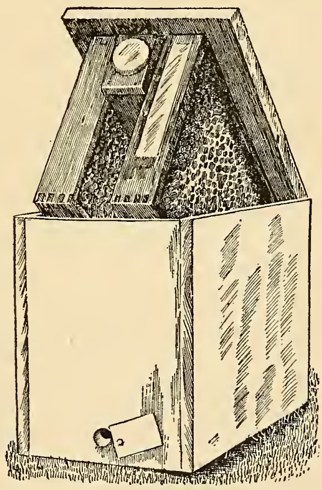


Fig. 189. — "Baby nucleus" hive devised by Pratt. An introducing cage is in place between the frames.

Mating hives.

In case it is desired to have the queens mated before introducing them to full colonies or if queens are being raised for sale, the queen cells or virgin queens (as most convenient) may be put in small colonies, usually known as nuclei. Two types of mating boxes are illustrated (Figs. 188 and 189), but it is usually most satisfactory not to use too small a mating box.

Many beekeepers prefer to use full Langstroth frames in boxes built to hold about three frames.

Classification of queens.

When a queen has mated (usually in five to eight days) and has begun to deposit eggs she is ready to use and is known in the queen trade as untested. At this time it cannot be determined whether she has mated with a drone of her own race, but if she is kept for a little over three weeks (until her progeny emerges) the color of the workers is taken as an indication of the purity or impurity of her mating. If apparently purely mated she is known in the trade as a tested queen. Further observations may cause her to be classed as select tested or finally as a breeding queen.

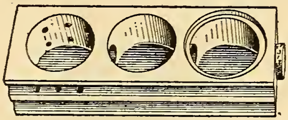


Fig. 190. — Queen mailing cage. The right-hand hole is filled with candy which is then covered with a circle of comb-foundation or waxed paper. The cork at the end is removed when used for an introducing cage.

Mailing cages.

If queens are to be shipped they are usually put in a queen mailing cage (Fig. 190) with some workers and an adequate supply of food, usually a soft paste or candy made by kneading together confectioner's (not powdered) sugar and honey without heating. Queens are frequently mailed across the continent or from Europe in these cages and have been shipped successfully to New Zealand. Usually a trip of over ten days results in considerable loss.

Introducing cages.

The queen mailing cage is also used as an introducing cage or special cages may be used for this purpose. Cages are so constructed that the queen is separated from the workers in the hive that is to receive her by soft candy. The workers gradually eat this out and in the meantime the queen acquires the colony odor so that when the candy is eaten away she walks out without excitement and is accepted. This is the most common method of introducing queens. Some beekeepers dip the queen in honey and place her in the colony. The workers promptly remove the honey and usually accept the queen. Others fill the hive with smoke and close the entrance after letting the queen run in. Whatever is done the queen should acquire the colony odor so that the workers will not attack her as they normally do strange queens. Young virgin queens are more readily accepted than mated queens. Colonies that have been queenless for a considerable time are usually difficult to requeen and this is especially true if in the meantime some of the workers have begun to lay eggs (p. 187). In introducing a queen it is necessary that the colony be queenless or the strange queen will be killed.

Improvement of stock.

In addition to the manipulations of queen-rearing there are some fundamental principles which should be considered. It should be the policy not only to provide queens as needed but to keep steadily improving the stock. For this work beekeepers usually depend on the specialists in queen-rearing but it is desirable that each beekeeper keep the ideal of bettering his stock constantly before him. The breeding of Italian queens for additional yellow on the abdomen, resulting in the so-called five-banded bees, clearly demonstrates that changes can be made by applying the principles of breeding to queen-rearing. While the merits of these bees is a subject of dispute the success in this line of endeavor should encourage the beekeeper to believe that as striking things are possible in other lines of bee breeding.

It is evident that certain characteristics which the beekeeper wishes to develop and some which he wishes to reduce or destroy must be inherited. Exceptional prolificness, gentleness, excessive swarming, protracted breeding and their opposites are characteristic of various races and strains of bees but not of the entire species. This leads to the belief that the bee breeder may hope to modify his bees along these lines by proper care in selecting his breeding material. The actual results of practical beekeepers also show that improvement may be made, as indicated by increased crops.

Study of breeding needed.

It is not practical in this place to enter upon an elaborate discussion of the methods and results of modern breeding. To what characters of bees Mendelian inheritance is operative has not been shown by the work so far done although color is probably so inherited. Bee breeding has not been subject to the researches of the theoretical breeders but work of this character is greatly to be desired. Certain fundamental facts should be mentioned, however, and they are chosen here because they have been misunderstood by beekeepers writing for bee journals. The fact that a queen is poorly developed because of inadequate care during development does not make her undesirable as a breeding queen and, conversely, prolificness induced by extra care and manipulation does not make a queen more valuable for breeding, because characters acquired during the life of the individual are not inherited.

Selection of drones.

As great care should be exercised in choosing the drones as is employed in selecting the breeding queen, but most beekeepers fail to give this subject adequate consideration. In general the drone (father) is just as influential in deciding the character of the offspring as is the queen (mother). Drones may be selected by allowing drones to fly only from the colony or colonies which are up to the breeding standard and drone production in these colonies may be increased by providing drone comb. Drone rearing in other colonies may be restricted by giving only worker comb or the undesirable drones may be trapped by a queen and drone trap (Fig. 30). While the beekeeper cannot choose the individual drone with which a queen mates he can increase the chances of desirable matings by providing plenty of drones of good stock and restricting undesirable drones. When the workers begin to drive drones from the hives they may be protected by putting them in a queenless colony, where they will not be molested.

Desirability of pure races.

Above all, the desirability of pure races should be emphasized. It is a common belief that hybrids (usually crosses of Italians and blacks) are good honey gatherers. Crosses of other races are also recommended. The first cross is often desirable from the standpoint of honey gathering but it is better to breed from pure stock only, for the offspring of a hybrid queen is exceptionally variable and it is rather a matter of chance if good stock results. Presumably the desirable characteristics of certain crosses might be fixed by judicious and intelligent selection, but this is a problem for a professional breeder and not for the honey producer or even for the commercial queen breeder.

Danger from inbreeding.

This has been much overestimated in the discussions of breeding in the bee journals. Inbreeding may accentuate undesirable characters but it may likewise help to fix desirable characters, and it has been used with good results in other lines of breeding. The commercial honey producer need have little fear of harmful results, for if any signs of degeneracy are observed it is easy at any time to introduce new blood.

CHAPTER XXIV

MISCELLANEOUS INFORMATION

Beekeeping does not consist solely in caring for bees and in using or selling their products. The activities of beekeepers are expressed in various allied fields and since these are things about which the beekeeper wants and should have information, it is proposed in a brief closing chapter to give a few notes which may be helpful, but which do not find a place in the previous chapters.

Literature on bees and beekeeping.

In the centuries during which men have been interested in the honeybee, hundreds and even thousands of books have been written on this subject. No other insect, and perhaps no other animal except man, has been so voluminously discussed. Many of these books are now of interest only to the collectors of old bee books, for the advance in our knowledge of these subjects through investigation has naturally left many of the older books far behind. That there have been in the ranks of bee enthusiasts some men of rare powers of observation, is attested by the enduring value of some of their works. Even to list the books on beekeeping would probably require a book the size of this one, so this interesting task must be set aside. The beekeeper will find it to his advantage to read almost every one of the few books now offered to the American beekeeper.

In addition to the works issued in book form, there is an extensive literature on bees in scientific journals, unfortunately not readily accessible to most beekeepers. Reference is made to many of these papers in the preceding pages.

Some of the journals devoted to beekeeping have contained articles of lasting practical value but unfortunately these journals are too often read and at once cast aside, not being properly filed and indexed for future references. The Bureau of Entomology has a working bibliography, arranged by authors and subjects, which is far from complete but which, nevertheless, is helpful and is probably the most extensive so far attempted for beekeeping literature. It contains about 20,000 titles.

At present there are four journals devoted to the interests of the beekeeper published in the United States and one in Canada. A larger number appear regularly in various European countries to which unfortunately few American beekeepers have access. There should be regular summaries and abstracts of the best articles in these journals prepared for American beekeepers either in a bee journal or separately.

Several valuable bulletins have been issued by state institutions.

Organizations of beekeepers.

There are in the United States probably 100 societies of beekeepers, organized to protect the interests of those now engaged in the work, to educate their members in the practical and scientific phases of beekeeping and to promote the industry. Most of these associations are active and helpful and they are nearly all growing and being improved. Every beekeeper should be a member of one or more of these organizations, to help and be helped. The National Bee Keepers' Association is an association of affiliated societies, the business being conducted through annual meetings of delegates.

Laws.

It is not proposed in this place to discuss the legal status of bees or to delineate the legal rights of their owners. Some of the associations of beekeepers offer protection to their members in case of legal complications.

The special laws in which beekeepers are most interested are those which provide for the inspection of apiaries for the control of bee diseases. This work falls on the individual states, there being at present no Federal laws on this subject. The number of states having such inspection has increased rapidly within recent years until now practically all the states in which beekeeping is an important industry offer such protection. The desirable work now is to improve and unify these laws and to bring about greater co-operation in the inspection service of the various states. The Association of Economic Entomologists now has a section devoted to apiary inspection which is attempting this work.

Some states have laws which prohibit the spraying of fruit trees while in full bloom, the purpose of these being to prevent the poisoning of bees at work on the blossoms.

Supplies for beekeepers.

It has been shown in earlier chapters that it is quite necessary that hives and other apiary supplies be accurately made, and for this reason it is usually desirable that a beekeeper buy his equipment from some manufacturer, unless he is a skilled wood worker. The American beekeepers are fortunate in that the supply business of the country is adequate. There are a number of extensive establishments, and most of them have agencies or branches in various parts of the country from which supplies may be obtained on short notice. The manufacturers will gladly send catalogs on request and give information concerning agencies. The addresses of manufacturers may be obtained from advertisements in the bee journals.

The uses of honey.

This subject might well form the title of a separate chapter, were space available for a longer discussion. While the production of honey does not include its use, this is a subject about which beekeepers should have information as an aid to the early selling of their wares. They and their families may set a good example to their customers by using honey freely in the homes.

That honey is preferable to other syrups is usually acknowledged. It is assuredly to be preferred to the cheap jams and jellies which are so common in our markets. The chief use of honey in the home is as a spread for bread, for which purpose it may be used in any form. It is often recommended in old recipe books and books on beekeeping for use for almost all human ailments, from boils and freckles to diphtheria and tape worms, but in these days such medicinal uses are not to be commended except on the advice of a physician.

A use of honey which should be more emphasized is in cooking. Fruits preserved in honey have long been relished for their superior flavor and are still in high favor among those who have tried them. The famous Bar le duc preserves are made with honey. It is used extensively in commercial bakeries, especially in cakes which will probably be kept for some time before they are eaten. It is also used in some of the finest confections as well as in the making of vinegar. In former days, and to some extent to-day in parts of Europe, considerable honey was used in making fermented drinks which are reported to have been as powerful as they were popular.

There has recently been issued by the United States Department of Agriculture a bulletin [1] on the use of honey in the home which should be in the hands of every beekeeper, every beekeeper's wife and every beekeeper's customers. Since it may be had on application it should have a wide distribution. The recipes have been carefully tested and only a few of the best are given. A substitution rule is given by which honey may be substituted for sugar in any cake.

[1] Hunt, Caroline L. and Atwater, Helen W., 1915. Honey and its uses in the home. Farmers' Bulletin No. 653, 26 pp.

Honey crop reports.

In 1914 the Bureau of Crop Estimates of the Department of Agriculture inaugurated a system of crop reports on honey. The first report was on the condition of the bees and of honey-producing plants on May 1st, to enable beekeepers and others interested to form an opinion as to the probable results of the season. At the close of the season a report of the crop was issued. When it is considered that this is the first attempt at anything of this kind, it is encouraging to learn from beekeepers that the estimate for the various states coincides closely with their experience. In 1915 a somewhat more elaborate program is proposed. It will, of course, be recognized that reporters need experience in work of this character before they can give data which are most serviceable, but there is every reason to hope that with an accumulation of data for several years these reports will be of great value to honey producers. The beekeeper will then be provided with reliable data which heretofore have been obtainable only by honey buyers through their business connections and he will thus be enabled to know what he should ask for his products.

Educational work in beekeeping.

The advances of past years in beekeeping have come chiefly through an exchange of ideas and results through the journals and books on this subject and more recently by the distribution of bulletins from the Federal and State laboratories devoted to beekeeping. It is now coming to be generally accepted that these educational agencies are not entirely sufficient and also that the industry is worthy of more recognition. Several agricultural colleges are now teaching beekeeping and it is being included to a limited extent in the extension work of various institutions. If this work can be enlarged adequately there is a great future for the industry along commercial lines and it is to the interest of every person engaged in any branch of beekeeping activities to further this development.

The Bureau of Entomology.

The author includes at the close of this book, with some hesitancy, a brief statement of the work of the Bureau of Entomology of the United States Department of Agriculture on beekeeping, with which he is associated. This is done for the purpose of informing present and prospective beekeepers of the activities and purposes of this office, with a view to enlisting their interest and support.

Since the various states are rapidly taking up work in beekeeping and since the state officials are in a position to carry on educational and extension work more advantageously, especially with the present small appropriations for Federal work, it seems desirable that the work of the Bureau of Entomology should be confined chiefly to investigation. At the present time these investigations include work on the activities of bees during the winter season and the practical wintering of bees, the development of bees, a study of the sense organs of the adult bee and the function of these organs in bee behavior and the diseases of bees. Some other lines of work of importance have been investigated and still others are waiting inauguration, and when funds are available work will be begun on them.

The work in bee culture is now carried on in a laboratory (see Frontispiece) located in Drummond, Maryland, a suburb of Washington. This laboratory may easily be reached from the city by trolley. All mail should be addressed to the Department of Agriculture, Washington, D.C.

In addition to the specific lines of investigation the office desires to assist in the many problems which are constantly arising, and correspondence of beekeepers is invited.

The results of the work of this office are published, in so far as possible, in the series of publications of the Department of Agriculture. These publications, so long as they are in print, may be obtained either from the Department or from the Superintendent of Documents, Government Printing Office, Washington, D.C. The following papers, originating in the Bureau of Entomology, have been issued since 1905:

Phillips, E. F., 1911. The treatment of bee diseases. Farmers' Bulletin No. 442.

Phillips, E. F., 1911. Bees. Farmers' Bulletin No. 447.

Demuth, Geo. S., 1912. Comb honey. Farmers' Bulletin No. 503.

Phillips, E. F., 1905. The rearing of queen bees. Bulletin No. 55, Bureau of Entomology.

Report of the meeting of inspectors of apiaries, San Antonio, Texas, November 12, 1906. Bulletin No. 70, Bureau of Entomology. 1907.

Phillips, E. F., 1907. Production and care of extracted honey. Bulletin No. 75, Part I, Bureau of Entomology.

Phillips, E. F., 1907. Wax moths and American foul brood. Bulletin No. 75, Part II, Bureau of Entomology.

Gates, Burton N., 1908. Bee diseases in Massachusetts. Bulletin No. 75, Part III, Bureau of Entomology.

White, G. F., 1908. The relation of the etiology (cause) of bee diseases to the treatment. Bulletin No. 75, Part IV, Bureau of Entomology.

Phillips, E. F., 1909. A brief survey of Hawaiian beekeeping. Bulletin No. 70, Part V, Bureau of Entomology.

Phillips, E. F., 1909. The status of apiculture in the United States. Bulletin No. 70, Part VI, Bureau of Entomology.

Gates, Burton N., 1909. Beekeeping in Massachusetts. Bulletin No. 70, Part VII, Bureau of Entomology.

Phillips, E. F. and White, G. F., 1912. Historical notes on the causes of bee diseases. Bulletin No. 98, Bureau of Entomology.

Casteel, D. B., 1912. The behavior of the honey bee in pollen collecting. Bulletin No. 121, Bureau of Entomology.

White, G. F., 1906. The bacteria of the apiary, with special reference to bee diseases. Technical Series No. 14, Bureau of Entomology.

Snodgrass, R. E., 1910. The anatomy of the honey bee. Technical Series No. 18, Bureau of Entomology.

Phillips, E. F., 1906. The brood diseases of bees. Circular No. 79, Bureau of Entomology.

White, G. F., 1907. The cause of American foul brood. Circular No. 94, Bureau of Entomology.

Phillips, E. F., 1911. The occurrence of bee diseases in the United States. Circular No. 138, Bureau of Entomology.

White, G. F., 1912. The cause of European foul brood. Circular No. 157, Bureau of Entomology.

Casteel, D. B., 1912. The manipulation of the wax scales of the honey bee. Circular No. 161, Bureau of Entomology.

White, G. F., 1913. Sacbrood, a disease of bees. Circular No. 169, Bureau of Entomology.

White, G. F., 1914. Destruction of germs of infectious bee diseases by heating. Bulletin No. 92, Department of Agriculture.

Phillips, E. F. and Demuth, Geo. S., 1914. The temperature of the honey bee cluster in winter. Bulletin No. 93, Department of Agriculture.

Gates, Burton N., 1914. The temperature of the bee colony. Bulletin No. 96, Department of Agriculture.

The following papers have been published in other series of publications of the Department and with one exception have not been prepared in the Bureau of Entomology:

Van Dine, D. L. and Thompson, Alice R., 1908. Hawaiian honeys. Bulletin No. 17, Hawaii Agricultural Experiment Station.

Phillips, E. F., 1914. Porto Rican beekeeping. Bulletin No. 15, Porto Rico Agricultural Experiment Station.

Browne, C. A., 1908. Chemical analysis and composition of American honeys, including a microscopical study of honey pollen by W. J. Young. Bulletin No. 110, Bureau of Chemistry.

Bryan, Given and Sherwood, 1912. Chemical analysis and composition of imported honey from Cuba, Mexico and Haiti. Bulletin No. 154, Bureau of Chemistry.

Westgate, J. M. and Vinall, H. N., 1912. Sweet clover. Farmers' Bulletin No. 485.

Hunt, Caroline L. and Atwater, Helen W., 1915. Honey and its uses in the home. Farmers' Bulletin No. 653.

APPENDIX

EXPLANATION OF SYMBOLS USED IN THE ANATOMICAL ILLUSTRATIONS

Since nearly all of the illustrations of anatomical parts are from the work of Snodgrass it may be best to give the list of symbols and alphabetical lettering prepared by him and given on pp. 141–147 of his paper. These will aid in identifying parts which are labeled in the illustrations, used in this book to illustrate certain portions only.

1. SYMBOLS

A,	anal vein; *1A*, first anal, *2A*, second anal, etc.
AcGl,	accessory gland of male reproductive organs.
AGl,	acid gland of sting, opening into poison sac (*PsnSc*).
AGlD,	duct of acid gland of sting.
An,	anus.
ANP,	anterior wing process of notum.
ANR,	anterior marginal ridge of notum.
Ant,	antenna.
AntL,	antennal lobe of brain.
AntNv,	antennal nerve.
Ao,	aorta.
Ap,	apodeme, any internal chitinous process of body-wall.
Aph,	anterior phragma of any tergum, prephragma.
Ax,	the axillaries or articular sclerites of the wing base, designated individually as *1Ax*, *2Ax*, *3Ax*, and *4Ax*.
ax,	accessory axillary sclerites of irregular occurrence in connection with the principal axillaries (*Ax*).
AxC,	axillary cord, or ligament-like thickening of posterior edge of basal membrane of wing, attached to posterior angle of scutellum.
AxM,	axillary membrane, the thin membrane of wing base, containing the axillary sclerites and forming in some cases the lobes called alulæ.

B,	bulb (bulb of penis or of sheath of sting).
BC,	body-cavity.
bc,	any particular part of body cavity such as that prolonged into the mouth parts, legs or pieces of the sting.
BCpx,	bursa copulatrix.
BGl,	alkaline gland of sting.
BM,	basement membrane.
Br,	brain.
1Br,	protocerebrum.
2Br,	deutocerebrum.
3Br,	tritocerebrum.
Brb,	barb.
BW,	body-wall.
C,	costa, first vein of wing.
Cb,	pollen basket or corbiculum on hind tibia of worker.
CC,	crystalline cone of compound eye.
Cd,	cardo.
Cer,	cercus.
CL,	crystalline lens of compound eye.
Cl, *Cls*,	cell, cells.
Cla,	claw.
Clp,	clypeus.
Clsp,	clasping lobes of ninth segment of male, perhaps equivalent to the four gonapophyses of ninth segment of female.
1Clsp,	upper or outer clasper.
2Clsp,	lower or inner clasper.
Com,	commissure (of either nervous or tracheal system).
Cor,	cornea.
Ctl,	cuticle, the chitinous layer of the epidermis.
Cu,	cubitus, fifth vein of generalized wing.
Cv,	cross-vein.
Cx,	coxa.
CxP,	pleural coxal process.
Dct,	duct.
DDph,	dorsal diaphragm.
Dph,	diaphragm.
DphCls,	diaphragm cells.
Dphmb,	membrane of diaphragm.
DphMcl,	muscle fibers of diaphragm.
E,	compound eye.
EAp,	apodeme of extensor muscle.
EjD,	ejaculatory duct.
Em,	lateral emargination of notum.
EMcl,	extensor muscle.

Emp,	empodium.
Enz,	digestive vesicles formed by ventricular epithelium.
Ep,	epicranium.
Ephy,	epipharynx.
Epm,	epimerum.
Eps,	episternum.
Epth,	epithelium.
F,	femur.
Fl,	flagellum.
For,	foramen magnum.
Ft,	front.
FtCom,	frontal commissure.
FtGng,	frontal ganglion.
FtNv,	frontal nerve.
Fu,	furca or median entosternal apodeme of thoracic sterna.
G,	gonapophysis.
Ga,	galea.
Ge,	gena.
Gl,	gland.
1Gl,	large pharyngeal gland in anterior part of head of worker.
2Gl,	salivary gland in posterior part of head.
3Gl,	thoracic salivary gland.
4Gl,	small median gland below pharyngeal plate (*s*).
Gls,	glossa.
Gng,	ganglion.
Gu,	gula.
H,	head.
Hk,	hooks on front edge of hind wing.
Hphy,	hypopharynx.
Hr,	hair.
hr,	surface disk of "auditory" organ of antenna, probably modified base of sensory hair.
HS,	honey stomach.
Ht,	heart.
ht,	individual chamber of heart.
HtCls,	pericardial cells.
HtTraSc,	pericardial tracheal sac.
Int,	intima, the chitinous lining of any internal organ.
IT,	tergum of first abdominal segment, the *median segment*, or *propodeum*, incorporated into thorax.
L,	leg.
Lb,	labium.
Lbl,	labellum.
LbNv,	labial nerve.

LbPlp, labial palpus.
Lc, lacinia.
Lct, lancet of sting, equivalent to first gonapophysis (*1G*).
Lg, ligula.
LGl, "lubricating" gland of sting (not shown in figures).
Lin, median lobe of lingua or hypopharynx.
Lm, labrum.
LMcl, longitudinal muscles.
lmcl, ventral longitudinal muscles of thorax.
LmNv, labral nerve.
Lr, lorum.
LTra, trachea of leg.
Lum, lumen, the cavity of any hollow organ, whether the glossa, sting, alimentary canal, or gland.
M, media, fourth vein of wing. M_1–M_4, first to fourth branches of media.
m, median plate or plates of wing base.
Mal, Malpighian tubules.
Mb, intersegmental membrane.
mb, membrane.
m-cu, medio-cubital cross-vein.
MD, disklike muscle apodeme.
Md, mandible.
1MdGl, outer saclike mandibular gland.
2MdGl, inner racemose mandibular gland.
MdNv, mandibular nerve.
Mes, mesathorax, designated by figure 2 placed after and below any thoracic symbol.
Met, metathorax, designated by figure 3 placed after and below any thoracic symbol.
Mi, the chitinous plates of the neck collectively, the "microthorax," individually designated *mi*.
mi, cervical (microthoracic) sclerites.
m-m, median cross-vein.
Mps, mouth parts or trophi.
Mt, mentum.
Mth, mouth.
Mx, maxilla.
MxPlp, maxillary palpus.
MxNv, maxillary nerve.
N, notum.
Nu, nucleus.
Nv, nerve.
O, ocellus.
Ob, oblong plate.

Oc,	occiput.
Œ,	œsophagus.
ŒCom,	circumœsophageal commissures.
Om,	ommatidium.
OpL,	optic lobe.
Ost,	ostium or lateral aperture of heart.
Ov,	ovary.
ov,	ovariole, individual ovarian tube.
OvD,	oviduct.
OvO,	opening of vagina or median oviduct.
P,	paraptera, small pleural plates below base of wing, typically two episternal paraptera or preparaptera (*1P* and *2P*) before pleural wing process (*WP*), and two epimeral paraptera or postparaptera (*3P* and *4P*) behind wing process.
1P, *2P*,	episternal paraptera, preparaptera.
3P, *4P*,	epimeral paraptera, postparaptera.
PA,	arm of pleural ridge.
Pcl,	postclypeus.
PD,	muscle disk of episternal paraptera, giving insertion to pronator muscle (not present in the bee).
Pd,	peduncle.
Pen,	penis.
PenB,	bulb of penis.
Peps,	preepisternum.
Pge,	postgena.
Pgl,	paraglossa.
Pgu,	pregula.
Ph,	phragma.
Phy,	pharynx.
Pl,	pleurum,
pl,	subdivision of pleurum.
Plf,	palpifer, palpus-carrying lobe of maxilla.
Plg,	palpiger, palpus-carrying lobe of labium.
Plp,	palpus.
Pmb,	peritrophic membrane.
PMcl,	pronator muscle.
PN,	postnotum or pseudonotum, the second or postalar tergal plate of the wing-bearing segments of most insects, the "postscutellum" of higher orders.
pn,	small rod connecting postscutellum (postnotum *PN*) with upper edge of epimerum, probably a detached piece of the former.
PNP,	posterior notal wing process.
PNR,	posterior marginal ridge of notum.

Pph,	posterior phragma or postphragma of any tergum, carried by the second notal plate or postnotum (*PN*), the "postscutellum" of higher forms.
PR,	internal pleural ridge, the entopleurum, marked externally by pleural suture (*PS*).
Prb,	proboscis.
PrbFs,	fossa of proboscis.
PS,	pleural suture, external line separating episternum and epimerum, marking site of internal pleural ridge.
Ps,	presternum.
Psc,	prescutum.
Pscl,	postscutellum (postnotum).
Psl,	poststernellum.
PsnC,	poison canal of sting.
PsnSc,	poison sac of sting into which opens the acid gland (*AGl*).
Pt,	sensory pit.
Ptr,	peritreme, spiracle-bearing sclerite.
Pvent,	proventriculus.
PventVlv,	proventricular tube or valve in ventriculus.
Qd,	quadrate plate of sting.
R,	radius, third vein of generalized wing. R_1–R_5, first to fifth branches of radius. R_s radial sector.
RAp,	apodeme of flexor muscle.
Rd,	posterior extension or reduplication of any tergal or sternal plate overlapping plate following it.
Rect,	rectum, the large intestine of insects.
RGl,	rectal glands.
r-m,	radio-medial cross-vein.
RMcl,	flexor muscle of mandible or wing.
1RMcl,	dorsal retractor muscle of ligula.
2RMcl,	ventral retractor muscle of ligula.
R_s,	radial sector, or second branch of radius at first forking.
S,	sternum.
SalD,	salivary duct.
SalDO,	external opening of salivary duct.
Sc,	subcosta, second vein of generalized wing.
Scl,	scutellum.
Scp,	scape.
Sct.	scutum.
Sga,	subgalea.
Sh,	sheath of sting, equivalent to the second gonapophyses (*2G*) or middle pair on ninth abdominal segment.
ShA,	basal arm of sheath of sting.
ShB,	bulb of sheath of sting or ovipositor.
ShS,	shaft of sheath of sting.

SInt, small intestine.
Sl, sternellum.
Slin, superlingua, embryonic lateral lobes of hypopharynx, true appendages of fifth head segment.
Smt, submentum.
SœGng, subœsophageal ganglion.
Sp, spiracle.
Spm, spermatheca.
SpmGl, spermathecal gland.
St, stipes.
StgNv, stomatogastric nerve.
Stn, sting.
StnPlp, palpuslike appendages of the sting, equivalent to the third gonapophyses (*3G*) or the outer pair on ninth abdominal segment.
T, tergum.
IT, first abdominal tergum, the propodeum, incorporated into thorax.
IIT, second abdominal tergum.
Tar, tarsus.
Tb, tibia.
Ten, large tentorial arms of head, the mesocephalic pillars.
ten, slender tentorial arch over foramen magnum.
Tes, testes.
Tg, tegula.
TMcl, transverse muscle.
Tn, trochantin (not separated from sternum in bee).
TnC, coxal condyle of trochantin.
Tr, trochanter.
Tra, trachea.
TraCom, transverse ventral tracheal commissures of abdomen.
TraSc, tracheal sac.
Tri, triangular plate of sting.
Vag, vagina.
VDef, vas deferens.
VDph, ventral diaphragm.
Vent, ventriculus.
VentVlv, ventricular fold or valve in small intestine.
Ves, vesicula seminalis.
Vlv, valve of sting carried by lancet.
VMcl, large vertical muscles of thorax.
VNR, internal, median V-shaped notal ridge, the "entodorsum."
Vx, vertex.
W, wing.

W_2Nv,	mesothoracic wing nerve.
W_3Nv,	metathoracic wing nerve.
WP,	wing process of pleurum.

2. ALPHABETICAL LETTERING

a,	clypeal suture.
b,	anterior tentorial pit, in clypeal suture.
c,	posterior tentorial pit, in occiput beside foramen magnum.
d,	thickened posterior edge of lateral wall of fossa of proboscis.
e,	process at upper end of *d* articulating with cardo of maxilla and forming maxillary suspensorium.
f,	internal median keel of vertex in cranium of drone.
g,	suspensorial ligaments of anterior end of œsophagus.
h,	pharyngeal rod.
i,	convolutions of dorsal blood vessel.
j,	anterior articular knob of mandible.
k,	ventral groove of glossa.
l,	ventral groove of maxillary rod.
m,	median plates of wing base.
n,	basal hooks of glossa.
o,	median ventral plate of ligula.
p,	dorsal plates of anterior end of mentum, supporting ligula.
q,	inner wall of canal of glossa.
r,	chitinous rod of glossa.
s,	pharyngeal plate, on anterior part of floor of pharynx.
t,	salivary pouch opening on dorsal side of base of ligula, receiving common duct of salivary glands (*SalD*).
u,	oblique muscles inserted upon dorsal side of salivary pouch of ligula.
v,	transverse or V-shaped suture on surface of mesonotum or metanotum, formed by the internal V-shaped ridge or "entodorsum" (*VNR*).
w,	lateral lobe of pronotum projecting posteriorly over the first spiracle.
x,	thoracic plate lying laterad of anterior part of sternum, often regarded as a part of presternum.
y,	accessory sclerite of fourth axillary (*4Ax*) of front wing, affording insertion for slender muscle (*cc*) attached below to common apodeme of mesosternum and metasternum.
z,	coxal condyles of mesothoracic and metathoracic sterna,

probably really the coxal condyles of trochantins (*TnC*) fused entirely with the sterna and episterna in each segment.

aa, muscle arising from inner wall of mesothoracic pleurum and inserted upon outer end of corresponding scutellum, probably accessory in function to the great vertical muscles (*VMcl*) between the mesothoracic sternum and scutum.

bb, coxo-axillary muscle, extending from upper end of coxa to third parapterum (*3P*).

cc, muscle inserted upon accessory sclerite (*y*) of fourth axillary (*4Ax*) from common entosternum of mesothorax and metathorax.

dd, notch of antenna cleaner on first tarsal joint (*1Tar*) of front leg.

ee, spine of antenna cleaner situated on distal end of tibia (*Tb*).

ff, so-called "wax shears" or "wax pincers."

gg, transverse chitinous band of empodium (*Emp*), which compresses its two lobes when not in use and spreads out by muscular effort.

hh, dorsal plate supporting empodium.

ii, ventral plate supporting empodium.

jj, dorsal groove of lancet interlocking with ventral ridge of sheath of sting.

kk, sting chamber within end of seventh abdominal segment, lodging sting whose accessory plates are derived from eighth and ninth segments.

ll, reservoir of thoracic salivary gland.

mm, receptacular chitinous pouches on ventral side of pharyngeal plate (*s*) receiving ducts of large lateral pharyngeal glands of head (*1Gl*).

nn, "stomach-mouth" at summit of proventricular projection within honey stomach (*HS*).

oo, pores on lancets and shaft of sting sheath opening to exterior from prolongation of body-cavity (*bc*) contained in each.

pp, gelatinous layer secreted upon inner surface of ventricular epithelium.

qq, food contents of alimentary canal.

rr, cells of ventricular epithelium apparently forming the internal gelatinous layer.

ss, cartilaginous mass on inner surface of dorsal wall of bulb of penis (*PenB*).

tt, dorsal plates of bulb of penis.

uu,	fimbriated dorsal lobes of penis at base of bulb.
vv,	ventral scalariform row of plates on tube of penis.
ww,	dorsal basal plates of penis.
xx,	ventral basal plates of penis.
yy,	basal pouch of penis.
zz,	copulatory sacs of penis.

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