

Extinction of *Melipona beecheii* and traditional beekeeping in the Yucatán peninsula

ROGEL VILLANUEVA-G, DAVID W ROUBIK AND WILBERTO COLLI-UCÁN

Rearing of the 'xunan-kab' bee (*Melipona beecheii*) had been practised widely by the Mayans of the Yucatán peninsula long before arrival of the Spanish in the New World, and had been a culturally and economically important activity in that region. *Melipona beecheii* is kept almost exclusively in traditional log hives. Beekeepers using this bee, from the Mayan zone in Quintana Roo state, Mexico, testify to a 93% decrease in hives during the past one-quarter century. Despite concern that stingless bee keeping is going extinct, there were scant data to examine direct impact of competition from feral African *Apis mellifera*, deforestation, hurricane damage and lack of instruction and incentive for new stingless bee keepers. We therefore made a survey of beekeepers constituting 20% of the largest traditional beekeeping group in the Americas. These data combined with our field studies, taken over 24 years, suggest that bees are threatened both by environmental changes and by inappropriate management and conservation efforts. Overharvest and failure to transfer colonies to hives or divide them are serious impediments. The major tactics to confront these problems are presented.

Introduction

A series of papers published during the last quarter century show a downturn in stingless bee keeping in at least part of the Yucatán peninsula, and attempt to analyse the causes.^{10,19,20,27,46} Long before arrival of the Spanish in the New World and subsequent introduction of a major honey resource from the Old World (honey bees – *Apis mellifera*), the Maya of the Yucatán peninsula were expert practitioners in husbandry of various native honey-making stingless bees, which were kept in log hives. Today and, we suspect, during historical beekeeping times, those bees used most for food and materials are the large-bodied meliponines, *Cephalotrigona*, *Melipona* and *Scaptotrigona*.^{3,27,37} Because of its ease of management (the large forager size, flight range and numerous virgin queens for colony propagation are a particular asset of *Melipona*) and excellent honey production, the favourite species has been *Melipona beecheii*, known by its keepers as 'xunan-kab' or 'colel-kab'.²⁷ It was apparently the only bee propagated using husbandry techniques in the whole of the tropical world. These bees were particularly important to the Maya civilization for medicines (antibiotic honey), sweeteners and mead (balche), and a vital small-scale economy. These bees even provided metaphors for the Maya, whereby they interpreted their place in the universe and relationship to the earth, deities, and later, to the Spanish invaders.^{8,39} Xunan-kab were

regarded as a gift from the gods to humankind and therefore were handled with utmost care and reverence by trained beekeepers.⁹

Melipona beecheii is one of several hundred bee species – almost all tropical meliponines – that produce abundant honey.²¹ This bee's natural range is from Mexico to Costa Rica.³ Originally a resident of tropical lowland forests, it was dependent on the variety and cycles of the forest resources, for example a major flowering period and honey storage during the dry season, followed by a dearth of nectar and pollen during the wettest part of the year, or in prolonged drought.^{29,45}

Over the centuries, the Yucatán peninsula has been deforested, first by the Maya and later particularly in the western and central portion, where agave, sisal and cattle ranching replaced forest, as its people became more involved in plantation schemes or cultural and economic alternatives to traditional slash and burn 'milpas' agriculture. As a result, xunan-kab (literally, the 'royal lady' bee) forage largely among secondary-growth plants.^{42,44} At both large- and small-scale, *Apis mellifera*, despite its sting, was economically a better option for many, as it was not commonly associated with relatively low productivity and low income.²⁷ Hence the Mayan stingless bee lost its place as provider of a sweetener (to sugar cane and to *Apis mellifera*) and to modern pharmaceuticals as a provider of medicine. It now continually competes with

Apis mellifera for floral resources and nesting sites, and has lost, due to modern cultural changes, central significance in Mayan customs and beliefs. Nonetheless, a potential boost to the local economy may yet come from the re-establishment of a vigorous meliponiculture in Yucatán.²⁷ Because there were no published long-term data that examine the biology and impact of competition from introduced feral African *Apis mellifera*, deforestation, hurricane damage, natural enemies, lack of instruction for new stingless bee keepers, or attendant lack of economic incentives for traditional stingless bee keeping, we therefore made a direct inquiry with a survey of beekeepers

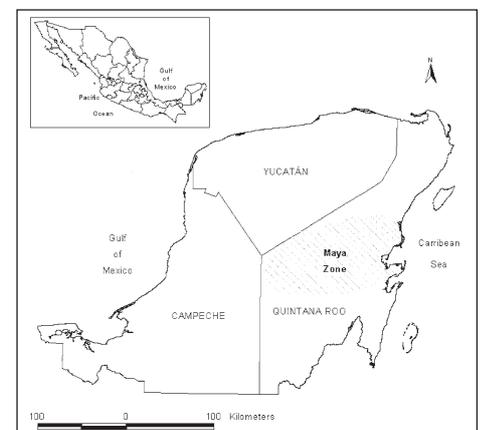


FIG. 1. Map of the study area in the southeastern state of Quintana Roo, Mexico, and the Maya zone, in which meliponiculture was monitored.

and long-term focal studies in the relatively forested area of eastern Yucatán peninsula, in the state of Quintana Roo. We note both similarities and differences, compared with the previous work of a considerable number of authors.

Melipona beecheii is apparently rare in the wild, even in forested areas,¹⁴ although tropical studies on stingless bee or honey bee nest abundance are surprisingly scarce.¹⁶ Its nests occur only in hollows within now relatively rare trees, of ≥ 30 cm girth.²⁷ At the same time, the traditional practice of propagating domesticated colonies is not being taken up by younger generations of Maya. In short, apart from the sustaining efforts of a handful of enthusiasts,

meliponiculture, or stingless bee keeping, at least in the areas that long have been deforested, is disappearing.^{11,20,27} Several institutions, business ventures, and non-government organizations are attempting to develop stingless bee keeping. As discussed here, we have observed stingless bee keeping efforts commonly fail in the Maya region, and transplanted colonies are lost due to varied reasons. Moreover, the large number of colonies lost recently by meliponiculturists and beekeepers in the states of Yucatán and Campeche, after hurricane Isidore, may well be irreplaceable.¹¹ The objective of this work was to analyse the biological problems related to the maintenance and management of *Melipona beecheii* in the relatively well-forested portion of the Yucatán peninsula,

and determine reasons why populations have declined greatly within Mayan communities.

Survey

To compile data which enabled us to evaluate the trends in stingless bee keeping, we took stock of overall changes at the end of 2004 in Quintana Roo state, Mexico, in an area known as the 'zona Maya' (fig. 1). A standard set of questions was asked in the Mayan language of meliponiculturists in the region. The data were assembled after first making a census of all Mayan communities with more than 50 inhabitants, for which population data¹⁵ were available. A total of 150 communities were thus identified, and 120 stingless bee keepers were found among

TABLE 1. Number of *Melipona beecheii* hives that beekeepers from the zona Maya have kept in the last 54 years.

Name of Mayan community	Name of beekeeper or institution	No. of hives kept between 1950 and end of 1981	No. of hives kept at end of 1990	No. of hives kept at end of 2004
Chan Santa Cruz	Delfino Naal	unknown	8	2
Chan Santa Cruz	Nemesio Pot	unknown	12	8
Chancá de Repente	Bernardo Peúa	42	25	8
Chancá de Repente	Anastasio Pérez	unknown	10	0
Chancá de Repente	Eduardo Yam	unknown	5	0
Chunyá	Patricio Canul	45	30	8
Felipe Carrillo Puerto	Inst. Nacional Indigenista	0	40	8
Miztequilla	Santiago Pat	unknown	6	2
Miztequilla	Fernando Yam	40	19	8
Naranjal	Francisco Cimá	25	15	3
Naranjal	Juán Mena	26	12	6
Nueva Loría	Celestino Camal	unknown	7	2
Nuevo Israel	Ponciano Tun	unknown	6	0
Palmas	Margarito Tuz	220	5	0
Presidente Juárez	Bernabé Kantún	unknown	16	4
San Hermenegildo	Humberto Ku Cauichl	60	40	0
Santa María	Francisco HuiCab	50	37	7
Seúor	Doroteo Pech	22	18	0
Seúor	José Pott	unknown	6	0
Tihosuco	Pedro Cahun Uh	unknown	5	12
Tuzic	Isidro Peúa Tuz	200	40	8
X hazil	Modesto Chuc	10	7	0
X hazil	Isaías Cahuich	15	10	0
Yo Actún	Rancho San Martín	unknown	10	4
Totals		likely >1000	389	90

For the last 14 years the stingless bee keepers have been losing, on average, about 22 colonies each year. Continuing that trend, by the year 2008 there will be no domesticated colonies left at all.

them. Previous work by Quezada-Euán and colleagues²⁷ estimated that there were fewer than 500 stingless bee keepers in all of Yucatán. We took a random sample of 24 beekeepers in the zona Maya (20%) and asked the questions in our standard questionnaire in 1985, 1990 and 2004. The meliponiculturists questioned were not strictly beekeepers and none had much formal education or economic means. Some examples of the questions asked were:

- 'How did you obtain your xunan-kab colonies?'
- 'How many did you inherit?'
- 'How many do you have?'
- 'Who taught you to manage the colonies?'
- 'Do you use 'rational hives' (wooden box hives)?'
- 'How many log hives and rational hives do you have?'
- 'Do you divide (propagate) your colonies?'
- 'How much honey do you produce?'
- 'Where or to whom do you sell it?'

In addition, we conducted further interviews on the general state of stingless bee keeping, including both local and statewide problems. Periodically (every two or three months) beginning in 1985 we interviewed five stingless bee keepers in order to learn of specific bee management problems. These were open-ended interviews in which key questions were asked, such as:

- 'What management problems have been encountered?'
- 'Have you divided your colonies?'
- 'Why have your colonies been weak or in poor condition?'
- 'What are the main reasons you are losing your colonies?'

Thus, our study attempted to assess the strengths and weaknesses of meliponiculture under present conditions, threats and opportunities related to honey production.

Decline of meliponiculture activity

Table 1 shows results from the 24 traditional meliponiculturists that were interviewed in

the zona Maya of Quintana Roo, indicating the numbers of *Melipona* colonies kept at the end of 1981, 1990 and 2004. The most alarming findings were that, out of the total number of domesticated colonies (755) known to be held in 1981, and probably hundreds more for which no precise records were offered by the participants, only 90 have survived or have been replaced. If we consider only the meliponaries ('bee yards', fig. 2) in which the number of hives present in 1981 was stated by the participants, then the decline between 1981 and 2004 has been one of over 93%.

Furthermore, nine out of the 24 questioned no longer had any colonies, a notable phenomenon within the last 14 years. Clearly, the keepers of xunan-kab either cannot maintain their colonies adequately, or they lack sufficient reasons to keep them. Such individuals may not have found a successor to properly care for the colonies, and they have failed to replace colonies lost due to mortality. For the last 14 years the stingless bee keepers have been losing, on average, about 22 colonies each year. Continuing that trend, by the year 2008 there will be no domesticated colonies left at all. Only Pedro Cahun-Uh, a meliponiculturist from Tihosuco, increased his colonies from 5 to 12 (table 1). He also divided three to produce three more, using wooden box hives. He was the only beekeeper who was successful in such husbandry efforts. None of the other meliponiculturists used box hives, but rather used traditional hollow log hives, or 'jobones'. Significantly, many beekeepers were reluctant to risk losing their colonies to parasitic phorid flies, *Pseudohyocera* or 'nenem', which often attack and kill colonies that have been moved or disturbed by opening of the nest cavity.⁴²

All *Melipona* colonies, except four belonging to Nemesio Pot from Chan Santa Cruz, were inherited either from the fathers or the grandfathers. Mr Pot obtained five of his log hives from wild colonies in the forest.

Loss of habitat

The peninsula of Yucatán (the states of Yucatán, Quintana Roo and Campeche), once covered with mature tropical forests (although not in some periods before the arrival of Europeans¹²), has been deforested

extensively in modern times. In the state of Yucatán, land reform programmes of the 1930s, cattle ranching, logging and large-scale cultivation of agave plants for production of sisal have resulted in nearly complete deforestation of that state.²⁷ The less populous states of Campeche and Quintana Roo have been less affected.

Although the nectar and pollen plants that now predominate in the zona Maya appear to be quite useful to *Apis mellifera* (171 pollen species used by the exotic honey bee have been recorded recently^{40,41,45}), it is reasonable to expect that, for native bees, significant adjustments were needed in response to the changes of flora resulting from human activities, both in historical times and more recently. However, logging, even if it is not clear-cutting, reduces forest habitat by felling large trees that contain *Melipona* nests, and at the same time removes suitable, unoccupied nesting sites. If there are no new natural colonies accessible to the beekeeper, hived colonies lost to natural causes, such as predators or hurricanes, cannot be replaced. At the same time, many beekeepers report colonies are dying from a lack of food. They observe their colonies have less and less honey, most notably in the seasons of reduced flowering. We also observed colonies diminishing in size until no longer viable, often succumbing under attacks of ants, phorid flies, toads or *Eira barbara* ('tayra', a Neotropical weasel); this happened mainly with colonies that were not checked regularly.

Competition between *Melipona beecheii* and Africanized honey bees

The extent to which the colonies of *Melipona beecheii* are in decline is difficult to determine. Many factors are involved, such as reduced or changing floral resources and whether they are unable to forage such resources because of competition from *Apis mellifera*, which also compete for nesting sites.^{26,28} We see the need for further investigations into these and other factors, such as effects of pesticides or changes in annual rainfall patterns,³⁶ and associated drought and flowering. However, there are marked influences on meliponiculture and bee foraging that coincide with the first arrival of Africanized honey bees in the late 1980s.

An understanding of competition between bees and its result cannot be resolved with short-term field studies, but, rather, requires population and community studies. The question of honey bee impact on native bees in natural habitats has thus been the subject of long-term research programmes, by DVWR and collaborators, in French Guiana, Panama



FIG. 2. A stingless bee keeper from the community of San Hermenegildo harvesting honey from his colony.

and in the present work.^{5,31,36} In the Yucatán peninsula, there is a case to be made that domesticated *Melipona beecheii*, often kept in the highly disturbed habitats that surround Maya villages, but also surviving naturally in the relatively intact forests of Quintana Roo, has undergone a population reduction due to competition with honey bees at flowers. The degree of competition for floral resources from *Apis mellifera* (now Africanized) depends on availability of resources and general abundance of honey bees. After their arrival, 18 years ago,^{40,43} Africanized honey bees appear now to saturate their habitats.^{28,29,36,45}

Xunan-kab foragers most often visit the flowers of shrubs and trees,^{42,44} rather than low vegetation such as herbaceous plants, while *Apis* bees visit all of the above.^{40,41} At the end of the dry season there are few or no blossoming herbs.^{40,41,44} Competition is then potentially more intense for the blossoms of shrubs and trees.⁴⁴ Particularly interesting are observations that *Melipona* appear to abandon resources where out-competed by other foraging bees, including exotic Africanized honey bees.^{45,29} Meliponiculturists in Tepich, Quintana Roo, reported lower honey production by their *Melipona* bees

when neighbours begin keeping *Apis mellifera*.⁸ At the same time, since the arrival of Africanized honey bees, the surrounding habitat is now for the first time filled with honey bees. This is in stark contrast to the scattered apiaries where European honey bees were once kept in Yucatán and where there was no widespread, naturalized, feral population of *Apis mellifera*, typical for Africanized bees in neotropical lowlands.^{32,33} Indigenous hunters of stingless bees in the Amazon basin also observed decreased honey from their bees after colonization by Africanized honey bees, but after 20 years 'production' levels normalized, presumably as population densities of Africanized honey bees decreased or the local bees adapted.²⁶

Long-term decline in managed bee populations

The reasons for the rapid decline, especially colony mortality and decline, in the xunan-kab have not been examined in detail by the scientific or conservation communities, or voiced by many scientific authors or students of Mayan culture and society. Economic replacement by *Apis mellifera* is not an issue that requires further discussion and is seemingly resolved.^{10,20,27} Here we focus on

biological and ecological factors and list the insights gleaned from several publications in the list of references cited here, in addition to recommendations that can be made as a result of our ongoing studies in Quintana Roo.

The keepers of xunan-kab report that their bees are starving. Honey production and colony size diminish until the bees can no longer defend themselves from natural enemies, or survive the normal or unusual dearth periods. The lack of food stores within the nest is often attributed to scarcity of resources due to deforestation²⁷ in conjunction with competition at floral resources from Africanized *Apis mellifera*.^{5,8,28}

However, the loss of colonies may also be attributed to the overharvesting of honey,³⁰ as we have observed in most of the Mayan communities where meliponiculture is practiced. Beekeepers, in order to meet commercial goals, offset the low honey stores in their hives by increased harvest intensity – clearly a counterproductive practice.

As already stated by other authors, there is little economic incentive to continue keeping xunan-kab and solve the discouraging problems it faces. Xunan-kab colonies now



FIG. 3. The stingless bee Xunan kab, *Melipona beecheii* and its log hives kept by 120 Maya stingless bee keepers studied among 150 villages occurring in the Maya zone of Quintana Roo, Mexico.

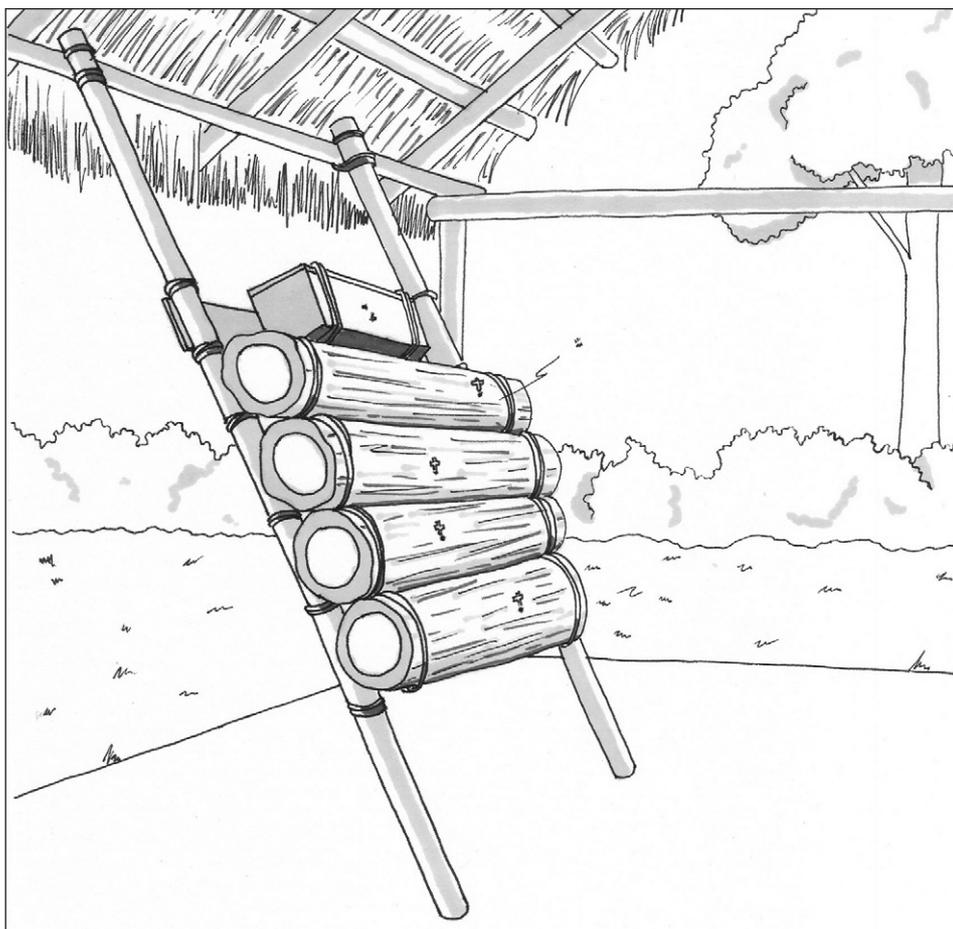


FIG. 4. *Melipona beecheii* colonies should be tight up to the internal structure of the 'palapa' (a bee house made with wood and palms), to protect them against the strong winds of hurricanes.

produce an average of two kg of honey each year,¹ compared with 20 or 30 kg produced by *Apis mellifera* colonies in the region (and averages of 130 kg by well-managed Africanized honey bee colonies in heavily forested French Guiana (B Gautier, D W Roubik, personal observation). Our collaborators in San Hermenegildo, Quintana Roo (table 1), indicated that, up until the 1980s, honey could be harvested from *Melipona beecheii* as often as five times a year. The testimony from this Mayan village is telling. In the early 1990s, three years of poor honey harvest were followed by complete harvest in 1993 of all honey stores of all colonies (30 lbs.). One new colony was brought in from the forest in 1994, and then nearly all colonies died or were sold to research groups shortly thereafter. This village had 40 colonies when we began our work, and now it has none.

Although the honey of xunan-kab has been analysed and used for medicinal purposes by local people, this knowledge has not spread far from scientific circles and local recognition, and more research is required in this field.²² The specific problems for securing a market for stingless bee honey are many. First, the *Codex Alimentarius* allows only honey from *Apis mellifera* to be marketed for human consumption in Europe.⁷ Second, hygienic standards are not always applied to harvesting procedures for stingless bee colonies, which results in lower quality and marketability of the honey. Third, there has been little concerted strategy for the marketing of xunan-kab honey. This honey is sold in small bottles (0.5 litre) in the local markets and within the community where the meliponiculturists live, where it derives no added value. Finally, there remains the question of capacity for fulfilling a steady market demand. There are now few knowledgeable beekeepers to continue the tradition of meliponiculture or to replace the older beekeepers. The younger potential beekeepers are understandably profit-motivated. Many are familiar with management of *Apis mellifera* and no longer appreciate the cultural or ecological value of keeping 'old-fashioned' traditions alive. Mayan villages are becoming depopulated as inhabitants pursue opportunities in cities and tourism areas like Cancún and Playa del Carmen. The techniques and knowledge necessary to maintain and propagate colonies are not being passed on effectively, in either an informal or a formal process of technology transfer, despite excellent published literature on meliponiculture, including extensive illustrations, although only recently has a guide been published in the Mayan language.^{6,13,17,23,24,25,38,42} According to Mayan

'U-HANLI-CAB' RITUAL

This is a ceremony performed by a Mayan priest called "Men" (in the Mayan language) twice a year. For this ritual, an altar is prepared, in which there is an offering of drinks and meals, then the Men asks permission from the gods to harvest the honey. During the ceremony there are prayers in the Mayan language and several musicians called "mayapax" play their instruments while the others are praying, the whole ceremony takes eight hours to complete.

Note: mayapax is a Mayan musician group that plays traditional music.

beekeepers that we have interviewed, this break began about 50 years ago. A result is that well-intentioned yet untrained persons or organizations, many familiar with *Apis mellifera* only, obtain colonies of xunan-kab, but then lose them out of carelessness, or out of ignorance of the dangers faced by these bees.

The Yucatán peninsula sits square in the path of trade winds carrying low pressure systems. In June to November those winds may develop into hurricanes. Nearly every year some area of the peninsula suffers hurricane or tropical storm damage. A survey of meliponiculturists in the state of Yucatán at the end of 2002 revealed an almost complete loss of meliponaries affected by floods brought by hurricane Isidore.^{11,42} Colonies surviving in other areas faced floral depletion caused by hurricane winds – literally all flowers and buds were blown off the trees. Hurricane Gilbert in 1988, Roxan and Opal in 1995, and Mitch in 1998, also severely affected both meliponiculture and apiculture of the peninsula. After a hurricane there is generally a drought that places the xunan-kab bees under food (nectar and pollen) stress, and limits their nest building activity (nests are made and modified with soft mud), and their populations decrease.

Conclusions

Studies of traditional stingless bee keeping in Yucatán conducted in the 1950s–1970s make no mention of a decline in bee abundance or honey production,⁴⁶ but a decline was noted, without a causal analysis, at the end of the 1980s.¹⁹ In the study presented here, approximately 20% of the stingless bee keepers in the zona Maya of the south-eastern Yucatán peninsula reported that over 90% of their colonies of xunan-kab had

perished in the last 25 years. The losses were probably more drastic for the past half century (table 1). The numbers of natural colonies has also dwindled. We have no data to rank the relative importance of exotic honey bee competition, habitat erosion, natural enemy attack, or waning management and husbandry practices. All are implicated, however. Ironically, with the objective of developing meliponiculture and pollinator 'conservation', non-governmental and governmental organizations and institutions have purchased hives from traditional stingless bee keepers. These have been placed with inexperienced individuals, which we believe constitute yet another mortality factor. We therefore suggest that training and management efforts are best directed at established stingless bee keepers able to propagate their colonies.

There are many benefits from preserving the xunan-kab tradition. Not only will an important member of the ecological community and pollinator of diverse plant and tree species^{2,27} be spared local extinction, but a public awareness of the importance of the forest and its biodiversity can be focused on a native species with a long and distinguished local history.³¹ Xunan-kab are among the few native organisms that possess a widely acknowledged status as a cultural, economic, ecological and conservation icon. It is thereby, as are other well-known bees, a de facto indicator of environmental health.^{18,35}

To encourage the present efforts to return to sustainable agro-forestry endeavours and cottage industries that directly benefit the villages of the zona Maya, we most emphatically recommend the following measures to forestall extinction of *Melipona* beekeeping:

- Instructing beekeepers in the construction and use of hives as well as techniques such as feeding that will ensure the survival of existing colonies.
- Hive designs permitting easy opening for inspection and to facilitate artificial feeding.
- Conservative rather than aggressive honey harvest from hives.
- Adopting regulations concerning limits on honey bee (*Apis mellifera*) colony establishment, with the aim of reducing honey bee concentrations in areas of meliponiculture activity.
- Legislation to protect forested areas from complete destruction, especially near villages and cultivated areas.
- Encouraging use of existing protected areas and reserves as sites for development of

meliponiculture and for re-introduction of colonies to suitable habitats.

- Creation of projects at local level focusing on both reforestation (or forest preservation) and meliponiculture.
- Researching product diversity and potentials, specifically in the areas of medicines and cosmetics derived from stingless bees.
- Researching marketing possibilities, especially in the tourism sector.
- Establishing standards for *Melipona beecheii* honey, conditions for hygiene, and hive types.
- Introduction of high school, vocational school and university courses concerning management of *Melipona beecheii* and other stingless bees.
- Informing beekeepers about precautions to be taken in the event of a hurricane.
- Creation of an institutionally funded central bank of colonies and expertise, where new meliponiculturists will be trained, given colonies, and expected to propagate those colonies so that they can return to the bank the colonies that they have borrowed.
- Communication with loggers requesting that trees containing nests of *Melipona beecheii* be spared or that nests discovered be given to appropriate organizations.

At this juncture, it would not be out of place to incite the Mayan ritual of 'u-hanli-cab', for protecting wild bees and the families that have them.¹⁹

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ROGEL VILLANUEVA-G,¹ DAVID W ROUBIK² AND WILBERTO COLLI-UCÁN¹

¹El Colegio de la Frontera Sur, Av. Centenario km 5.5, Apdo. Postal 424, Chetumal, Quintana Roo, C P 77900, Mexico

e.mail: rogel@ecosur-groo.mx

²Smithsonian Tropical Research Institute, Unit 0948, APO AA 34002-0948, USA

e.mail: roubikd@tivoli.si.edu