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THE PAST AND PRESENT STATUS OF BEEKEEPING WITH STINGLESS BEES

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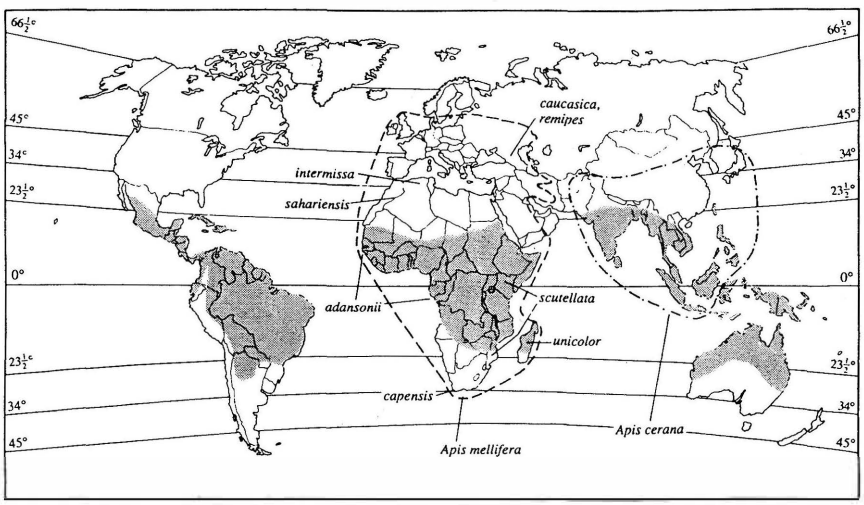
Origin and geographical range of stingless bees

'Stingless bees' are social bees, living in permanent colonies. They make and store honey as *Apis* species do, and Michener[20] calls them stingless honey bees. Like *Apis mellifera* and *A. cerana* they nest in cavities, and can therefore be kept in hives. The bees have no venom apparatus, and cannot sting; they do have a vestigial sting, but this is greatly reduced, without an effective tip.

The honey bees (Apinae), bumble bees (Bombinae) and stingless bees (Meliponinae) all belong to the family Apidae. Stingless bees were probably the first social bees to branch off from less social ancestors[33], and this occurred before the New World continents of America and Australia were separated from the Old World land mass of Africa, Asia and Europe. As a result, the bees are present in both Old and New Worlds (fig. 1). The oldest known specimen of any social bee is a stingless bee found in amber in New Jersey, USA[13]. It lived in the Cretaceous period, 80 million years ago, and has been named *Trigona prisca*.

Unlike some of the later honey bees (*Apis*), none of them have adapted to living

FIG 1. World distribution of Meliponinae[6]. Shaded tropical areas indicate Meliponinae, and broken lines the natural distribution of *Apis mellifera* (in Africa and Europe) and *A. cerana* (Asia).



outside the tropics. Roubik[26] discussed reasons for the world distribution of *Melipona* species.

Over 500 species of stingless bees are known, and the majority are in South America; in Brazil alone there are more than 250, and further new species are being discovered there every year. Some other species live as far north as Mexico. One or a few species are found on some of the Caribbean islands, and it is possible that colonies have been taken by man from one island to another in past centuries. In any region where nests were in the mangrove trees of coastal swamps, some probably dispersed in floating logs[26]. Relatively few species occur in Africa, Asia and Australia. Different species are adapted to different tropical habitats, but most live at fairly low altitudes. This fact had an important influence on gold-casting technology, which is explained later.

Species used for traditional beekeeping

The Meliponinae have been divided into five genera, the most extensive being *Trigona* and *Melipona*. *Trigona* species occur in every continent except Europe (which has no tropical region), whereas *Melipona* does not occur outside the Americas. *Trigona* bees have a body length from 2 mm upwards, and are long-winged; *Melipona* bees tend to be larger, some as large as *Apis mellifera.*

Table 1 lists 14 species of *Melipona* and 21 of *Trigona* that have been used in traditional beekeeping, all but two of them in the Americas. In parts of Africa, two *Trigona* species have been used, and (in Angola) the only known species of *Meliponula* and one species of *Lestrimelitta*. This last is one of several robber bees that get their food from nests of other bees; they have no corbiculae, and carry (and store) stolen honey and pollen together. The single species of a fifth genus, *Dactylurina*, which is similar to *Trigona*, is not known to have been kept in hives.

Traditional hive beekeeping with *Trigona* species has occurred occasionally in Asia, especially Indonesia, but not in Australia.

Biology of stingless bees in relation to beekeeping

The general biology of stingless bees has been described by various authors[20, 27, 28]. Many specific studies have been made recently, especially in Brazil where so many species live. The following characteristics of the bees are especially important in beekeeping.

Nest structure and honey storage

Different species build their nests in underground cavities, or in trees or other enclosed spaces such as termite mounds. Most parts of the nest are built with a mixture of wax and propolis known as cerumen, although some parts are of wax only. Figure 2 shows one nest, which is enclosed by a layer of batumen; this is cerumen plus mud, and sometimes also plant materials. The nest cavity is thus sealed from the outside world except for its flight entrance, some small ventilation holes, and possibly also a drainage tube. The flight entrance is made or lined with propolis

TABLE 1. Some species of stingless bees (Meliponinae) that are, or have been, kept in hives for honey and/or wax production (based on Crane, 1990[6]).

Species Subgenera of *Trigona* are in brackets	**Example of region where kept**
Melipona	
beecheii[1, 3]	Central America
compressipes	Brazil
fasciata guerreroënsis	SW Mexico
fasciata rufiventris[1]	Brazil
favosa phenax	Panama
interrupta[1]	Colombia
marginata[3]	Brazil
nigra	Brazil
pseudocentris pseudocentris	Brazil
quadrifasciata[1]	Brazil
schencki picadensis[1]	Brazil
schencki schencki[1]	Brazil
scutellaris[1]	Brazil
seminigra merrillae[1]	Brazil
Trigona	
(Axestotrigona) erythra togoensis	Angola
(Cephalotrigona) capitata[1]	Brazil
(Friesella) schrottkyi[4]	Brazil
(Hypotrigona) gribodoi	Angola
(Nannotrigona) testaceicornis perilampoides[2]	W Mexico
(Nogueirapis) mirandula	Costa Rica
(Oxytrigona) tataira[1]	Brazil
(Partamona) cupira[1, 3]	Yucatán (Mexico)
(Plebeia) emerina[3]	Brazil
(Plebeia) mosquito[3]	Brazil
(Plebeia) remota[3]	Brazil
(Scaptotrigona) depilis	Bolivia
(Scaptotrigona) pectoralis[2]	Yucatán (Mexico)
(Scaptotrigona) postica[1]	Brazil
(Scaptotrigona) tubiba[1]	Brazil
(Tetragona) clavipes[1]	Brazil
(Tetragona) mombuca[1]	Brazil
(Tetragona) nigra[2]	Yucatán (Mexico)
(Tetragona) silvestrii[4]	Brazil
(Tetragonisca) angustula[2]	Costa Rica
(Trigona) fulviventris[1]	Honduras
Lestrimelitta (Cleptotrigona) cubiceps	Angola
Meliponula bocandei	Angola

[1, 2, 3, 4] Size of nest: large (1), medium (2), small (3), very small (4)

FIG 2. Nest of *Melipona interrupta grandis*[4].

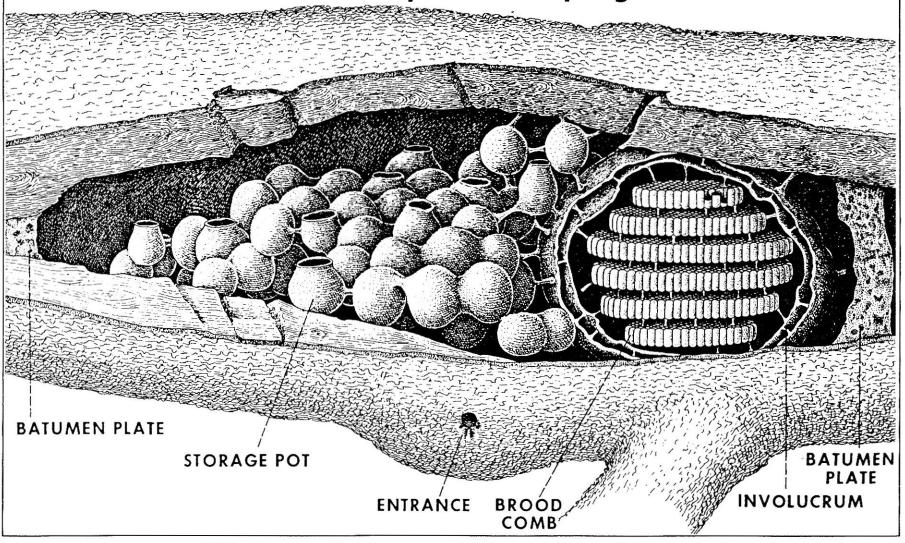
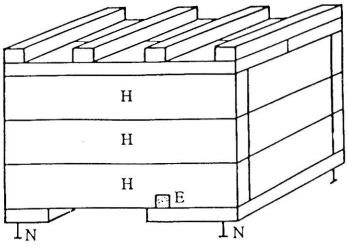
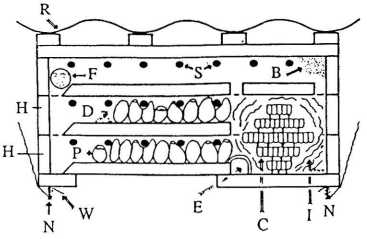


FIG 3. Rational hive for stingless bees, incorporating superimposed 'drawers' for honey storage[22].





left Exterior, viewed from the side.

B batumen
C brood combs
D debris
E entrance tunnel
F feeder
H honey storage drawers

right Interior, vertical section.

I involucrum
N nail
P honey storage pots
R roof
S bamboo sticks
W wire

or cerumen, and some species build a long protruding entrance tube which may be closed each night. Stored honey and pollen are kept in irregularly built 'honey pots' of soft cerumen, either separate or intermixed. Brood cells of many species are also irregular, but *Melipona* and some *Trigona* make regular horizontal brood

combs. Unlike honey bees, stingless bees mass-provision the brood cells: before an egg is laid, all the food for the resulting larva is put into the cell, which the bees then close. In figure 2 the brood nest is enclosed in a separate cavity by an involucrum of soft cerumen, but this is not usual.

Some species keep stores of their building materials, wax and propolis, in separate places in the nest; propolis is sometimes used also to immobilize enemies.

Figure 3 shows a 'rational' hive, referred to later, for species that build a nest like that in figure 2.

Colony reproduction

Reproductive swarming, and mating between drones and young queens, do not proceed in the same way in stingless bees as in honey bees, although the timing is similar — when colonies are populous, and drones are present. The following characteristics are usual, but not necessarily universal. Before the issue of a swarm, workers in the parent colony rear new queens, and also select a nest site for the swarm and take to it wax, propolis and cerumen — with which they start building the new nest. They also take pollen mixed with honey, in their honey sacs. In the parent colony the workers treat the young virgin queens as queens, but the queen heading the colony tolerates them. An issuing swarm consists of one of these virgin queens and many young workers. When it arrives at the new nest a congregation of drones is waiting nearby, and the queen mates, although not necessarily in flight; she soon starts to lay eggs in brood cells that the young workers in the swarm have constructed. Some details of the swarming process, and of variations between species, have been published for Brazilian bees[10, 17, 19, 22], and for bees in Gabon in West Africa[8].

Defence behaviour of stingless bees is much less hurtful to the beekeeper than that of honey bees, and smoke is almost never used on them. Defence mechanisms against an intruder include biting, ejecting a caustic fluid, and irritating by crawling into eyes, ears, etc.

Traditional beekeeping in Mesoamerica and elsewhere

One early American civilization developed traditional hive beekeeping with stingless bees, especially *Melipona beecheii*, to an outstanding level. This was the Maya culture centred in the Yucatan peninsula, of which parts are in present Mexico, Guatemala and Belize. It influenced a much larger region, which has been given the name Mesoamerica (fig.4); along the Pacific (drier) side this stretched as far south as the Nicoya peninsula in Costa Rica. *M. beecheii* is not found in Panama to the south, where *M. favosa phenax* is kept in hives instead[7]. The Maya civilization lasted from about 300 BC until the Spanish conquest in 1520. Spaniards who conquered the Maya people reported on their life and customs, and some referred to honey and beeswax, or described beekeeeping with *M. beecheii* which was the most important of the local stingless bees. Put together, the reports present a picture of traditional Maya beekeeping, especially in the Yucatan peninsula.

The most commonly described hive for *M. beecheii* in Yucatan was a horizontal

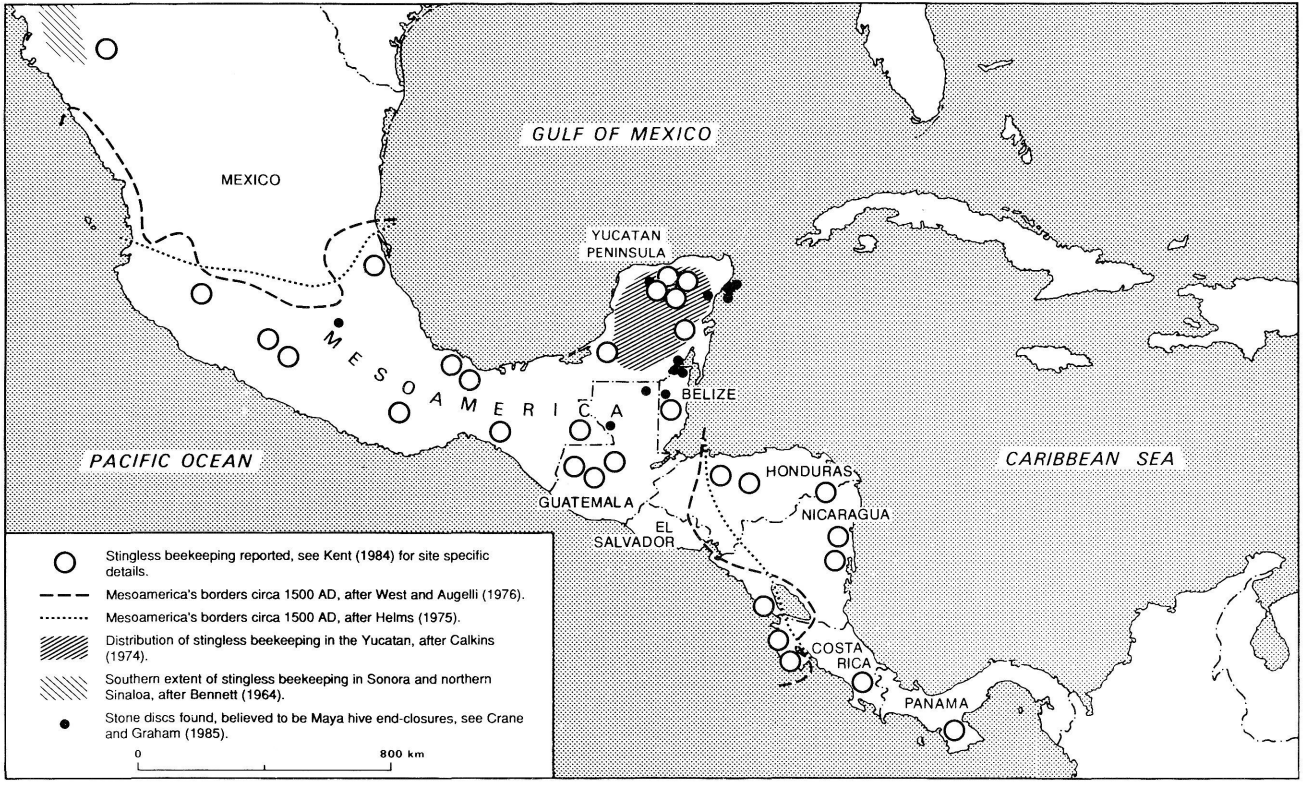


FIG 4. Map of Mesoamerica (the approximate extent of Classic Maya culture), showing beekeeping sites[3,18], and sites where stone discs resembling Maya hive closures have been found[5]. (map redrawn by R Kent)

hollowed log from a selected tree, closed at each end with a disc of wood or local soft stone, cut to fit inside the log. Honey was harvested by tilting the hive, removing the lower end disc, and breaking the honey pots near that end so that the honey ran out into a vessel held below, sometimes through a basket or other strainer as in figure 5. Hives were sometimes moved from their normal position when honey was harvested, and it was essential that they were replaced the right way up because the brood combs are horizontal, each cell opening at the top. On many hives, a plus (+) sign was cut just above the bees' flight entrance (half-way along the log), probably for this purpose. End closures similar to those described by Spaniards are still used for log hives[3, 32]; the use of stone for them would probably be confined to areas where wood was scarce.

FIG 5. Hive of *Melipona beecheii* opened to show honey pots inside, with straining-basket in position[32].

Kent[18] published a valuable account of past and present beekeeping in Mesoamerica, and quoted many original sources.

In the past few decades, stone discs similar to end-closures now used have been found in several archaeological excavations in Mesoamerica[11, 29, 31]; figure 6 shows some of them, and the 12 sites where such discs were found are marked in figure 7; all except no. 12 are in the main Maya culture area in Yucatan. These excavated discs have been tabulated and discussed[5]. Sites that can be dated are listed below, and the number of discs found at some of them is entered in brackets after the site number:

– Late Preclassic Maya period, *c.* 300 BC to AD 300: 7 (101 discs), 12.

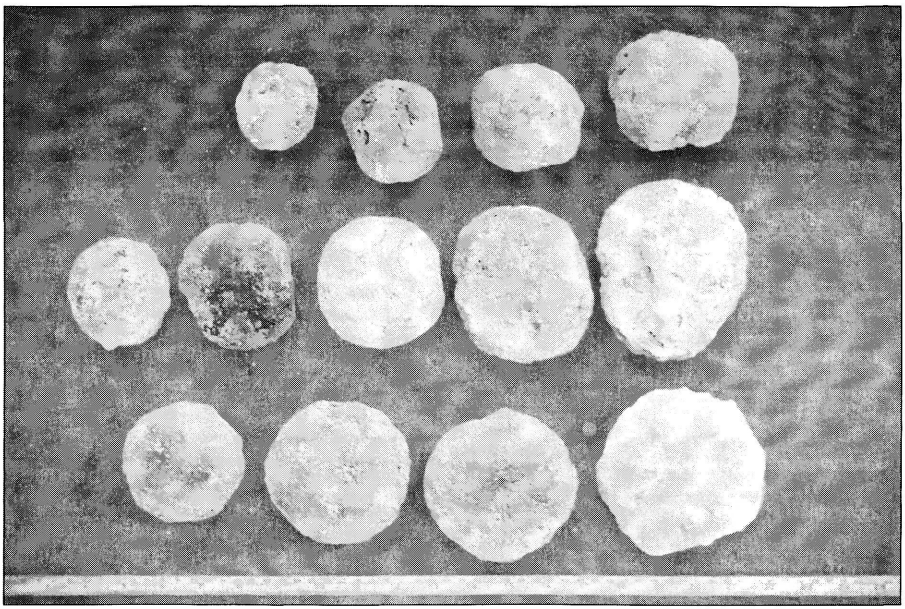
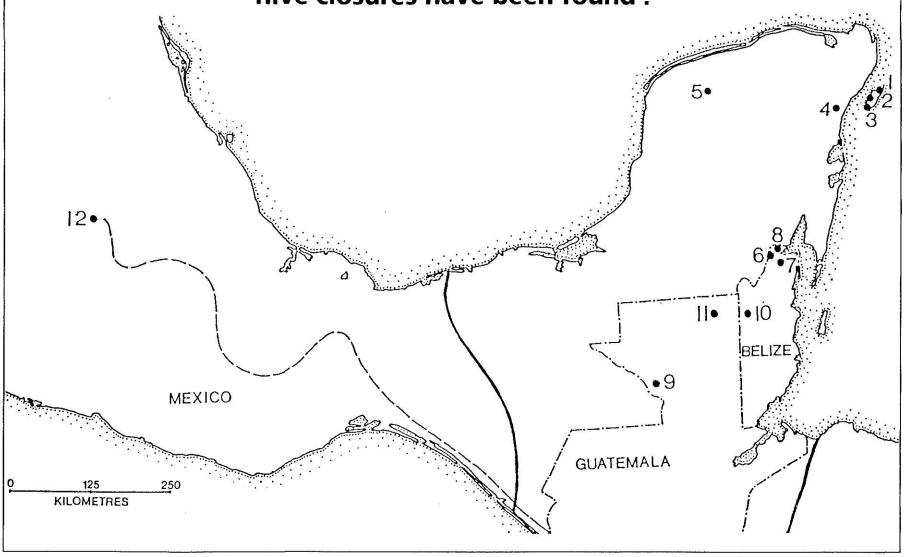


FIG 6. Thirteen limestone discs dated to 300 BC to AD 300, found at Chan Chen, North Belize, site 6 in figure 7 (*photo*: J R Andresen). Most discs have diameters between 8 and 10 cm and are 3–4 cm thick.

FIG 7. Map showing sites 1–12 where stone discs resembling Maya hive closures have been found[5].



- Classic Maya period, *c.* AD 300 to 900: 9, 10, 11.
- Postclassic Maya period, *c.* AD 900 to 1520 when the Spanish arrived: 1 (103 discs), 2 (87), 3 (37), 5 (55).

Sites 1, 2 and 3, which together yielded 227 discs, are on the island of Cozumel off the north-east coast of Yucatan. Site 12 (late Preclassic), where 2 discs were found, was on an Olmec trade route from the Maya area. Figure 4 shows sites 1–12 in relation to known beekeeping sites.

In South America, some of the early civilizations had gold, and they produced gold ornaments and jewellery of which the finest were made by the lost-wax process using wax from stingless bees. This could be done where beeswax was available, as in certain valleys now in Colombia, but not at high altitudes where the Inca people lived. It seems likely that lost-wax gold castings in South America were made before stingless bees were kept in hives, in which case the wax would have come from wild nests. But gold-casting technology using beeswax reached as far as the south of what is now Costa Rica, near the southern outpost of Maya beekeeping with *M. beecheii.*

Where traditional beekeeping with stingless bees existed, it continued throughout the Spanish period, and after the different regions achieved independence as sovereign states; figure 8 shows an example of traditional hives in 1991. Beekeeping with introduced European honey bees (*Apis mellifera*), from 1839 onwards, was a separate enterprise, mostly by people of European descent. Two circumstances in the late 1900s affected the beekeeping situation. Especially after the 1950s,

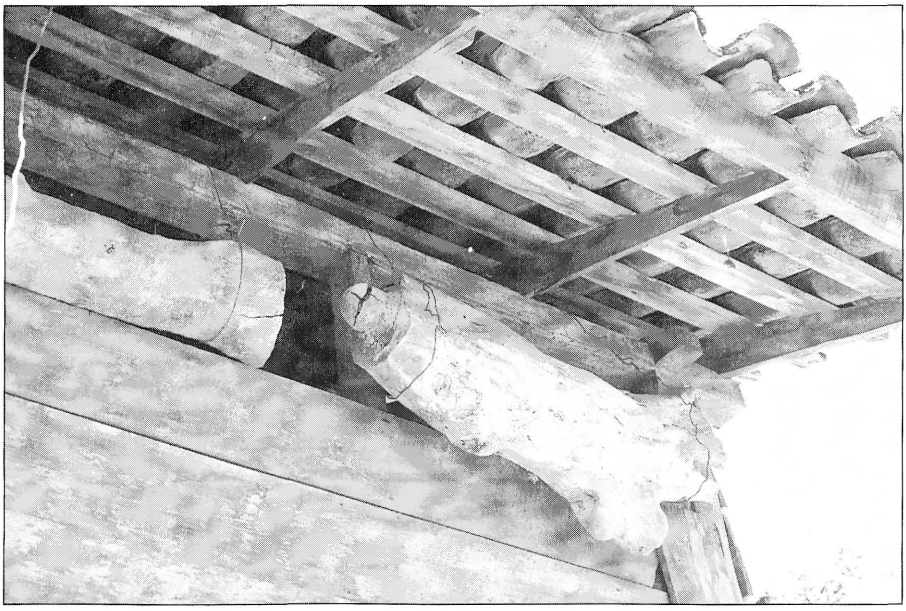


FIG 8. Two of a number of hives of *Melipona beecheii* suspended against the walls of a peasant house, Nicoya peninsula, Costa Rica, 1991 (*photo*: E Crane).

FIG 9. Box hive for *Melipona beecheii* opened to show a young nest inside, Costa Rica, 1991 (*photo*: E Crane).

deforestation destroyed large areas of forest, including dry forest that was the habitat of *M. beecheii*. From 1984, Africanized *A. mellifera* reached Costa Rica and the rest of Mesoamerica, with some disastrous effects on honey bee beekeeping as a rural home-based occupation.

New approaches to beekeeping with stingless bees

Meanwhile, from 1910 onwards attempts were made in Brazil to devise 'rational' hives for stingless bees, as Langstroth and others had done for honey bees. They were designed to make honey harvesting easier and less destructive of the nest; for instance by incorporating a separate honey-storage compartment in the hive. Since about 1950, environmental scientists, and others concerned with harvesting renewable resources in the tropics, have been interested in the rearing of stingless bees. Professor Paulo Nogueira-Neto in São Paulo, Brazil, led the study of stingless bees in relation to beekeeping with them. He wrote in *Bee World*[21], and published an important book on the subject in 1953, with a revised edition in 1970[22] and another due in 1992. The book describes and illustrates a number of designs for 'rational' hives, to suit species that build different types of nests. One, for species whose nest is like that in figure 2, is shown below this in figure 3. In 1990, Nogueira-Neto[23] described another horizontal hive with a central brood nest and, on either side, honey and pollen pots which can be transferred to another hive, where the bees recycle the wax.

In Angola, Dr Portugal Araújo[24] applied similar methods to the African species of stingless bees mentioned earlier.

Much research on the biology of stingless bees is still centred in São Paulo province of Brazil, where Professor Warwick Kerr and his colleagues and students have made many contributions. Interest in beekeeping with the bees as an economic activity for rural peoples is centred in areas farther north: Yucatan, where this beekeeping flourished so much in past centuries, Costa Rica, and Cuba in the Caribbean region. Large areas of the dry forest where beekeeping with *M. beecheii* was done are now destroyed, with the result that much bee forage, and many hollow trees with nesting sites for stingless bees, have been lost. Modern beekeeping must be developed to suit the new environmental conditions.

A three-year project by the University of Utrecht in the Netherlands was started in 1990 at the National University of Costa Rica in Heredia. The programme is based on scientific investigations of subjects that include natural colony reproduction and

TABLE 2. Native plants of economic value in Costa Rica, known to be pollinated by stingless bees[1].

Local name	Scientific name	Economic use
achiote	*Bixa orellana*	colourant
aguacate	*Persea americana*	fruit
algodon (cotton)	*Gossypium* spp.	textile
annona/guanabana	*Annona* spp.	fruits
ayote	*Cucurbita pepo*	vegetable
cacao	*Theobroma cacao*	chocolate
caimito	*Crysophyllum cainito*	fruit
calabazo	*Lagenaria siceraria*	crafts
camote	*Ipomoea batatas*	vegetable
capulin	*Prunus serotina*	fruit
chayote	*Sechium edule*	vegetable
chiverre	*Cucurbita ficifolia*	marmalade
coco	*Cocos nucifera*	fruit
guabas	*Inga* spp.	shade trees for coffee
guaitil	*Genipa americana*	timber
guapinol	*Hymenaea courbaril*	timber
guayaba	*Psidium guajaba*	fruit
maiz	*Zea mays*	bread/tortillas
nance	*Brysonima crassifolia*	fruit
papaya	*Carica papaya*	fruit
pejiballe	*Bactris gasipaes*	fruit
yuca	*Manihot esculenta*	vegetable
zapallo	*Cucurbita moschata*	vegetable

Stingless bees are also pollinators of many crop plants not native to Costa Rica, for instance *Citrus* spp., mango, coffee, macadamia, melon.

especially drone production in some species, to develop effective methods for increasing the number of colonies[7]. More efficient methods of harvesting honey and wax are being worked out. A simple box hive 1.2 x 0.27 x 0.27 m, with a removable lid (fig. 9), is used experimentally for *M. beecheii* in several areas of Guanacaste province (north-west) and Perez Zeledon (south). There are also projects in Yucatan (Mexico) and Cuba.*

In Africa, interest in beekeeping has been concentrated on *A. mellifera*, and since the 1950s beekeeping with stingless bees in Angola does not seem to have been followed up. However, the biology of several species in the African tropics has been studied by French workers, especially Dr Roger Darchen and his colleagues[8].

In Australia, recent interest has centred round environmental issues, especially the need to increase populations of native stingless bees because they pollinate native plants. There has been unease that the introduction of honey bees into some ecosystems is detrimental, because their foraging behaviour favours the pollination (and spread) of introduced plants at the expense of native plants, and because it can reduce the forage available to native bees. Attempts to promote the keeping of stingless bees have led to the publication of several simple designs of hives for *Trigona* species[9, 12, 14, 16].

Rindfleisch[25] made a general plea for the greater use of stingless bees as crop pollinators, referring especially to South America. Little experimental work has yet been done except on the nut-bearing tree *Macadamia integrifolia* in Australia where the tree is native. Vithanage and Ironside[30] and Heard[14, 15] showed that native *Trigona* were effective pollinators, and may be more effective than *A. mellifera.*

No quantitative data are known on the influence of pollination by stingless bees on crop yields, but table 2 lists native plants of economic value in Costa Rica that are pollinated by stingless bees.

There are several characteristics, in addition to the lower honey yields per colony from stingless bees, which prevent the development of a large-scale beekeeping comparable to that with European *A. mellifera*.

Modern hives with movable frames revolutionized colony management with *A. mellifera*, and allowed mechanization of both colony management and the handling of marketable products. Many of these developments depend on the fact that an *A. mellifera* colony builds a number of exactly parallel combs. Although some stingless bees kept in hives build parallel brood combs, honey storage cells are in amorphous groups that are unsuited to mechanical handling.

In addition, the world market is geared to *A. mellifera* honey and beeswax. Honeys from stingless bees are generally more acid and contain more water than *A. mellifera* honey, although — for reasons not yet clear — they are fairly resistant to spoilage by unwanted fermentation. (In countries where honey was traditionally produced from stingless bees, it is now more highly prized and fetches a much higher price than *A. mellifera* honey.) Beeswax from stingless bees commonly contains more propolis than *A. mellifera* beeswax, and also other materials.

Nevertheless it is worth fostering and upgrading beekeeping with stingless bees

*Names and addresses are given after the references.

— especially where the tradition has existed. It can provide a home-based source of income where *A. mellifera* cannot be kept near houses because of Africanization, and a self supporting method of increasing populations of stingless bees to pollinate indigenous flora. The rearing of stingless bees for research will doubtless continue and expand, because of the great biological interest of the 500 or more species.

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