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THE ECONOMIC STATUS OF BEES IN THE TROPICS

by

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THE ECONOMIC STATUS OF BEES IN THE TROPICS

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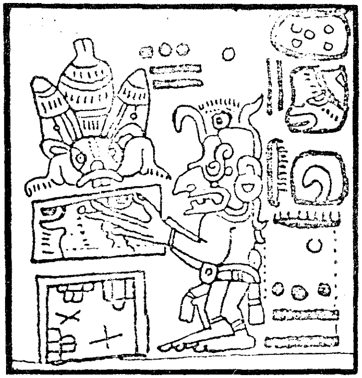

Bees were important to the Maya. The illustration above is from an old pre-Colombian book and shows the god, holding out a hive to receive a bee. In the lower left-hand corner, a comb is seen hanging from the roof of a hive.

SPECIES OF BEES IN THE TROPICS

INTRODUCTION

Most of the higher social bees originated in the tropics, and still thrive there. Indeed only one of them - *Apis mellifera* - can survive for long anywhere else. With the few exceptions of those solitary and small-colony building Bombidae which are specially suited to pollinate a specific agricultural crop, all the economically useful bees now inhabit the tropics. *Apis mellifera* and *Apis indica* are the two species that build large colonies with a number of parallel vertical combs, in an enclosed space. These can be "hived" and are the "hive bees" (Plate 1). The other tropical Asiatic *Apis* species, *A. florea* and *A. dorsata*, build a single vertical comb in the open; they are not susceptible to hiving.

No *Apis* species are indigenous to the New World, but in tropical America, and also in Africa and northern Australia, there are many species of social Meliponinae, notably in the genera *Trigona* and *Melipona*, and some of these have been "domesticated" and kept for honey for many thousands of years.

Finally there are many solitary and some semi-social tropical bees, both Old World and New World species, which may be economically useful as pollinators but not as producers of honey or wax.

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Apis mellifera and A. indica

Relationships between various *Apis* species have been well discussed but are still not altogether clear (e.g. **DEODIKAR, 1959; DEODIKAR** *et al.* **1959; MAA, 1953**). We still lack competent evidence as to whether or not *A. mellifera* and *A. indica* should be regarded as a single species; the answer is probably no. Reports of interbreeding exist, but they are inadequate in various ways (e.g. **VATS, 1953; TOMSIK, 1960**). There are differences in the copulatory organs of *mellifera* and *indica* (**BÄHRMANN, 1961; KAPIL, 1962; SIMPSON, 1960**), in their salivary glands (**KAPIL, 1958**), and in other structures. Moreover it is extremely difficult to get the form of *indica* occurring in Japan (referred to by some as *Apis indica japonica* and by others as *Apis cerana cerana*) to rear *mellifera* larvae (**INOUE, 1962; SAKAGAMI & KOUTA, 1958**). Introduction of *mellifera* queens to *indica* colonies in India has never been successful either (**SHARMA, 1960**).

Apis indica is indigenous in the tropics of Asia (Note 1). Importations of *A. mellifera* have been made many times (**SHARMA, 1960**) in order to increase the honey yield (see page 308), but they have always failed because *A. mellifera* cannot defend itself against the many indigenous animals and insects that attack it. In the Chinese subtropics, however, great strides have been made recently in replacing the poor-yielding local honeybees with *A. mellifera* (**OSCHMANN, 1961**); in Formosa, *A. mellifera* has long been in use (**FAN TSUNG DEH, 1959**). Importations have also been highly successful in other areas bordering on the tropics.

Tropical Africa is populated by several subspecies of *mellifera* (**SMITH, 1961**). The vigorous but often aggressive *A. m. adansonii* occupies the whole of the mainland south of the Sahara; *A. m. unicolor* occurs on Madagascar and other islands. The Saharan bee in a tiny enclave between the Atlas and Sahara (Plate II), and the Cape Bee (*A. m. capensis*) near the Cape, are interesting types on the fringes of the tropics. As in India, introductions of *mellifera* from Europe have failed because it succumbs to the many predators, and possibly for other reasons, for instance difficulty in orientation to the sun when this moves across the sky in the opposite direction to that that the bees have been used to.

America and Australasia have no indigenous *Apis*, but neither have the Neotropics got the indigenous enemies that preclude the use of *A. mellifera* in the Paleotropics. Having been transported there by man from the seventeenth century onwards, *A. mellifera* has therefore thriven in the New World as nowhere else (**CRANE, 1964**), and now has a continuous distribution there along ten thousand miles of latitude.

Other Apis spp. : Apis dorsata and A. florea

Both these species are restricted to India, Ceylon and other parts of south-east Asia, where they occur abundantly in both jungle and cultivated areas (**BUTLER, 1962**). Honey and wax are harvested from wild colonies, but these cannot be kept in hives or "managed".

Meliponinae

This extremely interesting group of social bees is entirely tropical, but unlike the Apidae it includes species indigenous in all continents except Europe: one hundred and eighty-three in America (**SCHWARZ, 1948**), 32 in Africa, 43 in Asia and 20 in Australasia. (**KERR & MAULE, 1964; MOURE** *et al.*, **1958**).

Other bees

There are very many other tropical bees. Only the Apidae and Meliponidae (and the Bombidae, which are found mainly outside the tropics) produce and store honey - and build comb in which they store it. There is thus no harvest of honey or wax from other bees. These can, however, play an important economic function as pollinators, discussed in page 313.

ECONOMIC USES OF BEES IN THE TROPICS

HONEY PRODUCTION

The productiveness of an area is commonly judged by one of two figures. The first is the theoretical potential honey yield per acre or hectare, assuming *all* the nectar to be collected and converted into honey. The second is the honey yield per hive in practice, the hive density not being so high as to restrict this yield. The limitations to each of these concepts are understood and accepted.

Honey yield per unit area

The concept of honey yield per hectare is used most widely in the communist countries, where it fits into their planning of land use, and so on. Most plant species for which this figure is available therefore grow in eastern Europe and northern Asia, outside the tropics. The honey potential varies from a few pounds to 600 lb./acre (or kg./hectare) or more. Some specimen figures are given in table 1.

It would be most valuable if similar figures for tropical plants - both wild and cultivated - could be worked out. There is no reason to believe that all the high yielders are outside the tropics; figures for the various eucalypts, for instance, are likely to be very high.

Honey yield per hive

This concept is used all over the world, in capitalist countries often in conjunction with the number of hives that can be managed per man: efficiency in terms of man-hours rather than of land resources.

Table 1

		Honey potential (lb./acre or kg./hectare)
Tobacco	*Nicotiana tabacum*	10-50
Sunflower	*Helianthus annuus*	30-70
Lavender	*Lavandula spica*	100-200
Cotton	*Gossypium*	100, up to 300 with irrigation
White clover	*Trifolium repens*	50-200
Birdsfoot trefoil	*Lotus corniculatus*	50-150
Rosemary	*Rosmarinus officinalis*	130-200
Coriander	*Coriandrum sativum*	500
Acacia	*Robinia pseudoacacia*	350-1700

The yield per hive obviously depends largely on the plant species available (see above), but two other factors can contribute to high yields: (a) at *low* latitudes the high temperatures allow the bees to fly and forage all the year round, instead of 6-8 months only; (b) at *high* latitudes the long hours of summer daylight allow the bees to fly and forage for say 20 hours out of 24 instead of 12 hours only; if the main honey crop occurs near midsummer, it can give higher yields than at lower latitudes (northern Sweden, northern Alberta in Canada).

Number of hives that can be managed by one beekeeper

The standard communist allotment is 100 : there is little if any mechanization and full employment is more of a *leit-motiv* than financial profit (**CRANE 1963a**). In English commercial apiaries, with modest mechanization and knowledgeable planning, it is 200-250; in Rhodesia it is about the same. In Australia, where there is much migration to really prolific flows, it reaches 300 or more. In California, almost complete mechanization, and good roads for moving trucks of bees, have raised the figure to 1000; in some apiaries it has now reached 1500 (**CRANE, 1957, 1963b**).

These details are given because they are relevant to development in the tropics. Even now, the five countries with the highest net exports of honey are all in or adjacent to the Neotropics; (in order) Mexico, Argentina, Australia, Guatemala, Chile (calculated from U.S.D.A., 1963). Except for parts of China and Siberia north of the tropics, and some of Australia to the south, virtually all the rich honey regions of the world still unexploited lie in the tropics or subtropics. The Neotropics is of course especially favoured, in that *A.mellifera* can be used, but this is true also of southern China, especially Yunnan Province, and this may equal or surpass Central and South America in future honey production. It may well be that the edges of the tropical zone prove to be more prolific than the true tropics. North Argentina gives 400 lb. per hive, and large areas there are still undeveloped (**VITEZ, 1965**). In Mexico the Yucatán jungle can yield even more (**CRANE, 1957**). Mexico also provides a classic example of what capital, ability and enterprise can do. In so-called poor honey country south of Mexico City (Morelos), the firm Miel Carlota (Plates I & II) pushed up its holdings from 10 to 20,000 hives between 1942 and 1957, and the yield per hive from 37 to 220 lb.

The pattern of development in any new area is largely governed by (a) the road system, which governs the possibility of moving hives regularly, and (b) the amount of capital available, (c) the relative costs of labour and machinery, and of salaries for organizers and accessory workers. In communist countries central planning on ideological lines tends to replace (b) and (c).

More primitive forms of honey production

The preceding paragraphs refer to modern beekeeping management with *Apis mellifera* in movable-frame hives, which undoubtedly gives the highest returns from human labour. But honey production from more primitive methods (or by more primitive bees) may well be better suited to less advanced tropical areas. In many African countries log or bark hives (Plate III) can give a useful yield of honey as well as of beeswax (see page 308). The adaptation of the traditional Greek "bar" hive (Plates IV & V), opens up a wider perspective of what can be done with suitable management without movable frames (**PAPADOPOULO, 1965**). This cheaply produced basket hive is wider at the top than the bottom. The bees do not attach their combs to the sides, provided these slope inwards towards the bottom at a suitable angle. (In an ordinary skep the walls are vertical or slope outwards, and combs are attached to them). Therefore parallel wooden bars arranged to form a roof to the hive can act as "top-bars" to combs which, although built free (not framed) can be withdrawn from the hive, as can be done with frames in a modern hive.

In the Neotropics the traditional beekeeping with Meliponins has been "rationalized" to a certain extent (e.g. **NOGUEIRA-NETO 1951, 1953; PORTUGAL ARAÚJO, 1951**), probably as far as is possible with bees that build an irregular array of honey pots. The honey yield per colony can then be up to say 20 lb. a year.

Lastly, honey hunting (collection of honey from *A.dorsata*, *A.florea* and wild nests of *A.indica*) provides a major part of the honey harvest in India and south-east Asia. Wild colonies of *A.m.adansonii* provide a much smaller percentage of the African honey crop. The harvesting of honey from *A.dorsata* (the highest yielder) has been rationalized to the extent of devising methods for removing only the part of the comb containing honey, leaving the brood nest intact (e.g. **GHOTGE, 1956, MUTTOO, 1952/53**). The single *dorsata* comb is up to 6ft. x 3 ft. in area, with the upper honey store 4 inches deep. An *Apis dorsata* comb can yield 30-40 lb. honey, the tiny *Apis florea* comb only an ounce or two.

It has been estimated (**CRANE, 1963b**) that the present world honey production is around 500,000 tons a year; at 1/- per lb. this is worth £ 50M. The tropics and subtropics contribute perhaps a seventh of this now, but their more thorough exploitation might well double the world's present total output.

BEESWAX

Large-scale honey production is made possible by the use of movable-frame hives. From the framed combs the honey can be extracted centrifugally, leaving the combs intact except that the 'caps' on the cells had to be cut off to allow the honey to escape in the centrifuge. The need for wax production in the colony is kept to a minimum, because wax-secreting bees tend to consume a lot of honey that could otherwise be harvested. The weight of beeswax produced is not more than 2% of the weight of honey.

In the old fixed-comb hives (straw skeps, logs, etc.) the wax combs were expendable, and all the combs containing honey were harvested as well as the honey, giving perhaps 8% as much beeswax as honey.

Today the beeswax market is supplied from areas of the world: (a) with a high enough temperature to facilitate wax secretion; and (b) where fixed-comb bee keeping is still the custom, of (c) where wild colonies are sufficiently numerous and accessible to be exploited. These areas are all in the tropics. Most of the beeswax is produced in Africa, by the vigorous and frequently-swarming *A.m.adansonii* (**SMITH, 1955**). In a large region of tropical Africa there is a long tradition of beekeeping, which is very highly developed in some tribes (**CROSSE-UPCOTT, 1956**). Since it is carried out in areas with few roads, transport of the products is a material factor in the economics of their production. Beeswax is collected by native bee*keepers* - who may own 300-1000 hives each (Plate III) - and also from wild colonies. Beeswax fetches 4-8 times as much per pound as honey. It is also more easily carried on the head, needing no container. Much of the honey produced is either thrown away, or converted into alcohol by the Africans (**ROSSI, 1959**).

India and other parts of south-east Asia supply a further small amount of beeswax. This comes from wild colonies of both *Apis indica* and *A.dorsata*. Very little beeswax is harvested in the Neotropics, because (a) there is no tradition of fixed-comb beekeeping with *A.mellifera*, and (b) it is more profitable to use movable-frame hives to produce honey. The materials used by Meliponinae in nest building have rather different properties (**BENNETT, 1951; SMITH 1954**), and can indeed be troublesome as an adulterant of beeswax (**SMITH, 1951*a***), lowering its market price. Improvement in the standards of processing beeswax (Plate VI) can go a long way towards establishing the bee-keeping industry on a better basis in tropical Africa (**SMITH, 1951*b***).

For many purposes beeswax is losing ground to other plastic materials, but some of its characteristics - especially its protracted melting point and plastic properties - lead to a demand which is still greater than the supply. Two main and increasing uses are in the cosmetic and armament industries.

Reliable statistics for beeswax production are impossible to come by, because most of the producing countries are not susceptible to such documentation. Much of the beeswax produced by the bees is either not collected or does not get as far as the market; most of it is destroyed by wax moths (especially *Galleria mellonella*) and the honey badger (*Mellivora capensis*). Export figures are in some ways more useful than production figures. Calculations from Schubring's paper (1940) give total exports in 1931 from tropical Africa, America and Asia respectively as 3500, 1400 and 400 tons, and from non-tropical countries 600 tons - 10% of the total. The balance between different countries has shifted since then, but the continental totals may still be similar. Tanganyika and Angola were, and probably still are, the most important countries in beeswax production. Madagascar, Nigeria, Mozambique, Malawi, Kenya and Congo are among other important contributing countries. The value of beeswax marketed (exported) may be £2-3 M. Of this total, Tanganyika and Angola contribute about 1000 tons each or more. Ethopia, Madagascar, Kenya, Congo, Mozambique, Nigeria and Northern Rhodesia contribute around 100-1000 tons each. Reliable statistics for beeswax are very difficult to come by: calculation from 1940 figures for beeswax exports (Schubring) give the proportions 7 : 3 : 1 for Africa, America and Asia. If totals for Africa are around 3500 tons, this would suggest 1500 tons from America and 500 tons from Asia, a total of 5500 tons. Exports from non-tropical countries add only a negligible amount, so this is about the world total.

POLLINATION

As in other fields, much more is known about insect-pollinated crops that grow in both tropical and temperate latitudes than about those peculiar to the tropics. Many general reviews have been written about the parts played by *Apis mellifera*, other *Apis* spp. and non-*Apis* bees in crop pollination, and the following can usefully be consulted as an introduction:

Wide variety of crops:	Krishchunas & Gubin (1956) Hansson (1950) Butler & Simpson (1953) Todd & McGregor (1960)
Legumes:	Hobbs (1958) Bohart (1960)

Fruit:

Free (1960)
Griggs (1953)
Horticultural Education Association (1961)
Lötter (1960)

Oil crops: No general review is known, but see e.g. Bitkolov (1961), Boch (1961), Overseas Food Corporation (1951), Radoev (1954).

Specific tropical crops

A recent appraisal of the pollination and yields of tropical crops (**CHAPMAN, 1964**) brings out our great lack of knowledge of the efficiencies of different insects in pollinating many entomophilous plants, and even of the mode (and agent) of their pollination.

The following information is additional to that given by Chapman, who discusses banana, cocoa, coffee, mango, pimento and acerola (not mentioned here), and also coconut, citrus and passion fruit.

Avocado. In the French Antilles the honeybee was found to be the most important pollinator (**LECOMTE, 1961**). In California insect pollination is essential for a commercial set, and *large* insects proved to be necessary. Zutano variety caged with and without honeybees gave 120 and 4 fruits respectively; Hass gave 284 fruits with and 5 without bees (**PETERSON, 1955**).

Citrus. With Clementine tangerines in Egypt, free pollination (honeybees present) gave a much higher set than either self-pollination or hand pollination with pollen from blood orange. Hand pollination with grapefruit pollen gave even more - 5-6 times as much fruit as with self-pollination (**MINESSY, 1959**). Caging Clementine tangerines with honeybees and bouquets of suitable flowers in Arizona gave 16 times as much fruit as caging against bees, and 13% more than leaving them uncaged; fruit quality was also better (**VAN HORN & TODD, 1954**).

Orlando tangelo (Bowen grapefruit χ Darcy tangerine) is self-sterile. Temple proved the best pollinizer, and honeybees at 1 colony per acre were adequate as pollinators (**ROBINSON & KREZDORN, 1962**). Minneola tangelo is also pollinated by honeybees (**BUTCHER, 1955**).

Coconut. In a paper since Chapman's review, **WHITEHEAD (1965)** discusses the flowering of coconut in some detail.

Cotton. A large amount of information is available on cotton pollination, from the U.S.A., U.S.S.R., Albania, Bulgaria, Egypt, etc.; forty papers on the part played by bees have been abstracted since 1949. *Apis, Melissodes* and *Bombus* are especially useful, and where populations of other bees are low, introducing honeybees always seems to increase both yield and quality of cotton (e.g. **McGREGOR** *et al.*, **1955; PAPARISTO, 1960; RADOEV & BOZHINOV, 1961; SHISHIKIN, 1952; WAFA & IBRAHIM, 1960**). Much damage is done to bees by indiscriminate spraying where the need for pollinating insects is not understood.

Cucurbits. The Bee Research Association Bibliography No. 4 (1964) includes the part played by bees in pollinating various types of cucurbits grown in the tropics, and details are not repeated here.

Lychee. A tree of Brewster lychee (*Litchi chinensis*) caged against insects gave 1 fruit; on four adjacent trees accessible to honeybees from colonies nearby the average was 99 per tree (**BUTCHER, 1956**).

Passion fruit. An earlier paper than that quoted by Chapman reported *Apis mellifera* and *Xylocopa varipuncta* to be the most important pollinators in all localities studied in Hawaii (**NISHIDA, 1958**).

Peanut. Bee-collected pollen has been used to pollinate emasculated flowers, and bees are considered to be the most likely natural pollinators (**HAMMONS, 1963, 1964**). In Georgia, U.S.A., honeybees and other bees visited the flowers, but no other insects (**LEUCK & HAMMONS, 1965**). Several species of Halictid and Megachilid bees are believed to be the most important pollinators (**HAMMONS** *et al.*, **1963**).

Pyrethrum. Analysis of flowers caged with and without honeybees, and uncaged, gave a strong indication (not quite conclusive) that the production of pyrethrins is increased by fertilization (**KROLL, 1961**).

Saguaro. Seeds and fruit pulp of *Carnegiea gigantea* have been used by Indian tribes for food and for an alcoholic beverage. Honeybees, doves and bats can all pollinate the flowers, which yield large amounts of nectar and pollen (**McGREGOR** *et al.*, **1962**).

Saunf. In Pusa (Bihar) 81% of the insect visitors to *Foeniculum vulgare* were *Apis florea*, and it was concluded that an adequate population of this bee and of Syrphidae was a major factor in seed production (**NARAYANA** *et al.*, **1960**).

Toria and sarson. In Pakistan *Apis indica* proved an effective pollinator of these *Brassica* spp., and its presence more than doubled the seed yield (**LATIF** *et al.*, **1960**).

Pollinating efficiency of specific insects

Some species of bees are spectacularly efficient at pollinating certain crops, which do not necessarily originate in the same region or even the same continent as the bees. Again, our information comes from temperate latitudes, but there seems no reason why the phenomenon should be limited to those latitudes. Only a few of the many references available are quoted here.

Nomia melanderi, a solitary bee nesting in soil of sufficient alkalinity and humidity, is a native of the western seaboard of north America (**STEPHEN & EVANS, 1960**). It is much more efficient at pollinating alfalfa (lucerne) than other insect - females tripping 95% of the florets visited

(**MENKE, 1954**) - yet alfalfa is an Asiatic species. Artificial '*Nomia* beds' are in commercial use beside alfalfa plots (e.g. **STEPHEN, 1960**).

Another solitary bee, *Megachile rotundata*, is indigenous in Europe and Asia. It was first recorded in America (Virginia) in 1937; since then it has spread rapidly and widely (**STEPHEN AND TORCHIS 1961**). It is very valuable as an alfalfa pollinator in areas unsuitable for *Nomia*. Bundles of paper straws can be provided for nesting sites, since *Megachile* nests in disused tunnels (**STEPHEN, 1961**).

Other, more familiar, examples of non-*Apis* bees that can be reared in artificial nests are the long-tongued *Bombus* species, which are very efficient at pollinating red clover. Methods of rearing these bees have been worked out by **HASSELROT (1960)**, **HOLM (1960)**, **HORBER (1961)** and others.

Bee 'keeping' has thus extended to species of bees reared specifically for their pollinating services. At the second International Symposium on Pollination it was pointed out that we have up to 20,000 species of wild bee pollinators to explore for their potential use in pollinating specific crops (**BINDLEY, 1964**). Once the most useful bee is found, the problems can be tackled of 'rearing' it and making it available on the crop at the right time. Although so far most of this work has been done in temperate latitudes, the methods of approaching the problem would seem equally applicable in the tropics.

Ensuring the pollination of entomophilous tropic crops

Up to the present many areas have had an adequately high population of pollinating insects. But this situation will change in the course of agricultural development (see page 316). There are then two ways of approaching the problem. One way is to seek a species of bee which is outstandingly efficient at pollinating a given crop, and which is susceptible to 'rearing' where the crop is grown (or to rearing elsewhere for transporting to the crop). The other way is to use the characteristics of *Apis mellifera** which make it such a useful general pollinator in modern agriculture:

1. It is able to utilize an enormously wide variety of plant species, and to pollinate them. (This feature is perhaps better attributed to the honeybee's 'general-purpose, highly opportunist nature' (Plate VII) rather than to any true adaptation: **PERCIVAL, 1964**).

* Very much more work has been done on *A.mellifera* than on *A.indica*, and in general we assume that *A.indica* shows fairly similar characteristics. The pollinating efficiency of *A.indica* for a few crops has been studied (e.g. **NARAYANA** *et al.*, **1961**; **LATIF** *et al.*, **1956, 1960**; **SHARMA, 1961**).

2. It builds large colonies, each of which can provide a foraging force of tens of thousands of bees.

3. It nests in an enclosed space, and can thus be "hived". Moreover methods have been worked out by which the colony in the hive is under a great measure of control by man - for instance with regard to size, and proportion of bees to brood - and hence the extent of pollen foraging.

4. Hives of honeybees can be moved in large numbers from crop to crop. They are thus available for use in irrigated areas with no indigenous population of pollinating insects. As many as 20,000 hives of *A.mellifera* are moved on to a single holding of alfalfa in California each year.

OTHER PRODUCTS OF ECONOMIC VALUE

Pollen

Honey can be of material value to primitive peoples in times of famine (**CROSSE-UPCOTT, 1958**). But as a carbohydrate calorie source it cannot normally compete in cheapness of production with cane and beet sugar. Pollen, which can also be harvested from bees, is in a different category.

Nectar and pollen supplies go to waste unless they are collected by foraging insects, both substances being tedious and difficult to collect by hand from all but a few plant species. Both can be collected by a colony of honeybees in great excess of its requirements, provided the colony is suitably managed. Unlike honey, pollen is a rich source of proteins and vitamins, and the foraging bees add enzymes and other substances. The composition of pollen varies somewhat according to the plant source: there are 'poor' and 'rich' pollens. The protein content can be as low as 7% (*Pinus*), or up to 26% (*Prunus*, *Eucalyptus*, Brassica). Vitamin C is present at 70-150 μg/g for the B vitamins representative figures are: riboflavin 18.5, nicotinic acid 200, panthothenic acid 30-50, thiamin 9.2 μg/g fresh weight. Pollen contains various biologically active substances, including a very active antibiotic (**LAVIE, 1960**). **CHAUVIN (1954) AND LUNDÉN (1954)** give references to some of the earlier literature; **CAILLAS (1959)** describes methods of processing pollen.

Pollen is harvested from a hive with a device which makes some of the bees enter by clambering through two parallel grids a few millimetres apart. The bees quickly learn to get through, but the pollen loads on their legs get pushed off in the process, and fall into a tray which forms the bottom of the 'pollen trap'. Yields up to 20 lb. or more per hive can be got in a season at temperate and subtropical latitudes without reducing the honey yield; *Bee World* (1963) gives references. The prospects have not yet been properly explored in the true tropics. An interesting although not altogether objective account of the value of pollen as a food and wound dressing to native peoples in the tropics is given by **McCORMICK (1960)**.

The use of bees for collecting pollen, as well as for making honey, would seem to be a useful development in countries where protein and vitamin foods are inadequate, and where the pollen and nectar produced each year are now wasted as far as man is concerned.

Royal jelly

Royal jelly is the "bee milk" secreted by hypopharyngeal glands of worker honeybees, and fed to queens, queen larvae and young worker larvae. (Note 2). In the last two decades royal jelly has been promoted as a material beneficial to humans and other mammals. This is not the place to enter into the controversy as to its value to humans; critical reviews by **JOHANSSON (1955, 1958)** are available. The following points at least are clear.

(*a*) Royal jelly is a biologically active material with a number of interesting properties;

(*b*) it can be produced commercially in good beekeeping regions (e.g. **SMITH, 1959**);

(*c*) there is a widespread demand for it, so that it is already permissible to speak of a "world royal jelly industry" (**INOUE & INOUE, 1964**). If this industry develops on a sound basis, it opens up yet another opportunity for exploiting honeybees in the tropics.

Live bees

North of the tropics, live bees are reared in early spring at low latitudes (e.g. Texas) and sold in "packages" of 2 or 3 lb. for use at higher latitudes (e.g. Minnesota). Package bees give the northern beekeepers the sort of advantage that a greenhouse gives to market gardeners. The industry is most highly developed in the U.S., where 600 tons of bees were produced for sale in 1947 - over half a million packages, each with a young queen. The demand has dropped somewhat since then, but an interesting development in 1963 was the export *to Britain* of 4000 packages. These helped to restock apiaries after the severe losses in the 1962/63 winter. In a survey of the results of this operation, **HILLYARD & CRANE (1964)** point out: "The 1963 imports were possible because a large package-bee industry existed in a region linked with Britain (via New York) by frequent and fast air services. But this region is only about 20^{0} further south than London - 1500 miles or 2400 km. The flight across the Atlantic, representing two-thirds of their journey, was 'necessary' only because no comparable package-bee industry exists east of the Atlantic. It may be that if and when there is substantial beekeeping development in Africa north of the Sahara, this could prove a nearer source of bees, more suited to north-European conditions. But the American packages would not have been available for export at such short notice, except for the existence of a large established domestic trade within the United States, of which the export represented only 1% or so".

Here again is an *opportunity* for beekeeping industry in the tropics, which will become more of a practicable possibility as air freight gets cheaper and faster.

Brood

In the Prairie Provinces of Canada, with long winters but very good honey-producing summers, it has become the custom to kill the bees in the autumn and restock with package bees each spring. HOCKING AND MATSUMURA (1960) estimated that besides the thousands of tons of bees that are killed each year in the three Provinces, some 130 tons of brood are also destroyed. They set out to explore the use of this brood in nutrition. Honeybee brood is widely acceptable as a food in Africa; Zambian beekeepers, for instance, are accustomed to eat brood from the comb, sometimes discarding the honey and sometimes swallowing it (see also IRVINE, 1957).

Methods of extraction and processing were worked out. The brood contained up to 18% protein according to age. Contents of vitamins A and D were up to 119 and 7,000 I.U. per g. respectively. The latter is astonishingly high; even cod liver oil contains only 100-600 I.U. per g.

Adult bees proved to be unpalatable to Canadians, and Africans do not eat them either.

Bee venom

Honeybee venom has been widely used in countries on the continent of Europe for many years, in the treatment of certain rheumatic conditions. Recent work on the (very active) hyaluronidase in the venom has suggested a basis for its effect (BARKER *et al.*, 1963; BEE WORLD, 1964). Methods of extraction have been worked out which do not kill the bees (e.g. BENTON *et al.* 1963).

Once again, all that can be said as far as the tropics are concerned is that bee venom production could form an integral part of a wider conception of beekeeping there, if markets expand. Its value per gram is very high, so, transport costs are not very material.

Propolis

In the tropics, as elsewhere, honeybees collect propolis from certain plants; they use it to "caulk" their hives and for minor building operations. It can be harvested for use in polishes and varnishes; it also has antibiotic properties (LAVIE, 1960) and is used for throat ailments. It is the only hive product which is an effective fungicide.

THE FUTURE: FACTORS AFFECTING BEE POPULATIONS

CHANGES DUE TO AGRICULTURAL DEVELOPMENTS

As virgin vegetation is cleared to make way for crops, many changes take place that affect bee populations, and in those areas which previously gave exceptionally high yield, the crops are likely to give less good bee forage. In large-scale agriculture, cultivated crops give a much more homogeneous and less "balanced" forage over the season as a whole than uncultivated land. This is due partly to removal of existing mixed vegetation, and partly to the absence of weeds within the crops. Where adequate roads exist, the bee-keeper can possibly remedy the position by moving hives from place to place, and so working several crops in the season. But this applies only to bees in hives (*A.mellifera/indica*). The removal of mixed bee forage can have more serious consequences for "wild" bees, which have no beekeeper to move them on to other forage, Their numbers may be reduced for another reason also: nesting sites in trees, or in the ground, are destroyed when land is cleared for agriculture.

In large-scale agriculture, populations of most pollinating insects are thus reduced when the land is prepared for the crops that may need them; in some areas the populations may be almost or completely destroyed. The one exception is the honeybee (*A.mellifera/indica*), whose population can be increased or decreased to fit in with pollination requirements, by regulating the number of hives. This is the one pollinator that can be taken to any type of crop, and it is able to pollinate a very wide variety of flowers.

EFFECTS OF PESTICIDES

The most direct method by which bee populations are reduced is the application of insecticides, many of which are highly toxic to bees.

Methods have been worked out for confining hive bees during spraying operations (see **PADMORE, 1964**); alternatively the hives can sometimes be temporarily removed. But wild bees have no such protection, and more are accordingly killed by pesticide applications that are toxic to them.

Almost nothing is known about the toxicity of any pesticide to tropical species of bees. Indeed, comparatively little is known about their effects on any species except *Apis mellifera;* some work has been done on *Nomia* (**MENKE, 1951, 1954b**) and *Megachile* (**JOHANSEN, 1963a**) used for alfalfa pollination. Until results are available, pesticides toxic to *A.mellifera* should be regarded as toxic to *A.indica,* and treated with the utmost caution as far as all other species of bees are concerned. **JOHANSEN (1963*b*)** gives useful lists of pesticides grouped according to their toxicity to *A.mellifera;* the extensive detailed literature on honeybee poisoning is hardly within the scope of this review.

The destruction of pollinating insects by pesticides is likely to become more serious in the tropics as further land is cleared for cultivation. Many areas now have more bees than are needed to pollinate the few crops grown there, but unless stringent care is taken to preserve enough pollinators to serve the increased needs of future agricultural programmes, the situation may become very different.

FURTHER EXPLOITATION OF BEES IN THE TROPICS

As new areas of the Neotropics are made accessible, the opportunity is presented to move in colonies of *A. mellifera* to harvest the nectar and pollen now going to waste. Experience suggests that many of these areas of virgin land will give very high yields. The aggressiveness of *A. m. adansonii* in Africa (Plate VIII) – and still more, the low yields of *A. indica* in Asia – present problems which still remain to be solved, problems which are linked with the failure of *A. m. mellifera* to survive in the true Palaeotropics. But a lot can be done by raising the standard of beekeeping – and hence the yields – in existing beekeeping areas (Plate IX), and by working for new products.

In some underdeveloped areas there are valid reasons for expanding primitive fixed-comb beekeeping rather than modern movable-frame beekeeping (see page 307). The products obtainable on an economic basis from the two types of beekeeping, and from wild bee colonies are in table 2.

Table 2

Note: Brackets denote that production is possible but not with high efficiency.

	Movable-frame	Fixed-comb	Wild colonies
Honey	yes	(yes)	(yes)
Beeswax	no	yes	yes
Pollen	yes	(yes)	no
Pollination	yes	yes	(yes)
Royal jelly	yes	no	no
Live bees	yes	(yes)	(yes)
Brood for food	yes	yes	(yes)
Bee venom	yes	(yes)	no
Propolis	yes	yes	(yes)

Pollen, package bees and venom are not now produced from fixed-comb hives, but this should be possible with suitable management.

One advantage of beekeeping as an industry in areas still underdeveloped is its very modest requirements compared with many agricultural ventures. The capital outlay is comparatively small; it uses almost no land (fifty hives - a truck-load and therefore the common size of an apiary - needs only a quarter of an acre (Note 3): Plate II). Beekeeping is also a very flexible occupation; it can be started in a small way and built up gradually; it can be done as a full-time occupation or as part-time work to fit in with other seasonal jobs; it can be done at any one of several levels of cost and mechanization, according to the needs and resources of the community. It should form an integral part of the agricultural programme, both because it provides a pollination service for entomophilous crops, and because the use of pesticides in other branches of agriculture can so seriously endanger the bees.

SPECIAL NEEDS FOR ANY EXPANSION OF BEEKEEPING IN THE TROPICS

Whereas the economic use of bees in the tropics abounds with problems and needs for information, these are almost all problems and needs common to many areas. There can be an enormous wastage of time, funds and skilled personnel if each new country or area tries to solve all its own problems, and to collect all its own information, on the spot. The first step is to establish:

(a) which problems have already been solved *in detail*, and require dissemination of information in an assimilable form, i.e. education;

(b) which have already been solved *in principle*, and need enlightened application rather than further research work;

(c) which are still unsolved, but need not be investigated in every area concerned;

(d) which are so peculiar to the new area that they must be studied on the spot.

Categories (a) and (b) cover far more than is commonly realized, and where money is short this could be spent more productively in paying for the collation and application of information already in existence, than in trying to solve a particular problem afresh. Where research is needed as in (c), most of this could be done better and more economically at some central point. Items in (d) are likely to comprise little more than a characterization of local bee forage and local honeys.

What would seem to be needed is a central clearing house for information and discussion of common problems. The Bee Research Association fulfils this function for the world in general as far as its funds allow. But many of the tropical countries are in a position to absorb assistance rather than to dispense it, and the cost of work specially oriented to them would have to be borne by the more advanced countries. It is likely that it would prove a very sound investment.

Note 1: It extends to Japan, North China and the Far Eastern Province of the U.S.S.R., though in these regions it appears unable to compete successfully with introduced European honeybees *(Apis mellifera)*. It survives cold winters in Kashmir and the type from the Far Eastern U.S.S.R. has been reported to survive two winters in Moscow.

Possibly one reason why European honeybees fail in the Paleotropics is that they cannot compete successfully with the tropically adapted *Apis* bees and in South East Asia cannot survive the monsoons.

Note 2: Described by some authorities as "food found in queen cells".

Note 3: Obviously apiary size is limited by the amount of bee forage within flying range rather than transport units. In this sense beekeeping does require a good deal of land and cannot be made a factory process like, say, pig or poultry rearing.

(Continued overleaf)

A typical bee skep, from the title page of Topsell's translation (1658) of Mouffet's *Theatrum Insectorum* (1634).