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Special Lecture

Dr. Eva Crane, a world authority on bees and author of over 150 books and papers on beekeeping and research, was currently in Thailand for two weeks as a special guest of Department of Biology and sponsored by British Council. Now she is honorary life President, International Bee Research Association also Scientific Consultant to IBRA Council.

THE WORLD PATTERN OF APICULTURAL RESEARCH

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Discoveries in past centuries

One important factor favouring the development of research on bees and their management in a region is a very long tradition of apiculture, so that bees are looked on with favour, and regarded as an interesting subject for study and research.

The previous article showed that Europe is such a region, and before 1800 it was the region where studies and discoveries about bees were made, for example:

- 1568 worker bees can rear a queen from a worker egg (Nikol Jakob, Germany)
- 1586 the queen is a female and in a colony she is the bee that lays the eggs (Luys Méndez de Torres, Spain)
- 1609 drones are male (Charles Butler, England)
- 1625 the first insect (honeybee) drawn under a microscope (Prince Cesi, Italy)
- 1678-1680 full anatomical drawings of honeybees, using a microscope (Jan Swammerdam, Netherlands)
- 1684 first correct account of the origin of beeswax (Martin John, Germany)
- 1739 function of the spiracles discovered (R.A.F. de Réaumur, France)
- 1750 function of the queen's spermatheca established; also the part played by insects in pollination (Arthur Dobbs, Ireland)
- 1771 description of mating between queen and drone (Anton Janscha, Austria)

Honeybees were introduced to North America in the early 1600s, within the period of the European discoveries listed above. In the continent, experimentation on **bee management** flourished, and innovations were encouraged by the absence of a fixed tradition as to how bees should be kept. And the excellent honey yields - much higher than in Europe - made it economically worth while to find more effective ways of managing bees and harvesting their honey. The following practical advances that form the basis of modern world apiculture were made between 1850 and 1900, and beekeepers in North America played a most important part in them.

1853 effective movable-frame hive developed (L.L. Langstroth, USA)
1865 centrifugal honey extractor (F. Hruschka, Austria)
1865 effective queen excluder (Abbé Colin, France)
1870 effective smoker (Moses Quinby, improved by T.F. Bingham, both USA)
1891 effective bee-escape (E.C. Porter, USA).

The men in Europe and North America who made the above discoveries and innovations before 1900 were active as interested individuals. From 1905 (USA) and 1909 (Canada), however, paid apicultural officers were appointed in the various states and provinces of North America. They carried out practical investigations to improve the new rational honey industry in all its aspects, and hundreds of reports and bulletins were issued in attempts to improve the health of the bees, the efficiency of their management, and the quality of their products on the market. Similar appointments were made in Europe and elsewhere, and apicultural research entered a new phase.

Economic factors

From about 1900, the modern honey industry was established on a fairly firm footing; economic factors became important in the development of apicultural research, and more of the research became government funded. The government of a country is more likely to allocate funds to apicultural research if apiculture itself is economically important, giving high honey yields - or if there is large-scale production of fruit, seed legumes or other crops that require bee pollination, so that apiculture is of wider indirect economic importance.

Direct government funding of this type is likely to support research on practical problems whose solution must be found if yields of honey (or of crops) are to be maintained. Such problems may be connected with pests and diseases, or the need to breed better bees (or crop plants), or ensuring product quality, e.g., preventing honey from fermenting. In countries where apiculture is part of the national economy, funding for research may also be allocated from other sources.

Certain newly exploited regions of the world gave very high honey yields, and there were periods earlier in the century when beekeepers encountered relatively few problems. Funds would not be allocated for research during such a period, but only when a formerly productive industry encountered a serious setback - for instance because of a newly introduced disease. Pressure would then be brought to bear on government sources in order to save the industry. There are examples in Argentina and Australia, and in these countries scientific research did not make an impact until after 1950. Australia, for instance, has a unique honey-yielding flora (including many *Eucalyptus* species), and therefore has many honeys not produced or studied elsewhere. It was the pollen of some of the native plants that made research work an economic necessity in Australia. Some species produce no pollen, or pollen unattractive to bees, or pollen that is nutritionally inadequate for them. It became necessary to identify the species involved, and to devise ways in which beekeepers could feed another source of protein to their colonies during the honey flow. Colonies can be fed with pollen substitutes or supplements or with nutritionally adequate and attractive pollen that has been previously harvested from hives fitted with pollen traps.

Nowadays scientific research on bees at universities and scientific institutions, especially in countries where apiculture is economically or traditionally important, has led to many basic scientific advances and discoveries. Not all such institutions regard it as their function to carry out applied research linked with what is economically useful, although some do: in the USA, for instance, all the Bee Research Laboratories of the US Department of Agriculture are closely associated with universities.

Political factors

The previous section refers largely to capitalist countries. In socialist countries, scientific research is centrally planned and controlled, according to policies laid down by the State. In the Soviet Union, for instance, there is a Central Beekeeping Research Institute at Rybnoe in Ryazan Province, near Moscow. Individual Republics of the Union, and certain other regions - especially within the very large Russian Federal Republic (RSFSR) - have their own Beekeeping Research Institutes, which are co-ordinated by the Central Institute. At each regional Institute special attention is paid to aspects of apiculture such as bee forage, local races of bees, and seasonal bee management, in the regions concerned.

Many such centrally organized countries carry out research aimed at assessing natural resources of different areas - for instance bee forage - in a way that is unknown elsewhere. Central planning leads to a 'rational' pattern of apicultural research, according to what is needed by the apicultural industry. This extends beyond bee health and management, to honey as the primary product of apiculture, and also - most vigorously when the market price for honey drops - to a systematic consideration of other bee products. These include royal jelly, pollen, propolis and bee venom, for any of which profitable pharmaceutical outlets can be found or created in some countries.

Central planning did not exist in any country during the early centuries of research on bees, and nowadays it is more or less confined to socialist countries. In capitalist countries, subjects on which bee research is undertaken tend to be more haphazard. There are universities and research institutions whose policies are largely self-determined on the basis of non-economic considerations, and not as part of a central plan. In fact, this gives more scope for creativity, and for new lines of research prompted by developments in other fields. An example is the discovery of the part played by pheromones in governing the behaviour of insects, which was quickly followed up researchers working on bees. There is also more chance for an outstanding scientist developing a new and promising field to build up a school of research students who advance the subject on a broad front - as Professor Karl von Frisch did with dance communication among honeybees.

Personal factors

An individual may conduct research on bees for a variety of reasons. A biologist who has a beekeeping background, and who likes handling bees, may be especially attracted to an appointment that involves bee work. Dr. R.K. Callow, after retirement from a career in medical research, took advantage of an opportunity to do research on pheromones of the queen honeybee, because he had a special interest in bees.

The first few years of Professor K. von Frisch'a work were devoted to the question of colour blindness in fish (which he showed did not exist). Wishing to extend this study to invertebrates, he started experiments on the possibility of colour vision in insects (bees), because his family kept bees and he was interested in them.

Bee research in Brazil owes much to the passionate interest of three men in their own bee-related fields: Professor W.E. Kerr in bee genetics, Professor J.S. Moure in the taxonomy of stingless bees (Meliponinae), and Professor P. Nogueira-Neto in their rearing.

The personal factor is often strongly correlated with an interest in hive bees, and pleasure in working with them. The living insects are the attraction, and the interest does not seem to extend much to bee-related subjects such as the plant substances used by bees, or substances produced by them. Additionally, possible therapeutic effects of hive products stimulate some members of the medical profession to devote their time and energy to clinical trials of bee venom, royal jelly, pollen or propolis.

Bees may also be used for research for another reason: they constitute convenient experimental material, since large numbers of individuals are readily available for most of the year. Much work on the insect eye has been done on drones, which have relatively large eyes, suitable for electro-physiological work.

Fashion

In research, as in many human activities, fashions come and go. During a certain period much attention may be paid to a subject (and sometimes more than it warrants), because for some reason it is the fashionable subject to study at that moment. Around 1970 environmental sciences were brought into prominence, and they were relevant to bees since bees interact in many ways with their environment. Some bee research work was therefore merged into wider environmental programmes, where it was at risk of being eliminated after a few years, when some other environmental interest attracted more attention. On a more specific level, any new pest or disease of bees that captures the popular imagination may be very widely studied, but not all the resultant publications are useful or profitable; examples are *Acarapis woodi* in the 1920s and *Varroa jacobsoni* in the late 1970s.

Some countries in other continents, whose development took place under European influences, tended to admire the basic research carried out in Europe, and to model their early researches on it, although material was at hand for researches in new fields. For instance research on bee behaviour has great scope in parts of the Old World where comparative studies can be made on a rich honeybee gene pool, and less in the New World where the gene pool is mainly restricted to what has been imported in past decades or centuries.

The 1970s saw an increasing interest in apicultural work in developing countries. This was partly due to a greater awareness among certain beekeepers and scientists in technologically advanced countries that they were in a position to help those in less developed areas. It was an idea that captured the imagination of many young people, and also of some who had already achieved a successful orthodox career. Thus apicultural work in tropical regions also opened up new fields of research, especially on characteristics of little-studied honeybees: *Apis cerana, A. dorsata* and *A. florea,* tropical species in Asia; the tropical mainland subspecies of *Apis mellifera* in Africa south of the Sahara, and two other subspecies: *A. m. capensis* the Cape bee, and *A. m. unicolor* native to Madagascar. The introduction of tropical African *Apis mellifera* bees into South America, and their spread in and beyond that continent, have similarly provided material for new scientific studies. Here, funding for research has been made available because of an economic and political factor: the apicultural industry in the USA has been fearful that 'Africanized' bees will spread into the southern USA, and that this will jeopardize both the honey production and pollination industries.

The special case of tropical Asia, and especially Thailand

Tropical Asia is unique in that it is the home of all three tropical honeybee species (which taxonomists are now subdividing into a larger number). Throughout the region there was honey hunting from very ancient times, and the large rock bee *A. dorsata* gave high yields. Much smaller yields were obtained from the little bee *A. florea.* Tropical Asia does not have a rich tradition of beekeeping such as exists in tropical Africa, and honey harvests from the native hive bee *A. cerana* are much lower than those from wild *A. dorsata* nests. An exception is Kashmir in the western Himalayas, where *A. cerana* is as large as *A. mellifera,* and where many traditional crafts, including beekeeping, were introduced early from the Middle East.

Peoples of Asia traditionally eat much less honey (or sugar) than those of other continents; see Table 1.

The much more productive temperate-Zone *A. mellifera* has been introduced into some areas of tropical Asia. There has been much conflict in some places when this was done, one reason being that new diseases and parasites were introduced with the new bees, and spread to *A. cerana.*

In general the native *A. cerana* is more effective at exploiting the native plants with which it evolved, and it is still kept in the non-agricultural areas of countries with introduced *A. mellifera.* On the other hand temperate-zone *A. mellifera* can be much more productive where agricultural areas provide large amounts of bee forage. It is also more likely to succeed in subtropical and temperate-zone Asia, or at higher altitudes in the full tropics, than in the tropical lowlands. In China it is the basis of a large honey industry, all developed since the Second World War. For several years now China has been the largest honey exporter in the world. Successful beekeeping industries have also been developed with *A. mellifera* in Taiwan and in Thaialnd.

Thailand provides an especially rich open-air laboratory for research and comparative studies, because all the honeybee species are available. Such researches should also help us to understand why introduced temperate-zone honeybees flourish there, and are becoming an important economic resource, whereas similar bees introduced to some other tropical regions have been much less successful.

Introduction of *A. mellifera* into Thailand carries with it the danger of transmission of new pathogens to bees already in Thailand. Introduction of *A. cerana* from outside the country has the additional hazard of genetic contamination. Two points are important in my view. First, initial introductions should be made on an island at least 20 km off shore, and where no other *A. cerana* are present, so that the new bees can be studied in isolation. Secondly, before they are introduced to any other area, the characters of the native *A. cerana* of the area should be studied and recorded, before their genetic characters are changed by hybridization with *A. cerana* from elsewhere.

Some suggestions for future apicultural research

In many places the direction of apicultural research is predetermined by economic or political factors that are outside the control of those working in apiculture. Where this is not so, any possibility for new research on bees or other apicultural subjects should be welcomed, in that it may add to the corpus of knowledge which is our concern. I am personally interested in the extension of knowledge on a global basis, and I should therefore like to give special encouragement to research in fields that have been little studied, especially if they are concerned with endangered living organisms. Much less is known about tropical species and subspecies of honeybees than about those of Europe, and I see a need to concentrate scientific resources on discovering more about them, even though this may bring no immediate direct economic benefit.

It is useful to distinguish between research that must be done in the bees' natural habitat, and research that can be conducted elsewhere in the same or another continent. Full safeguards must, of course, be maintained against introducing unwanted honeybee genes, or bee pathogens, parasites or pests, and effective liaison must be established with specialists in countries where the bees live. Some of the following types of research have been done or are in progress, and there is scope for much more.

Outside the bees' natural habitat:
- Bee physiology and behaviour in flight rooms
- Taxonomy of bees using specimens collected in the natural distribution range
- Pathogens of bee diseases (taxonomy, physiology, etc.)
- Honey (chemical analysis and pollen analysis)
- Beeswax (composition and properties)

Only in the bees' natural habitat:
- Colony behaviour in natural conditions
- Seasonal colony cycle
- Colony management
- Bee physiology and behaviour in natural conditions
- Foraging in natural conditions
- Factors affecting honey production
- Reactions of bees to diseases and enemies
- Field trials of control methods for bee diseases.

Appendix: The world honey industry today

It has been shown that funding for apicultural research, and to some extent also for research on bees, is closely linked with the economic importance of honey in the country concerned. The world pattern of honey production and trade is therefore very relevant to such research, and Table 1 summarizes the position. Is gives figures for 13 countries, which together represent two-thirds to three-quarters of the totals for the world as a whole, and therefore indicate the world situation. The figures are taken from statistics of the United States Department of Agriculture (USDA Foreign Agriculture Circular FS3-83).

Table 1 shows the high honey yields per colony in Canada and Australia and the low ones in Europe. It also shows the high total honey production of USSR, China and USA - all large countries - 190, 100, 93 thousand tonnes. The high honey exporting countries are China, Mexico and Argentina (58, 64, 28 thousand tonnes), and the high net importers the German Federal Republic, USA, Japan and UK (63, 38, 28, 21 thousand tonnes). Until 1981 Japanese imports exceeded those of the USA.

The three largest exporters are thus in the subtropics, and countries to which the European honeybee is not native. All of the four largest importers are comparatively rich countries, and all are in the north temperate zone. Germany and the UK belong to the traditional bees-and-honey region in Europe, and the USA was peopled from this region. Japan, alone, has developed as a honey-eating country since the Second World War. The final two columns in Table 1 give figures for honey and sugar consumption per capita for the continents, and these are lower for Asia than for any other continent. This situation may change as honey production increases, but only when incomes also rise: Table 1 shows that honey is now a food of affluent societies.

Table 1
The world honey industry, as represented by figures for 13 countries.

	1	2	3	4		5	6
Country	*Colonies* × *1000*	*Yield per colony*	*Total honey* × *1000*	*Net exports* × *1000*		*Honey per capita*	*Sugar per capita*
Europe						0.4	45
France	1200	12.7	18.5		− 6.7		
German F.R.	1118	12.6	15.0		−62.9		
U.K.	212	6.3	1.2		−20.8		
North America						0.7	49
Canada	657	51.3	34.8	+ 9.5			
U.S.A.	4275	22.8	93.0		−37.9		
Australia + New Zealand						0.5	57
Australia	405	56.0	21.5	+ 1.1			
New Zealand	191*	30.0*	7.6	+ 2.0			
Latin America						0.1	42
Argentina	1300	25.5	28.0	+29.9			
Brazil	1800	13.3	22.0	+ 0.6			
Mexico	2300	25.5	64.0	+40.0			
Africa						0.26	11
No single country of world importance							
Asia						0.0004	7
China	5700	19.6	100.00	+58.1			
Japan	299	21.4	6.5		−28.1		
U.S.S.R.	8000	23.0	190.0	+16.0		0.5	45
Total	27457		602.1	157.2	156.4		
World total			896.3	214.3	224.7		
% of world represented by the 13 countries			67%	73%	70%		

* from the same source as column 5

Column 1 *Colonies* × 1000 gives the number of occupied hives in thousands in 1983.

Column 2 *Yield/colony* gives the average honey yield in kg per colony, 1979-83.

Column 3 *Total honey* × *1000* gives the estimated total honey production for the country in 1983, in 1000 tonnes.

Column 4 *Net exports* × *1000* gives the country's estimated honey exports *less* honey imports, in 1000 tonnes, for 1982. Figures prefixed by + are net exports, and figures prefaced by − are net imports.

Column 5 *Honey per capita* gives the estimated average honey consumption in kg per capita for the continent as a whole, from sources quoted in E. Crane, *Honey: a comprehensive survey*, published in 1975, but relating to various earlier years. Figures for Africa and Asia are less reliable than others.

Column 6 *Sugar per capita* gives the average sugar consumption in kg per capita for the continent as a whole, from the United Nations Statistical Yearbook (1970); most figures relate to 1969.