BEEHIVES, BEES AND BEEKEEPERS

Eva CRANE

ENGLAND

Introduction

In this paper introducing a session on beehives, bees and beekeepers, I shall deal with the subject only in a basic and general way. Speakers who follow will, I am sure, apply their expertise to specific problems concerning interactions between the hives, the bees, and the beekeepers, that face the industry today. The interactions themselves seem to me to be summed up in the concept that "the *hive a beekeeper* used is the outward and visible expression of his capability for managing *bees* for his own purposes".

Hives have certain common features throughout the world, but are subject to quite wide and interesting variations; the same is true of beekeepers, and of honeybees. If what I say appears somewhat theoretical, it is because I want to focus attention on factors that are common throughout the world, rather than on practical details which highlight regional or other differences. At the same time I shall have to bring into the discussion both the frames used in the hive and the honey extractor used in the honey house.

Bees have a fairly wide tolerance with respect to their hive or other dwelling, and this adaptability is one of the reasons why man can exploit them. I deliberately avoid saying "man can *domesticate* them", because domestication implies a greater change in behaviour patterns than is yet possible with insects.

Beekeepers – unlike bees – can *think*, and through the ages beekeepers have had many ideas as to what bees require of a hive. Some of these ideas have been *conservational*: "I use such-and-such a hive because it is the hive my father and grandfather used". Some later ideas were *anthropomorphic*: "My door is downstairs, in the middle of the front of my house, and my bees would like the entrance in the same place". Fortunately other ideas have been truly *innovative*, and these have a special interest for us today.

The requirements of bees and of beekeepers are different, because what constitutes success for them is different. Success for a colony of bees is survival, coupled with reproduction (sending out swarms that themselves survive). Success for a beekeeper is most commonly a satisfactory return on his investment of money and time, and this is most likely to be achieved if the colony of bees stores honey greatly in excess of its own requirements, in a part of the hive from which the beekeeper can easily remove it. Usually this excess honey is produced at the expense of suppressing or diverting the bees' natural reproduction, that is, by using a system of swarm control.

Between 50 and 60 million hives are used for honey production in the world today. These same hives are adapted for the production of beeswax, royal jelly, pollen, or bee venom; for the rearing of bees for packages, or of queens; and for general interest, ornament, or pleasure. But for education, study and research, and for pollination purposes, hives may differ considerably from the norm. Subjects of present economic interest include: materials for hives, especially substitutes for wood; disposable hives, and other frameless hives; multi-colony hives; and finally standards for hives and hive parts, and their metrication[11].

The brood space and the honey space

In hives designed for honey production, the brood space is separate from the honey-storage for two reasons. First, this separation is convenient to the beekeeper when he harvests the honey. Secondly, the bees' requirements in the brood space and in the honey space are different, in important ways which can be taken advantage of in hive design.

Fundamentally, there is only one measurement that must be adhered to precisely in hive design, to conform with the bees' requirements. This is the distance between adjacent combs (centre to centre) in the brood space. All other measurements either lie within farily wide limits of tolerance for the bees, or are chosen to suit the beekeeper, not the bees. If the hive is provided with comb foundation or pre-cast combs of wax or plastic, then – additionally – cell diameters must be precisely correct. Both the distance between combs and the cell diameter differ somewhat between different races of bees, and between the two species of hive bee, *Apis mellifera* and *Apis cerana*. (In the other two species of *Apis, florea* and *dorsata*, the colony builds only a single comb, and "distance between combs" has no meaning).

At the time in prehistory when purpose-built hives were first used, the hives were simply containers in which the bees sited their own combs, and this continued for a very long time. Then came a stage when some beekeepers applied "guides" where they wanted the combs to be. These guides were parallel strips of wax applied to the inner roof of the hive, or parallel scratches in pottery hives, or parallel incisions in wooden hives. But they had to be at the correct distance apart, or the bees would not follow them.

The next mainstream development was a movable-comb hive, known to have been used in Greece in the 1600s and possibly even in Aristotle's time. This is like a round wastepaper basket, with a series of parallel bars covering the open top. The width of each bar is equal to the natural distance between combs, and the bees build a comb down from each bar. The hive walls slope inwards, as naturally built combs do, and the bees do not attach their combs to the walls: each bar with its combs can be lifted out of the hive as a separate movable unit.

In 1851, Langstroth devised his movable frames – primarily for the brood box of a hive. "Each comb in this hive is attached to a separate, movable frame, and in less than five minutes they may all be taken out, without cutting or injuring them, or at all enraging the bees." The surplus honey was not necessarily taken from the frames, but from "upper boxes or glasses in the most convenient, beautiful, and salable forms"; glass bell jars were commonly used. Langstroth's precisionbuilt hanging frames, inside which the bees build their combs, are still used today. In the brood box they must be at the correct distance apart, and at the correct distance from the hive wall and from frames in other boxes immediately above or below.

The primary benefits of movable combs in the brood box are that each combs can be inspected and its contents assessed, and that combs can be interchanged – within a hive or between hives – or removed completely. The round Greek bar hive with its movable combs gave the first benefit, but not the second, because the bars had different lengths. Interest in movable-comb bar hives without frames was revised in the 1960s and these hives were devised with a rectangular cross-section instead of a round one; all the bars then have the same length, and all are interchangeable. Such hives are now used quite extensively in Africa[10]; some are long, single-storey hives; one type, called the Afrihive, has the same cross-section as a Langstroth hive, and is supered with Langstroth supers for honey storage.

The honey space

The bees will accept a larger distance between combs in the honey space than in the brood space, provided fully built combs are inserted, and not flat sheets of foundation. In fact no dimensions need be very precise unless the beekeeper wants them so, which he may well do. In order to understand what beekeepers have imposed on themselves, it is necessary to recall the sequence of development after Langstroth's hive was introduced. Langstroth's book describing his hive was published in the United States in 1853. In 1857 Mehring in Germany produced beeswax sheets embossed with hexagons, to stimulate the midrib of the bees' combs: comb foundation. Frames filled with comb built out from this rather thick foundation were used for honey storage as well as for brood, and in 1865 Hruschka in Austria was able to spin the honey out of these framed combs, having first removed the wax cappings from the cells: his invention is known today as the centrifugal extractor. At about the same time, Abbé Collin in France perfected the queen excluder, a metal grid used to confine the queen (but not the worker bees) inside the part of the hive where the beekeeper wants the brood to be reared – the brood box. This leaves a hygienic honey-storage area, uncontaminated with brood rearing; it also enables the beekeeper to design honey storage boxes to suit his own convenience.

By the 1870s, framed combs built on wax foundation, prestrengthened by embedding wire in it, could be removed from the broodfree honey supers in a hive, then uncapped, and spun in a centrifuge to remove the honey. For a hundred years and more, this is what beekeepers have done. I want to emphasize today that the honey-storage frames *need not be movable* (they can be fixed in the hive or dispensed with altogether), that precision – which is always expensive – is not inevitably essential in making honey boxes, and finally that it may be possible to dispense with the tiresome and often messy procedure of uncapping, and the subsequent treatment of the cappings.

The reason for using movable frames in the honey supers is based on circumstances that are becoming past history. The sequence of innovations in beekeeping practice was: movable frames, then comb foundation, and then the centrifugal honey extractor. In early honey extractors the combs were placed tangentially, with cell openings on one side facing the centre, and the frames had to be inserted singly (and of course reserved to extract the other side). The placement of each comb along a radius was tried out as early as 1867, but it did not come into general use until the 1920s, by which time electric motors were available to provide the high speeds required. More recently radial extractors have been constructed that are large enough to accommodate four honey supers with the frames in place (or 8 or 16 supers, or even more). The axis of the large extractors may be either vertical or horizontal, but the frames are always in the radial position during operation. I myself first encountered honey production involving these very large extractors ten years ago this month, in New South Wales. At Kempsey, Roger Blackwell had installed an extractor taking 72 supers, and in his apiary near Tamworth he was using supers with fixed frames fitted with plasticreinforced wax foundation. A multiple uncapping machine was used to uncap both sides of each combs, with the combs *still in the super*; at no time were the frames removed.

In 1893 a patent had been taken out for a mould to cast complete wax comb, with cell walls, and many ways have since been devised for making both full-depth and half-depth wax combs. Metal combs were tried as early as 1870, but were acceptable to bees only in certain circumstances. A wide variety of plastics were developed after the Second World War, and a number of them have been tried out with varying success, for manufacturing both comb foundation and comb itself, the cells usually being rather less than their full height. Such plastic combs are stronger, more resistant, and easier to sterilize than beeswax combs and *they can also eliminate the need for uncapping.* In the current issue of Journal of Apicultural Research, B.F. Detroy and E.H. Erickson of the United Sates Department of Agriculture report tests in which they were able to spin the honey out of prewarmed plastic combs – which had been filled and capped by the bees – without previously uncapping them[3]. The cell walls of the plastic comb were not full depth, and in the extractor the wax cell-extension built by the bees sheared off, with the wax cappings, leaving the plastic comb clean and empty. Uncapping could be eliminated with all three plastics tried: polypropylene, polypropylene with a talc filler, and acrylonitrile butadiene styrene.

Where does all this lead us? It shows the practical possibility of using honey supers with built-in plastic combs (frames have become irrelevant here); when are driven out of the super this is immediately ready for the extractor, and it can then be replaced on a hive or put for storage – after heat sterilization if this is required.

Depth of hive boxes

One of the primary requirements of a hive from the beekeepers' point of view, which has nothing to do with the bees, is compatibility and interchangeability of parts. All boxes must have the same external and internal cross-section, to which floor-boards, cover-boards, roofs and so on must also conform[7].

For the beekeeper the simplest plan is to have all hive boxes of the same depth – one standard box throughout. There are, however, reasons for using two depths of hive box, the honey super being shallower than the brood box; it is usually just over half as deep. In my view the reasons are overriding ones, though I know that that here in Australia many beekeepers use deep boxes only, and Dr. C.L. Farrar in the United States, whose research gave us great insight into the scientific basis of hive management, was one who used shallow boxes only, the brood space occupying several of them. The first reason has to do with hygiene: for maintaining the highest standards for honey quality, it is desirable that the combs used for rearing brood and for storing honey should be kept separate. Secondly, honey can be darkened by contact with brood combs[9], and its price thereby reduced. Thirdly, honey boxes are lifted and carried more easily than brood boxes, and in spite of mechanical aids the beekeeper is likely to do quite a lot of lifting. He must also conform with any legislation about the weights his employees may lift. Weight limits are therefore relevant, and a deep hive box can be too heavy when it is full of honey – say 40 kg compared with 20 kg for a full shallow box. Lastly, the beekeepers must drive the bees out of each honey super before he can extract the honey, and chemical repellents so far used are effective for a depth somewhat less than that generally used for shallow honey supers[8]. This restriction does not apply to bee blowers, which can be used even with deep boxes[4].

Now let us consider the brood box. For a hive of any given cross-section, the depth of the brood box determines the comb area in it, and hence the number of cells in which the queen can lay eggs. Most – though often not all – the eggs that are laid give rise to adult bees after a period of say 21 days, and the cells are empty again. A 10-frame Langstroth brood box allows an average rate of laying of 2000 eggs a day, if we equate eggs to brood reared. Of course two or more brood boxes can be used to allow more laying space, or to carry out hive manipulations required by the management programme.

Hive size is intimately connected with swarm control. In experiments reported by J. Simpson and Inge Riedel in England in 1963s, restriction of the queen's laying space did not in itself induce swarming, but restriction of the total hive space, with congestion of adult bees, did induce swarming. (These experiments were done with small hives, and should be repeated with very large colonies in large hives.) Adding honey supers consistently in advance of requirements, so that the total hive space is overlarge, is thus one easy way to discourage swarming. But providing additional brood space is no more likely to be effective than providing additional honey storage space.

Cheap hives

In some circumstances low cost is an essential requirement in hive design. Where it is not honey and was that are wanted, but the bees themselves, expendable hives may sometimes be used. An example is the sale of bees to farmers for pollinating a specific crop, after which the bees are disposed of. Here the cost of precision is unwarranted and a box of weather-proof cardboard or biodegradable plastic will serve; usually something suitable can be obtained from a local industry that packages ice cream or other foodstuffs.

Moving into a much wider field, almost all primitive hives were made from materials that cost nothing; the beekeeper collected them from round about[2]. The construction of many types of hive was time-consuming, but in primitive communities time does not cost money in the way it does in our own society. I am at present writing a paper on hives of the Ancient World, in collaboration with a classical scholar and archaeologist, and I am frequently astonished at the high level of practical knowledge among the most advanced beekeepers 2000 years ago. They carried out all sorts of hive manipulations, using hives with a variety of special characteristics – for instance a variable size, and separate honey-storage units, which might even be removable from the main hive.

This is not the place to go into the subject in depth. I have already mentioned the one ancient hive that has been a starting point for recent developments in hive design. This is the round Greek bar hive with sloping sides, now used in a long rectangular form with the honey-storage area at one or both ends. In its more nearly square form, with a Langstroth cross-section at the top, it provides a cheap brood box for use with orthodox honey supers. Whether with this or an orthodox brood box, ordinary shallow honey supers can with care be used with top bars only, saving the cost of both frames and foundation. Alternatively, in England W.B. Bielby has devised a method whereby the beekeeper can make nylon-reinforced wax foundation, which may be used with a top-bar but no frame, and this is strong enough to put in the honey extractor[1].

Hyper-hives

I must say a few words about the hyper-hives at the other end of the scale: not cheap and simple hives, but complex hives manipulated with mechanical aids. From time to time articles are published in bee journals describing elaborate hives with a built-in honey extractor, or incorporating hoists to lift parts too high for the beekeeper to reach; skyscraper hives were especially fashionable around 1950. Some of these hyper-hives are ingenious but not commercially practicable. Nevertheless, ideas in this direction must continually be explored, because developments in materials and techniques may one day convert an apparently nonsensical idea into an economic proposition.

The most sophisticated hyper-hives I have seen in commercial operation were the coffin hives run by Sid Murdock and Ken Gray in Western Australia. The unit consisted of a row of six 8-frame Langstroth brood boxes, separated by dividers, and with entrances facing alternately to either side of the row. Sid Murdock was using a single super holding 50 frames, placed across all the brood boxes, each of which had its own queen excluder. Ken Gray used a three-decker outfit, with a row of six separate honey supers below the hyper-super. All lifting was mechanical, by gantry or by a mobile mini-gantry. I am sure that you will hear more about these hyper-hives during the Congress, and I hope you will see some in action.

Conclusion

In closing, we must come back to the question: where are we now going with hives? I think that advances in the immediate future will be on a very broad front. In the middle are the unexciting, but most necessary, movements towards standards, possibly world standards, for the hives in current commercial use. At one end of the advancing front are the low-cost hives – some traditional, some inspired by a renewed concept of self-sufficiency, and some devised specifically for their cheapness. At the other extreme are the high-rise and hyper-hives. It seems to me that useful developments may be achieved anywhere along the line: we must be ready to re-question the necessity for every hive fitting and part, and for every manipulation we make in dealing with bees and their honey. Above all we must be continually open to new ideas, wherever they come from, whether inside or outside the beekeeping fraternity. I feel sure that the present session will make a valuable contribution towards this end.

REFERENCES

1. BIELBY, W.B. (1977) – Home honey production. *Wakefield; EP Publishing Ltd*.
2. CRANE, E. (1977) – The shape, construction and identification of traditional hives. *Bee World* 58 (3): 119-127 Reprint M90
3. DETROY, B.F.; ERICKSON, E.H. (1977) – The use of plastic combs for brood rearing and honey storage by honeybees. *J. Apic. Res.* 16 (3): 154-160
4. DIEHNELT, B. (1966) – The bee blower. *Am. Bee J.* 106 (7): 246-247
5. ERICKSON, E.H.; THORP, R.W.; BRIGGS, D.L. (1977) – The use of disposable pollination units in almond orchards. *J. Apic. Res.* 16 (2): 107-111
6. SIMPSON, J.; RIEDEL, I.B.M. (1963) – The factor that causes swarming by honeybee colonies in small hives. *J. Apic. Res.* 2 (1): 50-54
7. SMITH, F.G. (1966) – The hive. *Bull. Dep. Agric. West. Aust. No 3464*

8. TOWNSEND, G.F. (1965) – Benzaldehyde for driving bees. *Am. Bee J.* 105 (7): 250
9. TOWNSEND, G.F. (1974) – Absorption of colour by honey solutions from brood comb. *Bee World* 55 (1): 26-28
10. TOWNSEND, G.F. (1976) – Transitional hives for use with the tropical African bee *Apis mellifera adansonii*. *Full report on 1st Conference on Apiculture in Tropical Climates*: 181-189
11. WALTON, G.M. (1975) – The metrication of beekeeping equipment. *Bee World* 56 (3): 109-118