Eva Crane Trust

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These articles have been extracted from the *Digest* which consisted of articles published in *Bee World* during 1953 and 1954 under the title 'Science and Practice'. Each reference number in the text tells the reader which Abstract gives further details.

Reference numbers (e.g., 214/53) are the serial numbers of Abstracts from which the information here has been taken

Methods of management

Summer management centres round the problems of decreasing the number of swarms and increasing the yield of honey. Many methods of swarm control have been found successful by their sponsors. Taranov shakes the whole colony (before swarming takes place) on to a sloping board set up in front of the hive entrance but separated from it by 4 inches ; the potential swarm clusters under the board and can be hived separately, while the non-swarming bees fly across the gap back into the hive [109/50; 113/52]. Frau Paschke describes how the building-frame can prevent swarming [83/50], and Blumenhagen recommends an elaboration with two building-frames, in which comb can be built and cut out alternately [85/50]. Shepherd uses a tube leading from the upper of two (separated) brood chambers which contains most of the brood, to just outside the hive entrance, so that the flying bees are continually drained from the upper chamber to the lower one [145/51]. Mrs. Colthurst recommends the use of a nucleus by the side of each hive, which can later be united back to the parent colony if desired [143/50]. In England a first attempt has been made to obtain an objective evaluation of selected methods of management [37/53], and crop reports give some information about current practice. In the counties studied only about half the beekeepers reporting used any method of swarm control [140, 160/50] ; the number using more than a single brood chamber for the brood nest of any of their colonies varied between 36 and 70% [71, 72, 140, 187/50].

One problem which puzzles most beginners who try to follow a recommended method of management is how to know *when* each operation should be carried out. Studies have been made in Czechoslovakia which enable the flowering dates of the hazel, cherry and false acacia to be used as guides [188/52] ; studies with similar aims have also been made in Scotland [183/51] and France [182/50]. The building-frame is another, more direct, guide to the timing of operations [83, 85/50].

The use of larger units than the normal hive with one queen heading a colony is always attractive to some beekeepers, but in general it seems to be profitable only under special circumstances. Given long hot summers and ample flows, the use of skyscraper hives can be very successful [182/50], but it can be disastrous in an unfavourable season [41/50]. In Canadian experiments, honey yields were consistently higher (over a 9-year period) from two-queen colonies than from those with only one queen [163/50], and in U.S.A. double packages gave higher yields than single ones [26/51]. In France a system using a double horizontal hive has been recommended [191/52], and in Poland a doubling system with an officially sponsored hive [15/51]. In Russia, systems allowing the use of a second queen, in either a double brood chamber or a long hive, are advocated, and multiple-queen colonies have been much studied recently [156/50; 48, 80/51; 108/52].

Canadian experiments showed that putting fresh supers directly above the brood chamber instead of adding them at the top (which is easier) did not increase the honey yield [170/50], and the use of *wire* queen excluders was not detrimental to it [154/52]; other experiments, in which different proportions of drawn comb and foundation were used, showed that a limited number of new combs could be drawn without seriously affecting the honey crop [169/50]. In Minnesota package bees gave less honey than overwintered colonies, but double packages (one above the other, each with a queen) have high yields [26/51]. Accounts have been published of methods claimed to be successful for requeening a laying-worker colony [188/50], for uniting colonies in a cold winter [108/50], for transporting bees in unventilated boxes [82/50], and for removing the honey crop with the aid of carbolic acid [48/52]; a large-scale investigation of drifting (on 1,000 colonies) leads to recommendations for preventing it [152/52, 107/50].

Migratory beekeeping is practised in many countries, but it reached its climax in Australia, where two beekeepers moved 1,600 hives more than 2,400 miles for flows lasting 6-9 months [141/50; 79/51]. In the Punjab (India) regular migration between the plains, foothills and higher hills has been found profitable [174/51]; and in South Africa, migration to the aloe [32/53]. In Germany migration to specific flows is common and profitable [179/52], and much thought is given to the design of movable beehouses [118/51; 38/53]. In Denmark the clumsiness of the hives commonly used has discouraged migratory beekeeping, but a special migratory hive has now been designed and should open up opportunities for gathering larger harvests [64/51]. English experiments show how greatly the distance of the hive from the crop can affect the yield [167/52].

Methods of management have been described which aim not only at honey production (including comb honey [153/52]), but also at the production of wax — in the Pyrenees using the sweet-chestnut flow [185/50], in Russia [81/52] and in U.S.A. [201/52] — and of bee venom in southern Germany [179/52]. Specialization is considered essential [166/51].

Wintering is still a favourite topic for experiment and discussion. In Canada the smallest losses occurred in hives with both top and bottom entrances [139/50]. In Scotland large colonies and adequate ventilation are recommended to reduce losses by *Nosema* [20/50], and the value of top ventilation is also stressed in France [39/50]; on the other hand, in Germany bees have been wintered successfully in hives kept airtight from November to mid-March [102/50], and the humidity inside a hive covered with an impermeable material except for the entrance was found to be normal [168/52]. Russian beekeepers are instructed to have large colonies well packed and in winter beehouses [78/51]; a high concentration of carbon dioxide is considered desirable — the highest concentrations were found in strong colonies and with northern races of bees [138/51]. In Yugoslavia, beekeepers who are forced to winter their bees on inadequate stores are recommended to restrict the colony to as few frames as possible, and to winter two colonies in one hive so that they help to heat each other [9/53]. Artificially heating the hives has been found to produce premature development of the colony [144/50].

We are so used to the wealth of literature on our own honeybee *Apis mellifera* that it is not easy to realize how little information exists about methods of managing other honeybees. Work has been done in India on managing the other species of *Apis* [40/50; 57/51; 60/53], and in Brazil on housing some of the stingless bees which are common there [47/51]. The collection of wild honey or wax from some of these other honeybees can be profitable — for instance in India [165/51], the Belgian Congo [24/52] and the Philippines [147/52]; nor is the collection of wild honey from *A. mellifera* always without its rewards [51/51].

Several subjects which are related to methods of management will be dealt with in future months; these include new beekeeping equipment, bee diseases, bee breeding and queen rearing, and the biological basis for beekeeping operations.

EVA CRANE

Feeding bees

Research on the feeding of bees has developed on four main lines. Firstly, *new feeding materials* have been tried out. Feeding with vitamin extracts has been found to speed up larval development [10, 11/53]. Good results have been obtained in many countries with various pollen substitutes (especially those containing yeast) [105/50, 13/51; 84, 110, 155/52] and for pollen itself [110/52]; (soya flour lacks certain essential vitamins and is not so useful [15/50]). In some districts this type of feeding is unnecessary [138/50].

Secondly, the *effects of syrup feeding* have been studied, both in spring and in autumn. In spring the effect on the development of the colony depended greatly on its size — from zero for very large colonies to 36% increase in bees and 55% increase in brood for small colonies [68/52]. (Russian experiments showed that small, but not large, colonies benefited from a reduction in the frame-spacing during the period of spring development [134/50]; it seems that the most beneficial methods of spring management for large and small colonies may be very different.) Three sets of experiments have been carried out on autumn feeding. In England about ⅓ more stores were produced from concentrated syrup (67%) than from dilute (38%), but the concentrated syrup — especially if fed as early as August — led to more breeding; 64% syrup is finally recommended [109/52]. In Denmark the proportion of the sugar fed which was converted into stores was found to be greater for 60 and 67% syrups than for more dilute ones [12/53]; German experiments lead to the recommendation of 60% syrup as offering the best all-round advantages [244/52]. The effect of syrup feeding on the distribution of temperature in the hive has also been studied [16/50].

Thirdly, experiments have been carried out to discover why *honeydew honey* is bad as winter food for bees [34/52]. The conclusion reached is that its high mineral content is to blame [200/52; 24/53]; it is emphasized that honeydew honey should only be used when there is opportunity for cleansing flights. Honey from wild mustard has also been found unsuitable for wintering [172/50].

Lastly, *training bees to specific crops* by feeding scented syrup was again shown to increase the seed yield of red clover [156/52], and a comb of freshly collected nectar put in with a colony slow to work a fresh flow is said to encourage it to do so [145/50].

EVA CRANE

Taking the honey crop

First to get the honey off the hives: the perfect method of emptying bees from the supers has yet to be invented, but a useful new escape board has been produced in New Zealand [215/52] (it has no springs and works as a funnel), and in Russia a new bee escape which uses tiny hinged flaps [128/52]. An Australian beekeeper has found *pure* carbolic most satisfactory [48/52]; in 'cool' weather he adds 10 - 20% methylated spirit.

The modified American bag truck [117/51] makes it easy to move the supers to the honey house. (If you are designing a honey house, you might with profit consult New Zealand specifications [220/52], one for an apiary of 300 hives, and one for 800 - 1000 hives ; full details are given of equipment as well as the buildings themselves.)

Now to uncap the honey : an American commercial beekeeper has developed two uncapping machines [150/50] which have cutters rather like flails, and uncap at the rate of 6 combs a minute ; one machine is hand fed, the other is fed mechanically. There is also an (American) Hodgson wobble-saw uncapper [117/51], and a simpler New Zealand uncapper with (fixed) steam-heated knife [249/52].

Next, extracting and straining : British standards for extractors, strainers and tanks have been published [91/53], and a description of equipment used at Buckfast [36/53], but there has been little development recently in extractor design. In Germany [48/52] trouble has been experienced in extracting larch honey, and special methods have had to be devised ; New Zealand has produced a new type of self clearing honey strainer [135/52]. The great interest in the last few years has been not how to get the honey out of the comb, but how to treat it to remove excess moisture and so reduce the danger of fermentation (which can however occur even in the hive [121/51]). New Zealand experiments [146/51] showed that it was easier to remove water *before* the honey was extracted from the combs, since a greater surface of honey was then available. In Canadian experiments uncapped honey lost 3½% (capped honey ½%) moisture in 12 hours [151/50] ; in U.S.A. a Humidry machine removed over 200 lb. water in 23 days from a store containing 130 supers, reducing the water content of the honey from 21 to 17% [33/51].

Finally, bottling : the bottles themselves must by law satisfy certain conditions in Argentina [122/53], and in Britain [136/52] and Germany [120/51] recommended standards have been laid down. A new American bottle filler [92/53] reduces air bubbles by filling jars from the bottom up.

The production of comb honey short-circuits nearly all the processes mentioned above, but has its own problems [30, 83, 115, 183/53]. Killion's book [153/52] gives full details — including again the use of a Humidry machine for removing excess moisture. EVA CRANE

Bee breeding and bee genetics

Bee breeding

The rearing and mating of queens is discussed in *Science and Practice* for July 1953. The selection of strains for breeding is a problem which is occupying the minds of leading beekeepers in many countries ; work on bee breeding is going on in Austria [214/53], England [192/52 ; 36,195/53], the Netherlands [85/53], Scandinavia [16/51], Yugoslavia [87/52], and Germany [238,245/52 ; 13/53], whose *Körung* system [13/53] has however been strongly condemned [195/53]. A search for the best strains still existing among the races of bees in Europe [195/53] and Mediterranean countries [111/53] has been undertaken by Brother Adam. Outside Europe, the U.S.A. takes the lead with an intensive government breeding scheme [1,69/52 ; 214/53 ; 41/54] ; government schemes are also in operation in New Zealand [75/50] and other countries.

Time-saving systems of mating have been devised for inbreeding (*e.g.*, by stimulating the virgin queen to lay drone eggs before she is mated) [144/51; 70,111/52], and formulae for determining the change in heterozygosity with various systems have been published [86/52]; there is also a paper describing a system for keeping the 'stud records' [213/52].

In Russia, breeding *larger* workers by using foundation with larger cells has been advocated [115/51], but increasing the size of queens by similar means was not so easy [112/51]. Breeding for resistance to A.F.B. has been successful in the U.S.A. [5/50]; it has been claimed elsewhere that such resistance could in some circumstances be learned, and not inherited [176/51].

Comparison of different races

The history of the differentiation of the European races of honeybees has been worked out [186/53], and their present distribution mapped [9/51, 214/53]; an early fossil 'honeybee' is recorded from France [4/51]. Characteristics and merits of a number of races have been set out: Italian and black [237,238/52; 13/54], Carniolan [8,75,238/52], Caucasian [156/50; 102/52], Portuguese [291/53], Punic [134/53], and those found in Iraq [185/53] and Israel [7/54]. Racial differentiation by means of the cubital index is complicated by asymmetry [126/51, 60/52].

The emergence weights of bees of different races have been compared [8/51], and also their behaviour in dancing [62/52; 143,144/53] — not only do some types of dance occur with some races and not with others, but bees of one race can 'misinterpret' the information provided by those of another race which are performing a dance common to both. Parthenogenetic queens and workers are produced by some races [139/51].

Bee genetics

A valuable paper by Ruttner and Mackensen [214/53] surveys the information available on the peculiar genetics of the honeybee, whose males are fatherless; this covers the ground of the publications mentioned here (up to 1952) and also much earlier work.

Certain rare inherited characteristics can be important in practical beekeeping. A case of addled brood inherited over six generations is reported from France [85/51], and it is suggested that certain anomalies observed in the wings of queens of poor laying power are hereditary [184/52]. Gynandromorph honeybees occur from time to time, and the genetic constitution of the drone parts of some obtained recently (by instrumental insemination) seemed to be affected by that of their *drone parent* — in contradiction to the commonly held views on inheritance in honeybees [6/51, 16/53]. Five new mutations have just been reported from the United States [51/54].

Sex determination

A battle has recently been raging over the possible existence of a sex chromosome in the honeybee. In 1951 the existence of a sex (X) chromosome was reported by Manning [26/52], on which basis a mature drone egg has 15+X chromosomes and a fertilized (female) egg 30+X. Kerr [95/52] confirmed the existence of this X-chromosome, which was however denied by Sanderson and Hall [148/52], who maintained the orthodox view that none of the 16 (or 32) chromosomes is associated with sex. Manning replied in 1952 [263/53, 49/54], publishing photographs of the X-chromosome in cleavage nuclei and blastoderm cells. However Ris and Kerr [50/54], using a different staining technique from that employed earlier [95/52], found 16 Feulgen-positive chromosomes, and concluded that the 'X-chromosome' was probably the nucleolus, and that there is *no* morphologically visible sex chromosome. Meanwhile Mackensen has put forward evidence [98/52] which suggests that sex may be determined in the honeybee as in *Habrobracon*, with practical consequences which would be important in beekeeping [69/52].

Work on the genetics of stingless bees has led to the interesting discovery that in *Melipona* the queens and workers are genetically distinct [4/52], and occur in the ratios 1 : 3 and 1 : 7 in different species. The two castes are reared in the same sort of cells and fed on the same food, and they emerge at random from the comb [105/51, 86/54]. EVA CRANE

The Queen

A wealth of information has been published during the last few years on queen rearing, mating and introduction, and on the behaviour of queens and the diseases which affect them.

Queen rearing

Accounts have been published of the queen-rearing methods used at Buckfast Abbey in England [36/53], in New Zealand [41/53], and in Germany[157/52]. Practical advice includes putting the grafted larvae in the honey super of a queenright colony (above an excluder)[106/50], keeping the queen caged in the colony until all brood is capped[43/50], and giving the larvae to the rearing colony only 2-4 hr.[129/51]—or one day [43/50]—after dequeening it. Taranov, Editor of the Russian bee journal *Pchelovodstvo*, has given data on the size of queen cells[112/51]—cells built over a worker egg or larva varied greatly, and those built when there was no flow were smaller than those built during swarming time. Other Russian results are quoted[65/51] to show that the weight of queens, and their subsequent performance, deteriorate if more than about a dozen are reared together by the same colony. French results[214/52] show the necessity of rearing queens in colonies large enough to maintain an adequate temperature ; optimum temperatures for queen rearing have also been studied in Hungary[5/52]. The old problem of the nature and extent of the difference between the food given to larvae destined to be queens or workers—and its bearing on the practical problem of the best age for grafting larvae — is still to the fore and still not resolved [43, 54/50, 109, 111/51, 212/52, 141/53]. The evidence that, in some strains of honeybee, queens can be produced from unfertilized eggs has been collected and reviewed[139/51].

Mating

An interesting Swiss review-article[133/53] gives beekeepers most of the information they need about the physiology of mating ; a Russian paper[5/53] discusses in detail the signs of mating and the queen's behaviour immediately after it ; there is also an English record[155/51] of an observed mating, and a Russian one[113/51] of mating with overwintered drones. Another Russian paper[14/53] describes in detail the procedure used for mating queens from micronuclei containing 10-15 bees.

Much more has actually been published recently on instrumental insemination than on natural mating. Results are recorded from Britain (in a colour film)[192/52], France [168/50], the Netherlands[85/53] and New

Zealand[75/50], and advances in technique from Britain[143/51], from the U.S.A.[59/50, 69/52], Australia (including the effects of electrical stimuli on drones)[164/51], and Japan[186/51]. Hand insemination is recommended in France[71/52] and in the U.S.S.R.[112/52] ; a German writer relates a cautionary tale based on a comparison with ants[204/51]. Electric shocks have proved successful in speeding up the initial egg laying of queens after insemination[97/52]. Instrumental insemination has made mother-son matings possible, which enable certain genetic experiments to be speeded up considerably[144/51].

Queen behaviour

Interest in the queen's behaviour centres round her egg laying ; an observation hive has been devised in France[239/52] which contains only half-combs (the midrib being replaced by glass), so that each cell is visible through both the open end and the base, and this has been used for continuous observation. The whole sequence of the queen's egg-laying behaviour in relation to the swarming cycle has been observed and recorded in Russia[65/50]. An ingenious mechanism has been suggested for the queen's control over the fertilization of each egg she lays, based on the action of the spermathecal valve[114/51]. Anaesthetizing the virgin queen with carbon dioxide is recommended for producing drones early in the season[129/52].

An interesting theory of the mechanism of the queen's piping has been put forward[110/51], and there are observations of the piping of two virgins — one emerged and one kept in her cell by the bees[234/52]. Observations on queens in multiple-queen colonies have led to some surprising and interesting results concerning their reactions to each other[108/52, 134,150/53].

Transport and introduction of queens

Transport of queens by air from Britain to New Zealand has proved successful ; the journey took 5 days[58/52]. It is emphasized in Norway [84/50] that caged queens need water.

Brother Adam has described his own successful method of introducing queens — he believes that their behaviour determines acceptance or rejection[18,187/51]. An Italian article questions this and maintains that odour is also important[15/53]. Queens taken on a 7-day journey from the Caucasus to Moscow were successfully introduced by the use of a large cage which was pressed into the comb, confining the queen with 20-30 young bees of the nucleus[88/52]. A further method is recommended from Czechoslovakia[89/52] ; it involves interchanging the sites of two portions of the colony. Laughing gas is also recommended[193/52] ; the effects of this and other anaesthetics on queens have been studied[42/52]. A method for storing mated queens until they are needed for introduction has been published in Yugoslavia[130/52].

Diseases of the queen

Any disease or anomaly which reduces the queen's egg-laying capacity can affect the honey crop obtained by the beekeeper, and the exhaustive study of the causes of sterility made by Fyg in Switzerland[177/51] throws much light on their number and variety. Anomalies in the wing venation[184/52] and doubling of the spermatheca[156/51] were also associated with partial or total sterility. A form of addled brood was inherited by 7 queens of 6 generations[85/51]. Brood from a queen infected with *Nosema* showed no stage of the disease[174/52].

Several useful general publications on the queen honeybee have recently appeared in the United States : a comprehensive textbook on queen rearing[50/51], another book in which Jay Smith gives his own methods and views[29/52], a review-article on the queen[109/51], and an account of the progress of queen rearing[17/51]. The application of American methods in Scandinavia has also been discussed[16/51]. EVA CRANE

The Drone

There can be few species for which so much is known about the female, and so little about the male, as the honeybee. The number of *Science and Practice* dealing with the queen (page 9) was based on some seventy recent publications, and several hundred publications have been abstracted which deal with worker honeybees. Yet it is difficult to find twenty which contain significant new information about the drone — and two-thirds of these deal with him only in relation to his mating with the queen. Indeed honeybees are often referred to collectively as feminine [55/50], as though there were no males at all.

Mating

The anatomy of the reproductive system of the drone has recently been described and illustrated in detail [133/53, 104/54], and several earlier misconceptions cleared up. The process of mating — peculiar to honeybees (and perhaps stingless bees [18/54]) — is also fairly well understood [8/54], and it is generally agreed that the drone's copulatory organ everts fully and ruptures (the end part remaining in the queen's reproductive system), the drone usually falling away from the queen, and never surviving [155/51; 5,133,237/53; 104/54]. One piece of evidence has been put forward to show that queens can mate with more than one drone *on the same flight* [5/53]. We still do not know how common it is for a queen to mate with a drone from her own hive ; one writer believes it to be the usual thing [6/54].

The development of instrumental insemination has led to a number of investigations into the age at which a drone reaches sexual maturity, and most of them [133/53, 89/54] suggest an age somewhere about 10 days. Some workers believe that a drone's ability to mate does not last more than a week or so, others that it lasts for the rest of his life. Some say that only 10% of the drones on the alighting board will fly after the queen [112/52]. Successful mating with overwintered drones has occasionally been reported [113/51].

Interest in instrumental insemination has also led to studies of the drone's spermatozoa [164/51, 105/54], and the possibility of storing semen at very low temperatures [105/54]. Drones show a very high acid phosphatase activity (14 times that of workers) [98/53] ; a similarly high activity is also reported in semen of mature mammals.

Other activities

It is the rest of the drone's life about which we are so ignorant — and there is surely great scope here for careful observations by beekeepers. The average life of the drone is about 6 weeks, he flies when about 8 days old, first taking orientation flights lasting several minutes, and later taking much longer flights, up to an hour or so, presumably in search of queens; most flying is done in early afternoon [79/50]. It seems likely [180/50] that drones congregate in specific areas — as bumble bee drones are known to do — and it is suggested that the queens seek out these places on their mating flights.

Many beekeepers believe that drones drift promiscuously from hive to hive, but in Russian investigations [150/52] less than 2% of the drones did so (usually on their orientation flights). The drones did not seem to be especially attracted by queenless colonies, nor by those containing virgin queens.

Although akinesia (shamming dead) can be induced in queens or workers, all attempts to induce this state in drones have failed [233/52]. Drones as well as workers have been used in biometrical studies of different races [127/50, 7/54].

Nutrition and development of drones

We are similarly ignorant about the food that drones live on, either as larvae or adults. It has been claimed [54/50] and denied [96/52] that drone larvae are given food slightly different from that fed to worker larvae. The results of experiments in which 'radioactive' syrup was fed to foraging bees (drones showed less radioactivity than any other bees or brood) have been interpreted as indicating that the nurse bees feed adult drones on brood food, and not on honey or nectar [147/53]. There is some evidence that the bees which feed the drones are nurse bees around a week old [159/51].

Some beekeepers believe that it is advantageous to allow strong colonies to build drone comb [83/50], and even to rear drone brood [95/50; 196/53], freely.

Gynandromorph bees (part worker, part drone) can be produced by chilling queen or worker brood [from fertilized eggs], but not by chilling drone brood [from unfertilized eggs] [201/53]. Gynandromorphs [6/51], and the recent evidence they provide [16/53] on inheritance in the honeybee, were referred to last month.

EVA CRANE

The Worker

Only characteristics of the foragers are dealt with here; communal activities in the hive are left for a later article, including the 'division of labour' which we now know to be very flexible [35/50; 162/53; 8,93/54].

Discovery of food

Bees locate flowers by both sight and scent [246/54], sight at long distance and scent at short range [124/52]. The scent is learned when flying up to the flower, not when taking the nectar or when flying away [56/50]. The communication of the position and scent of flowers to other foragers by means of round and wagtail dances is now well known [55/50; 7,77,87, 93,197,200/51; 144/53]. (Some of these dances were observed, but not understood, long ago [10/54].) The *tendency* to dance is influenced by the general availability of crops [200/51].

It has recently been shown that bees use a sickle dance to indicate forage very near the hive [62/52; 143/53], and that they cannot communicate a vertical direction or distance [90/54], nor colour [146/53].

Choice of food

Bees certainly prefer a plentiful nectar supply to a sparse one [236/52], and a high to a low sugar concentration [125/52], and this can lead to difficulties for seed and fruit growers [101/52; 122/54]. They also prefer some sugars to others, and even some mixtures of sugars [37, 184/51; 139/53; 5/54], and may be 'put off' some varieties of apple (such as Bramley's Seedling) because the nectary is difficult to get at [27/50]. Foragers are also attracted to food by other bees from their own colony already there (presumably by their scent [145/53]).

In one set of experiments [91/54], dances by returning foragers showed that 90% of them came from crops less than $1\frac{1}{4}$ miles away. In another [167/52, 132/53], honey yields $\frac{3}{4}$ mile away were only 68% of those obtained at the crop. This was in a good season ; in a bad one the figure dropped to 18%, showing how much the foraging conditions affect the bees' choice. Seed yields which depend upon bees for pollination show a similar distance effect [141,181/52; 127/53; 117/54].

The whole question of *constancy* has recently been reviewed [61/51] ; foragers are constant not only to a species, but in some circumstances even to a single variety [64/53]. Bees also remain faithful to remarkably small areas when foraging conditions are good—one bee spent 8 days foraging on a 17×10 ft. patch of golden rod [91/51]. Foragers show much individuality : some remain faithful to a single source and others desert it when a better one is available. There are still others which act as scouts and continually seek fresh sources of food [56/50] ; these seem to be endowed with certain special abilities which the other bees have not got [98/50]. Some bees work two crops at once, or two at different times of day [1/50]. Some never collect pollen at all [162/53] ; others forage for nothing but water all their lives. When the hive temperature becomes too high, many of the foragers will collect water [47,151/52] ; many also will cluster outside the hive [99/50].

Foraging for pollen

Pollen collection is inevitably governed by the time of day at which the pollen from each plant is available [176/50; 62, 182/51] (this is also true for nectar [130/51, 80/52, 4/54]). The process of packing the pollen in the 'pollen baskets' is now understood [221/52], and experiments with pollen traps [52/54] have shown how the foraging force of a colony can be diverted from nectar to pollen collection by this removal of incoming pollen. While pollen is collected from many sources [136/50], the bulk of it comes from only a few [280/54] ; almost, but not quite, all the loads brought in represent only a single species [176/50, 280/54].

Bees anaesthetized with carbon dioxide or nitrogen tended to switch over from pollen to nectar collection [138/53].

Foraging for nectar

Whether a forager sets out from the hive for a food source near or far away, she takes with her a supply of sugar adequate for the outward journey [136/53] ; similarly she collects slightly more nectar from a distant source, as though to provision herself for the longer journey home [137/53]. Her blood sugar alone only lasts for about 15 minutes' flight [135/51]. Foraging bees are more sensitive to light than house bees [94/51], and many foragers return home when the sky clouds over [128/51]. Much can be learned by watching the bees come and go from the hive [292/53], and an apparatus has now been devised for registering their flight from it [82/53]. *Drifting* of bees from one colony to another is related to the flight line between hive and forage [152/52].

Abnormal foraging

One peculiarity observed is the 'stealing' of nectar through holes made by other insects in the corollas of certain flowers [126/53, 45/54]. But bees cannot *make* such holes, nor can they pierce the skin of fruit (except a few varieties of raspberry [209/52] and one early fig); they do however suck fruit juices through holes already made.

Foragers will take substances repellent to them if these are mixed with sufficiently concentrated sugar syrup [140/53]. But it was found that they deserted apple blossom immediately after thinning sprays were used, although nectar was still being secreted [151/51]. They are also repelled by salt, acid and bitter substances [200/51] and by some insecticides [20/51], and abnormal dancing behaviour was observed in bees which returned to the hive with water contaminated with dinitrocresol [133/52].

Bees able to forage only in a small confined space stopped rearing brood and behaved abnormally in other ways [184/54].

EVA CRANE

Acarine disease

Important advances have been made since the war, both in the treatment of acarine disease and in the study of the life history and behaviour of the mite itself, which had never before been clearly understood. Careful German work [182, 283, 284, 287/53] has shown how the mites pierce the tracheal walls to obtain nourishment, and how they migrate from one bee to another. It has also been shown [284, 287/53] that it is the *intermittent* stream of air from the first thoracic spiracle which attracts them to it (in young and old bees alike), and the stiff barrier of hairs which prevents entry except in very young bees.

Within the last decade acarine disease has been so severe in some areas — such as south-west Germany [131/52], Czechoslovakia [170, 171/52] and Sardinia [115/52]—that it has threatened to make beekeeping impossible. In parts of Switzerland [110/50] it is still the commonest disease; in Scotland [171/50, 87/53] about one colony in twenty is infected. In North America [7/50] and New Zealand [77/50, 58/52] the disease is not known, and the fact that in Europe severe outbreaks so often occur near the boundary with another country [131, 170/52] suggests that the restrictions on imports of bees are a very wise precaution. The presence of acarine mites in Argentina [76/52] has caused some concern among beekeepers on the American continent.

Clear instructions for microscopic diagnosis of the disease are available for English beekeepers [53/51]; a Swiss method [87/50] which does not need a microscope consists of pulling off the hind wing of a 'crawler'—if acarine disease is present the wing comes away readily, with part of the body wall attached.

The problem of treatment is complicated. Frow mixture†, which was so successful in the English epidemic after the first war [184/50],

* Treatment by smoke blown into the hive

and other chemical remedies [111/50], have recently proved singularly ineffective in many countries, although commonly used [140, 160, 187/50, 19/51] and successful [21/53] in others, and much work has been done to develop more satisfactory control methods. In England the sulphur* treatment has been revived [88/50], and in Austria Mito A_2 (98% methyl alcohol + 2% mustard oil) is recommended [146, 190/50]. The disturbance among the bees caused by introducing this vapour — or presumably others — can last for several days [140/51].

In Czechoslovakia, treatment with hydrochloric acid [171, 173/52] or BEF [171, 173/52] has proved successful during the broodless period [19/53] (or BEF†‡ can be used when there is brood) ; hydrochloric acid† tends to excite the bees. In Belgium, PK* has been shown to kill all mites within three weeks and not to damage bees or brood [39/53] ; it does however seem to stimulate the colonies rather much [40/53].

All the above treatments are chemical ones, but in France good results have been reported with a yeast *Acaromyces* [171/51]—a suspension of it is sprayed on to the combs [20/53]. In Czechoslovakia and Germany a biological treatment [131/52], based on the separation of sealed brood from the diseased bees, has been used successfully to clear badly infected areas. It involves much work in transporting bees and brood, and the whole operation takes about four months, but it does get rid of the mites completely.

Laboratory experiments in France [111/50] and Germany [170/51, 286/53] have shown how extraordinarily *resistant* the mites are — and how much more resistant than the bees they infest. For instance, within the bees' tracheae mites outlived bees over all ranges of temperature and humidity, and many of the treatments used had little effect on the mites at all, while the bees quickly succumbed. In England success has been claimed [36/53] in breeding bees resistant to acarine disease.

Unidentified mites have been reported recently in the air sacs of bumble bee queens and workers [48/50] ; the possibility of honeybees becoming infected from bumble bees (or wasps or ants) has been discussed [17/53], but finally rejected.

EVA CRANE

American and European Foul Brood

It is instructive that over five times as many publications have been abstracted on A.F.B. as on E.F.B., that half those on A.F.B. deal with treatment by antibiotics, and that of these the majority conclude in the end that it is better to destroy colonies with A.F.B. than to treat them with any drug so far available.

There are many handbooks which explain how to diagnose A.F.B. and E.F.B., including the revised American circular [7/50] ; ultraviolet light is now a useful aid to locating scale material [132/52].

Distribution of foul brood

Foul brood is a scourge of beekeeping in both northern and southern temperate regions (but not in the tropics — see article by F. G. Smith in *Bee World*, December 1953). Some 3% of English colonies have A.F.B., and less than 0·1% have E.F.B. [112/50] ; the

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† Treatment by vapour of substance slowly evaporating within the hive
‡ Composition not available

figures for Denmark are 3% and 0·8% [52/51, 270/53], and for Switzerland (Canton Vaud only) [110/50] 0·1% and 0·3%. A.F.B. is in all States of Australia, although only since 1949 in Queensland [23,44/50]; in New Zealand [77/50] 2% of the colonies are affected [58/52]. In parts of north America it is much more serious — some States having more than 10% of their colonies infected.

Treatment of A.F.B.

Experiments in many countries—U.S.A. [96/51, 29/54], Canada [22, 173/50], England [221/53], France [19/51], Denmark [45/50, 270/53] and New Zealand [77/50, 58/52]—have led those who carried them out to recommend beekeepers to continue destroying infected colonies instead of treating them with sulpha drugs or by shaking. Many agree that sulpha drugs are of great value [22/50, 29/54], but that the results are just not worth the considerable labour involved from the beekeeper's point of view. On the other hand some — *e.g.*, in U.S.A. [271/53], France [299/53] and Czechoslovakia [222/53] — are completely satisfied with the results they obtain. More experiments with a variety of the new drugs will surely lead to a satisfactory answer to the problem [22/50].

Disinfecting hives

Not all those who recommend destroying infected colonies think it necessary to destroy the hives and combs as well. Sterilizing combs with formalin is recommended in Canada [167/50] and France [299/53]; in Australia [23/50], boiling parts in 1% caustic soda solution has been found satisfactory. Laboratory experiments in America [30/54] have shown that fast electrons kill *B. larvae* in both combs and honey; heating honey to a very high temperature (*e.g.*, for 2 minutes at 270°F.) also killed the spores [74/53].

Laboratory experiments

We have recently lost two pioneers in the bacteriology of foul brood — Professor Burri [306/53] who first distinguished between the bacteria causing E.F.B. and A.F.B., and Dr. Burnside [42/53] who further clarified the several bacteria associated with E.F.B.

Valuable work has been done in Canada lately on the resistance of *B. larvae* (which causes A.F.B.) to antibiotics. Aureomycin was most effective; 1 part in 50 million inhibited growth completely [22/50, 97/51, 196/52]; however in the apiary terramycin and sulphadiazine proved better than aureomycin [194/52]. Other experiments [28/54] have shown that susceptibility of worker larvae to A.F.B. is not linked up with the lack of royal jelly in their diet. In these experiments the susceptibility disappeared when the larvae were 54 hours old — there are however still some puzzles about the age resistance to A.F.B. [8/50]. Although the growth of *B. larvae* outside the hive also presents difficulties [67/51], the spores are extraordinarily resistant [74/53], and high concentrations of many toxic substances leave them unaffected — this is what makes the use of infected honey so dangerous.

Disease-resistant strains

The other great line of attack on A.F.B.— which has met with considerable success in U.S.A. [5/50, 1/52]— is the breeding of strains of bees resistant to the disease. But this again is not the complete answer [96/51]. The 'resistance' is presumably due to exceptional zeal on the part of the workers in cleaning out the cells (one author claims that this characteristic is learned by each generation, and not inherited [176/51]). The story of the discovery and subsequent use of a disease-resistant strain in Hawaii is by now well known [116/52, 157, 158/53, 27/54].

European foul brood

In some parts E.F.B. is even more disastrous to the beekeeping industry than A.F.B., and we still do not understand what lies behind these sudden severe outbreaks ; for instance in Colorado (U.S.A.) [175/52] over 5000 colonies were infected in 1950 — 7% of the total number — and there was a severe outbreak in a commercial English apiary [112/50] in 1946.

No method has yet been found for growing *B. pluton* outside the hive [189/51], but there are very promising reports of successful treatment with new drugs. Streptomycin has been reported completely successful in France [216/52], and terramycin in Switzerland [246/53]. Both these drugs also proved successful in Canada [31/54] — both in preventing infection and in reducing infection already present — when fed to the colonies ; spraying infected combs did not help.

EVA CRANE

Uses of honey and other bee products

For many centuries honey has been believed to have healing properties, although there is far less real evidence that this is so than some of its advocates would have us believe. Some evidence has been brought forward within the last few years of its bactericidal properties and its value as a dressing for wounds (195, 196, 197, 198/50, 137/52). One interesting method of preparing eye ointment (168/51) has been developed : a colony is fed with honey mixed with an infusion of eucalyptus leaves, and the honey stored by the bees is subsequently extracted. Honey to eat is recommended for chorea (194/50) and various other diseases (137/52), and it is used in the cough cure Melsanin (179/52). Honey has also been prepared in a form for injection under the name *M2 Woelm*, and this has been shown to have effects on the heart and circulation of both man and animals which could not be reproduced with a solution of similar concentrations of sugars (53, 54, 137/52).

Other products of bees have also been investigated from the medical point of view. Propolis has been shown to kill bacteria (83/52), and pollen is regarded, on account of its vitamin content, as a new raw material for the pharmaceutical industry (125/50) ; it has also been found to reduce the incidence of tumours in mice (166/52). Bee venom, used on the Continent for many years as an injection for rheumatic and other complaints (179/52), has now also been shown to inhibit the growth of certain tumours (166/52). A young commercial beekeeper has described how gradually increasing injections of diluted bee venom were successful in making him immune to bee stings after he had become allergic to them (150/51). Two new methods of preparing the venom have been described (199/50), and also a new property of both wasp and bee venoms (199/51) which as far as we know has not been applied—under some circumstances they behave similarly to tear gases.

Several new foodstuffs with honey as a main constituent have been developed in the United States. One is a ' smooth, non-sticky fruit-honey spread ' made from honey and fruit juice or puree, which can be stored without deteriorating (55/52) ; others are dried or condensed mixtures of milk and honey which can be stored and used when wanted, in baking and in preparing infant foods (138/52). The preparation of ' honey butter ' is also described (106/51). Unsaleable thin extracted honey has been disposed of profitably by feeding it back to the bees and getting them to fill sections with it—one colony fed 285 lb. of such honey yielded 187 saleable sections (11/52). The use of honey for cooking is certainly not new, but individual recipes sometimes are—some interesting ones are given in a French article (104/51). The history of the uses of honey has been recorded in a book published in 1949 (95/50).

Apart from its medical uses, pollen collected by bees is becoming important commercially for applying to fruit trees in order to increase pollination. One hindrance to this development was the fact that pollen stored by bees would not germinate (177/52). It has now been found that if bee-collected pollen is quick-frozen and stored in ice (72/51), or if it is suspended in syrup and then plated on agar containing sugar (178/52), it remains capable of germination. A study has now been made of aeroplane and bomb methods of applying the pollen to the trees (227/52).

Old and new uses of beeswax are set out in a recently published book on the subject (201/52).

Honey, pollen, wax, propolis and venom : these form the complete set of bee products used by man so far ; the bees themselves have however been used from very ancient times as a weapon of war, and a new reported wartime use for them is the transport of microscopical documents across enemy lines (59/52).

EVA CRANE

The Historical Aspect

After what might be called the prehistory of beekeeping, landmarks in its long-term development fall into two main categories : scientific discoveries about bees, and developments in technique and equipment.

Prehistory of beekeeping. There are many references to bees and honey in early writings [95/50] such as the Bible [23/51] and Virgil's works [96/50]; a second edition of the detailed study *Beekeeping in antiquity* has recently been published [22/52]. In some early societies we know that beekeeping was carried out (although there are no written records) because of archaeological finds ; these include pre-Inca [1/51] and Aztec [3/52] civilizations, where the bees 'domesticated' were the stingless Meliponins [95/50]. A study of the derivation of beekeeping terms [94/50] throws some light on our ancestors' conceptions of bees, honey and wax.

Fossil bees have been found which date from a very much earlier period and probably represent the earliest forms of social bees [4/51]. Also before beekeeping proper came (in Neolithic times) the hunting of wild honeybees for their honey [22/52]— this is practised even to-day by the primitive Guayakis in Paraguay [164/52] and in modern North America [51/51] — and out of this arose the transitional occupation of *Zeidlerei*, the preservation and tending of bees in natural nests, which was both important and highly organized in parts of mediaeval Europe [31/53].

Scientific discoveries. The invention of the compound microscope just before 1600 made it possible for scientists to learn something of the bee's anatomy [165/52], but many of the fundamental discoveries on which our present beekeeping is based were not made until the second half of the eighteenth century : parthenogenesis by Charles Bonnet [50/50], the fertilization of the queen by Anton Janscha [30/52], and many more — including the process of wax secretion and comb building — by François Huber [5/51]. Advances in the battle against bee diseases came over a century later still — a successful treatment of acarine disease by Frow [184/50], a study of septicaemia and fungal disease of bees, and of the causative organism of E.F.B., by Burnside [42/53] and others. Professor E. F. Phillips [25/51, 226/52] was the first to realize clearly the relation between mismanagement and diseases such as E.F.B. and *Nosema* ; to Cockerell [50/53] we owe much of our knowledge of the native bees of many countries.

Developments in technique and equipment. A summary has been published of the development of beekeeping in England up to the fourteenth century [22/52], and the development of certain Swiss hives has been traced back as far as the eighth century [145/52]. Bamboo hives and frames in Sicily date from Roman times [14/51] ; in the forests of White Russia one of the very earliest forms of hive — made from a hollow log — is still in use [144/52]. Some modern writers still advocate skeps and fixed-comb hives [164/50], and also a modern variant of the leaf hive (whose history is recounted) [42/50]. Shortages of usual hive materials in Israel — where clay hives were in use at least 2,000 years ago [95/50] — have now led to the development of a clay movable-frame hive [81/51]. The *best* type of hive is still in dispute. The relative merits of different British hives have been discussed [104/50], and it is estimated that nearly half the world's movable-frame hives are Langstroths [127/52]; this hive is gaining popularity over the Dadant in France, and standardization which would allow some interchangeability is pressed for there [85/52]; in the U.S.S.R. the (long) Dadant-Blatt hive is still the most popular, and there also standardization (of four hive types) is proposed [12/52]. It is estimated that the Dadant-Blatt frame may actually be the most used frame in the world to-day [127/52].

Accounts of the development of beekeeping in France [73/51], in India [195/51], and in Europe generally [165/52], have been published, and also the story of the part played by women in the history of beekeeping [172/51]. A memorial volume to the Staffordshire beekeeper Joseph Price [70/50], and (for the first time) a pamphlet devoted to the life of Charles Butler [109/53], have recently appeared. There is also a historical account of the uses of bees in warfare [59/52].

Beekeeping was unknown in North America (north of the range of the stingless bees [95/50]) until the honeybee was introduced from Europe [59/53]; since then some of the most important developments in the technique of beekeeping have been made there — the discovery of the bee space by Langstroth in 1851 [4, 61/53] and also, since then, rapid advances in bee breeding [17/51]. The history of beekeeping in Hawaii [116/52] is especially interesting because of the chance development of a strain of bees especially resistant to A.F.B.

Settlers from Europe found New Zealand to be a country without bumble bees or honeybees. Honeybees were introduced in 1839, but it was not until bumble bees were successfully transported there in 1885 that seed crops were obtained from red clover; a survey of bumble bees in New Zealand has recently been undertaken because the seed yields have been decreasing, and suggestions have been made for introducing other species of them [230/52].

EVA CRANE