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PERFORMANCE OF STINGLESS BEES (*Tetragonula biroi* Freise) IN DIFFERENT HIVES UNDER DIFFERENT ECOSYSTEMS[1]

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ABSTRACT

Seven (7) meliponaries in the Bicol region were evaluated for productivity and adaptability of stingless bee colonies hived in traditional and box/OATH/Rafael types. Number of brood layers, pollen and honey pots produced were counted; environmental conditions and other factors influencing their performance were described.

Stingless bees in traditional hives produced more brood, honey and pollen pots, thus better than the OATH Box/Rafael's hive. Meliponaries in different ecosystems had bees producing more broods in traditional hive in forest ecosystem (Barcelona's farm) while lowest in the agroecosystem (Rafael's apiary), but more pollen pots were produced. Higher number of honey pots was obtained in the forest ecosystem hived in traditional type and lowest in the mangrove ecosystem (Servilla's apiary).

Adaptability of techniques for keeping stingless bees is influenced by the technical knowhow of the beekeeper and the environmental conditions. Significant differences among the ecosystems were influenced by the abundance of pollen and nectar sources for the bees, presence of canopies as barriers and shelter for the bees, and absence of pollutants, human disturbance, and pests affecting the bees. Meliponaries in agroecosystem, forest, mangrove and coastal ecosystems differed significantly in adaptability in keeping stingless bees.

Key words: Meliponary, stingless bees, ecosystems, hives

INTRODUCTION

Beekeeping is an agro-industry that promises additional income and nutritious products. It is the art of keeping bees such as the European honeybees, native bees and stingless bees. The stingless bee, *Tetragonula biroi* Freise, locally known as "lukot", is found abundant in the Bicol Region. It is cultured for its honey, pollen and propolis, particularly by local farmers in the Bicol Region (Mostoles and Ruiz, 2004). Its endemicity and abundance in the region made the stingless bees a potential and economical pollinator of agricultural crops. In the wild, stingless bees nest in hollow trunks, tree branches, underground cavities, or rock crevices, but they have also been encountered in wall cavities, old rubbish bins, water meters and storage drums (Mostoles et al 2006).

Bee production is basically ecosystems-related since it is dependent on the biotic and abiotic factors surrounding them. Disturbance of the natural dwellings of organisms can cause devastation or even extinction of the species. Bees are vital to the environment. As such, development works are focused on ensuring that habitats are protected with the involvement of the local people. Bradbear (2004) stated that beekeeping offers a good way for people to create income from natural resources without damaging them, and contributes to the maintenance of biodiversity and pollination. When people know that natural resources have an important role in their livelihoods, and have access to the satisfactory markets for natural resources products, they are motivated to conserve the resource base.

Culturing of stingless bees is being done in areas with sufficient sources of pollen and nectar which are important for its development. Some of the commercial growers of T. *biroi* are in Guinobatan and Ligao City in Albay. Likewise, feral colonies were found in the municipalities of Oas, Camalig, Daraga, Tabaco, Malilipot, Bacacay, Guinobatan, Ligao, Pili, Baao, Tigaon, Goa, Libmanan, Del Gallego, Sipocot, Naga City, Talisay, Daet, Vinzons, Mercedes, Juban, Irosin, Pilar, Casiguran and Sorsogon City (Mostoles et al 2006).

Adaptability trials of stingless bees are needed for a successful pollen and honey production which include determination of the foraging areas of bees, pollen and nectar as well as resin sources, which are all important in brood development. Use of the appropriate hive in the area, as well as assessment of factors influencing bee productivity, is essential before it can be considered as a potential meliponary.

Mostoles et al (2006) conducted an adaptability trial of stingless bees to Japanese-designed hive. *T. biroi* could adapt to the Japanese-designed hives. However, there are some limitations such as difficulty in harvesting of pollen and honey; production of propolis adversely affecting brood development; and lack of protection from parasites and predators.

Mostoles et al (2010) noted that *T. biroi* can adapt to different types of hives such as halved coconut shells used in the traditional method where highest production of honey was obtained, Rafael's hive (Apartment and the Kith type modified) that can produce more pollen pots, Japanese type (Oath type) which has a lesser production of honey and pollen as compared to the two types of hives mentioned.

This is one of the considerations in putting up meliponaries for a successful beekeeping activity. Establishment of meliponaries in the different ecosystems in the provinces of the Bicol region will enhance the industry, provide alternative livelihood to people living in marginal areas and, ultimately, be a means to alleviate poverty.

Thus, this study was conducted with the following objectives: 1) to assess the production of stingless bee products under different ecosystems/meliponaries in the region using different hives; 2) to determine the ecological factors contributing to productivity of the bees in the said ecosystems.

MATERIALS AND METHODS

Description of the meliponaries

Meliponaries are areas where stingless bees are kept or cultured for production of more colonies as well as their products. Seven (7) meliponaries were selected representing different ecosystems distributed in the provinces of Sorsogon, Camarines Sur, Masbate, Catanduanes and Albay. No meliponary exists in Camarines Norte, thus, this province was not represented in this study.

Philippine Honeybee Industries Inc. (PHI) Apiary (Castilla, Sorsogon)

The PHI apiary is owned by a beekeeper trained by the Regional Apiculture Center at Central Bicol State University of Agriculture and Provincial Apiculture Center at Sorsogon State College. It is situated along the left side (going to Sorsogon) of the national road of Barangay Del Rosario, Castilla. Mr. Tim de Los Reyes manages the apiary, together with his in-laws. It is an apiary since they culture both the stingless bees and the native honeybees. They have at least 50 colonies of *Apis cerana* and 10 colonies of *Tetragonula biroi* (Figure 1a). They also sell both honey and colonies. They earn income as well from educational tours/visiting the apiary.

The PHI is considered as an apiary located in an agroecosystem since it is situated in a coconut-based cropping area with an assortment of fruit and ornamental crops.

Fr. Rogelio Barcelona's Meliponary (Pilar, Sorsogon)

The meliponary located in the hilly part of Pilar is owned by a hobbyist, Fr. Barcelona, who manages the Training Center for Seminarians. The location inspired him to put up a meliponary with solely stingless bees being cultured in the area. Feral colonies have been collected from the wild, 30 colonies are maintained by a trained local beekeeper using the traditional hive and the modified OATH type (Figure 1b). At present, he is again putting up a new meliponary in Camarines Sur.

Rafael's Apiary (Paulog, Ligao City, Albay)

Mr. Henry Rafael is the owner of the Rafael's apiary which cultures both *A. cerana* and *T. biroi*. He was trained by the Regional Apiculture Center (RAC) through the City Agriculturist. He produces both starter colonies and honey in his apiary which is located in barangay Paulog, Ligao City. He designed a hive which was named by the RAC as the Rafael's hive. Aside from bottled honey, he sells chunk honey of the stingless bees. He maintains 100 colonies of stingless bees and 25 colonies of laywan in his apiary (Figure 1c).

Abad's Meliponary (Aroro, Goa, Camarines Sur)

The meliponary at Aroro is one of the oldest farms owned by Mr. Eriberto Abad who obtained his training in keeping bees as early as 1998. His apiary is located in the mountain barangay of Mt. Isarog Park West. It is not so accessible due to the limited public conveyance facilities in the area. He maintains no less than 30 colonies of stingless bees. He sells only honey but not his colonies. The vegetation is rich, thus his colonies remain strong throughout the year (Figure 1d).

MTB Farm (San Vicente, Pamplona, Camarines Sur)

The farm owned by Atty. Marito T. Bernales (MTB) is an agroecosystem and basically a coconut-based area suitable for keeping stingless bees. Initial stocks were maintained and studied in the farm. At present, the bees have adapted in the area with abundant plants to be pollinated. There are 45 colonies of stingless bees from the initial 10 colonies pollinating the coconut (Figure 1e).

Servilla's Meliponary (San Pascual, Masbate)

The meliponary is owned by one of the authors, Mr. Ezra Servilla, who started putting up bee colonies in the mangrove area of San Pascual, Masbate. He maintained 12 colonies in his apiary which were hived using the traditional type (Figure 1f).

Balmadrid's Meliponary (Virac, Catanduanes)

The meliponary found at Virac is owned by Engr. Balmadrid. He maintains both feral and purchased colonies from established beekeepers. His meliponary is situated near the coastal area (Figure 1g).

Monitoring and Evaluation of Meliponaries

For each of the meliponaries evaluated, three colonies (both the traditional and OATH type, if available) were marked to serve as colony samples. Initial numbers of brood layers, pollen and honey pots and amounts of propolis were determined. After three months, the colonies were examined again for the number of broods which developed, number of pollen and honey pots. Data obtained from the different apiaries were compared.

Figure 1a. The apiary of Mr.Tim de los Reyes of Castilla, Sorsogon

Figure 1b. The apiary of Fr. Barcelona at Pilar, Sorsogon.

Figure 1c.The apiary of Mr. Henry Rafael of Paulog, Ligao City, Albay.

Figure 1d. The apiary of Mr. Abad of Aroro, Goa, Cam.Sur.

Figure 1e. Apiary of Mr. Marito Bernales of San Vicente, Pamplona, Cam.Sur.

Figure 1f. Apiary of Mr. Ezra Servilla of San Pascual, Masbate.

Figure 1g. Apiary of Mr. Gil Balmadrid of Catanduanes

Identification of the pollen sources of the stingless bees and plants in bloom within the vicinity of the apiary was done to gauge the adaptability of the bees to the ecosystems. Photo documentation of these plants was done. Other factors affecting the performance of the colonies of stingless bees, aside from the bee forage, were identified.

The means for the number of brood layers, pollen and honey pots produced were used to describe the differences in productivity related to the type of hive and the meliponiary (ecosystem). The differences in ecosystems in terms of suitability to meliponiculture were compared using the analysis of variance.

RESULTS AND DISCUSSION

Productivity of the stingless bees in different hives and ecosystems/meliponaries

Brood development involves the number of layers of brood combs produced by the colony. For every stingless bee colony, increase in brood production corresponds to emergence of more workers capable of foraging food (nectar and pollen) from the wild and signals a beekeeper when the colony is due for division. Brood development in the colony is a parameter in determining the adaptability and performance of the bee colony in an ecosystem. Strength of the colony is measured by the population of the emerging adults in addition to the number of pollen pots produced which serves as their protein source and the honey pots as their energy source.

Colonies hived in traditional and OATH/Rafael types of hives in the apiaries at Ligao, Pilar and Libmanan showed differences in the number of brood layers developed after three months, as well as the number of pollen and honey pots produced. The use of traditional hives resulted in more brood layers than the OATH or the box type when grown in the apiaries of MTB and Barcelona. However, at the Rafael's apiary, the number of broods in the OATH type was found relatively higher than those in the traditional hives. More brood layers were found in the Barcelona's farm and lowest in the Rafael's apiary. The apiary of Fr. Barcelona is suitably located far from the main highway and residential area with sufficient water supply from a nearby river and the topography is rolling, thus, sparing it from strong winds during typhoons. Sources of nectar are the coconut trees blooming all-year- round. Trees are the natural windbreaks in the area which also provide canopy to the bees. All of these conditions account for the enhanced development of the brood. Samejima et. al. (2001) found that net density of the vegetation is positively related to the density of large trees. Colonies were more abundant in the primary forests and lesser in disturbed forests.

With pollen pot production, colonies in traditional hives had higher mean counts than in the OATH type in apiaries of Barcelona, Rafael and MTB. Among the apiaries having traditional hives, more pollen pots were produced at the Rafael's apiary, followed by Balmadrid's apiary. Rafael's apiary is situated in an agroecosystem area having abundant sources of pollen from corn, fruit trees and vegetable crops. It was noted that the coastal area where the Balmadrid's apiary was located had abundant coconut and fruit trees accounting for the higher pollen pots produced. On the other hand, Barcelona's colonies had lower pollen pots produced but brood development was faster, implying that less pollen grains were stored since these were effectively utilized by the bees in enhancing colony strength.

Similarly, the number of honey pots produced by colonies in OATH type was low at the Barcelona and MTB apiaries, but high at the Rafael's apiary. Those colonies in traditional hives produced more honey pots at Barcelona's apiary due to the abundance of nectar from coconut. Colonies at Servilla's apiary had the lowest number of honey pots produced due to the limited source of nectar in the mangrove area.

However, productivity of the bees in the ecosystem and the type of hive are not merely attributed to the number of brood layers, as well as the number of pollen and nectar pots produced, but also to other factors such as pollen and nectar sources, presence of pests of bees and prevailing environmental conditions in every type of ecosystem.

Ecological factors influencing success of meliponiculture

One of the essential factors for the success of meliponiculture in an ecosystem is the presence of abundant bee forage. As such, identifying these plants frequently visited by the bees and noting the time of blooming are major activities in the meliponary.

Pollen sources of stingless bees.

Bee bread collected from the various meliponaries was processed through acetolysis to identify the plant pollens which are foraged by the worker bees. Some of the sources of pollen collected by the bees are shown in Figure 2 and 3.

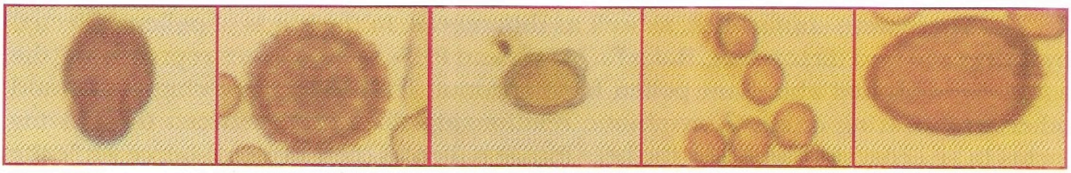
At the Rafael's apiary, Paulog, Ligao City, the most common pollen sources were corn, jackfruit, coconut, kuri-kuri, squash, ampalaya, *Euphorbia*, *Mimosa pudica*, santan, legumes and eggplant. Corn and coconut were the most abundant sources in the area.

The PHI or Tim de los Reyes' apiary at Cumadcad, Sorsogon had coconut, mango, avocado, star apple, papaya, banana, jackfruit and other flowering plants as sources of pollen. Through examination though, the bee bread showed a dominance of coconut and avocado pollen types.

Barcelona's apiary at Pilar, Sorsogon: Coconut, mahogany, gmelina, mango, narra, cacao, and pili were found in the area. However, pollen types collected from the bee bread were of coconut, narra and mango. Other fruit-bearing trees were found in the apiary but no indications of presence of their pollen types were observed in the acetolyzed samples.

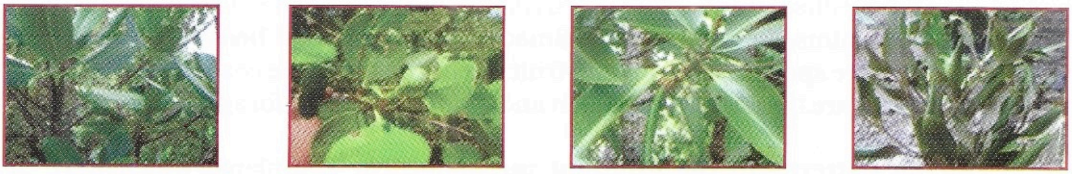
Servilla's meliponary showed the presence of pollen from mangrove plant species as well as coconut. Other crops such as corn, banana, jackfruit and mango were also considered as the pollen sources.

Balmadrid's meliponary had coconut as the major pollen collected by the stingless bees. Other pollen types found in the samples were acacia, golden shower,



Musa sp. *Cucurbits* *Avecinnia alba* *Tuba-tuba* *Cocos nucifera*

Figure 2. Some of the acetolyzed plant pollens identified in the bee bread of stingless bees.



Rhizophora mucronata *Sonnerata alba* *Rhizophora apiculata* *Avicennia alba*

Zea mays *Averrhoa balimbi* *Persia americana* *Cocos nucifera*

Pithecolobium dulcis *Leucaena leucocephala* *Musa sp.* *Mangifera indica*

Cucurbita maxima *Wedelia biflora* *Carica papaya*

Figure 3. Some of the pollen and nectar forages of stingless bees in the different apiaries.

mango, banana, papaya, guyabano, avocado, santol, mango, corn, guava and some flowering plants.

MTB meliponary had the following pollen sources: coconut (as the most dominant), papaya, banana, ipil-pil, balimbing, lemon, avocado, squash, kamias, lipote (baligang).

There were similarities, as well as differences, in the kinds of pollen collected by the bees to feed their young. Rafael's, MTB's and PHI's meliponaries representing the agroecosystem had abundant pollen from coconut, fruit trees, flowering plants and other fruit-bearing crops. A symbiotic relationship does exist between these living forms in an ecosystem whereby the bees forage pollen as their protein source while the plants benefit from the bees through pollination. In coconut areas alone, a 70% increase in fruit production was observed. The same benefits can be derived from meliponiculture in other ecosystems. Abad's and Barcelona's apiaries situated at higher elevations considered as forest ecosystem, had as pollen sources forest trees, fruit crops and palms. Servilla's and Balmadrid's apiaries had bees foraging pollen from mangrove tree species, coconut and fruit trees growing in the coastal lines. Shown in Figures 2 and 3 are the acetolyzed pollen and plants serving as forage for the bees.

Bloom patterns in the different meliponaries. The plants which were in bloom during the conduct of the study were summarized based on the kind of ecosystem that the meliponary is classified to belong as shown in Table 1.

During the 3-month calendar, it was observed that in the mangrove area represented by Servilla's apiary, there were six plant species which continuously bloomed from December to February while myiapi bloomed only in February.

Twelve species were in bloom in the meliponaries under an agroecosystem for the period of three months while star apple and avocado were in bloom only in February and January-February, respectively. In apiaries in upland and semi-forest areas, there were 3 plants in bloom from December to February, narra and santol from January to February and mahogany in February. In the coastal areas of Catanduanes, coconut and the vegetable crops were in bloom within three months, whereas baligang and santol were in bloom from January to February, while balimbing was in bloom only in February.

The bloom pattern assessment conducted in this study was limited to three months due to budgetary constraints and support from the apiary owners in terms of providing information. As such, a year-round monitoring will be done to have more comprehensive data which can serve as guide to the beekeepers in every province.

Pests of stingless bees. Stingless bee hives in different containers in the different meliponaries were affected by pests which led to colony collapse or absconding. In almost all of the meliponaries visited, the frequently encountered pests were vespids, small hive beetles, metallic beetles, wax moth, predatory bugs (reduviids), lizards, cockroaches, frogs and chicken. Small hive beetles infest the colonies only when water penetrates into the hive and dampens the brood. This results in the collapse of the colony. Similarly, the lizards and cockroaches enter the hive when the colony becomes weak. Their infestation results in damage to the pollen and honey pots, the brood chamber and even the propolis surrounding the brood. The vespids,

Table 1. Bloom calendar (marked with X) from December 2011 to February 2012 in the different meliponaries in the Bicol region, 2012).

Ecosystem	Meliponary	Plant Species	Common name	Dec.	Jan.	Feb.
Mangrove	Servilla	*Rhizophora apiculata*	Bakawang lalaki	X	X	X
		Rhizophora mucronata	Bakawang babae	X	X	X
		Acacia sp.	Acacia	X	X	X
		Nypa fruticans	Nipa	X	X	X
		Sonneratia alba	Pagatpat	X	X	X
		Avicennia alba	Myiapi			X
		Cocos nucifera	Coconut	X	X	X
Agroecosystem	Rafael	*Mangifera indica*	Mango	X	X	X
	MTB	*Artocarpus heterophyllus*	Jackfruit	X	X	X
	PHI	*C. nucifera*	Coconut	X	X	X
		Musa sp.	Banana	X	X	X
		Zea mays	Corn	X	X	X
		Canarium ovatum	Pili	X	X	X
		Solanum melongena	Eggplant	X	X	X
		Wedelia biflora	Kuri-kuri	X	X	X
		Pithecolobium dulcis	Camachile	X	X	X
		Chrysophyllum caimito	Star apple			X
		Persia americana	Avocado		X	X
		Carica papaya	Papaya	X	X	X
		Averrhoa bilimbi	Camias	X	X	X
		Cucurbita maxima	Squash	X	X	X
Forest/Upland	Barcelona	*C. nucifera*	Coconut	X	X	X
	Abad	*Sweitenica macrophylla*	Mahogany			X
		Pterocarpus indicus	Narra		X	X
		Gmelina arborea	Gmelina	X	X	X
		Leucaena leucocephala	Ipil-ipil	X	X	X
		Sandoricum koetjapi	Santol		X	X
		Musa textiles	Abaca	X	X	X
		Canarium ovatum	Pili	X	X	X
Coastal	Balmadrid	*C. nucifera*	Coconut	X	X	X
		Averrola carambola	Balimbing			X
		Sygium polycephaloides	Baligang		X	X
		S. koetjapi	Santol		X	X
			Vegetables	X	X	X

frogs and reduviid bugs affect the colonies. They prey on the foragers either while the latter are outside the hive or even at the hive entrance. This results in weakening of the hive and the adverse effect is colony death.

One of the pests noted only in the Sorsogon meliponaries is a bluish green beetle which feeds on the batumen and cerumen inside the hive and constructs pots at the bottom of the hive using the propolis.. Colonies propolize when there are invading pests or the temperature is lower than that required for their development.

Adaptability of stingless bees under different ecosystems. Environmental concerns and technical considerations were two of the factors which influence the success of keeping stingless bees in an ecosystem (Table 2).Further tests showed that comparing the different ecosystems, the forest ecosystem (Goa) significantly differed from other ecosystems (Table 3) in terms of providing suitable conditions contributing to the success of beekeeping.

Table 2. Ecological adaptability of meliponiculture in the different ecosystems where meliponaries in the Bicol region are located (CY 2012-2013).

ECOLOGICAL ADAPTABILITY ASPECTS	MEAN RESPONSES*
Social Acceptability	3.10 ab
Economic Viability	3.05 b
Technical Considerations	3.37 a
Marketability	3.14 ab
Environmental Concerns	3.55 a

*Means followed by the same letter are not significantly different at 1% DMRT.

Table 3. Adaptability of meliponiculture in meliponaries found in different ecosystems in the Bicol region (CY 2012-2013).

ECOSYSTEM	MEAN RESPONSES*
Barcelona's Farm , Putiao, Pilar (Sorsogon)	2.67 b
MTB Farm, San Vicente Pamplona (Camarines Sur)	2.17 b
Abad's farm ,Aroro, Goa (Camarines Sur)	3.33 a
Rafael's farm, Paulog, Ligao City (Albay)	3.17 ab
PHI, Del Rosario, Castilla (Sorsogon)	3.17 ab
Balmadrid's farm, Palta Small, Virac (Catanduanes)	3.17 ab
Servilla's farm, San Pascual (Masbate)	2.67 b

*Means followed by the same letter are not significantly different at 1% DMRT.

Meliponaries situated in an undisturbed ecosystem produce more adapted bees and thus, success in beekeeping is quite high. Stingless bees are naturally found in the wild particularly in forests, therefore, once collected, they should behaved under conditions similar to those in their natural habitat for better adaptability. The three other apiaries, namely: Rafael's, PHI and Balmadrid's apiaries, also did not differ significantly in terms of ecosystem suitability for stingless bees. All of them are characterized as agroecosystems; thus, there is also an abundant source of pollen and nectar from coconut and other fruit trees. However, these apiaries are situated near residential areas and near the national highway, thus more prone to disturbance.

Based on the evaluation of the possible factors in the ecosystem which are important for the success of meliponiculture, the following were identified: 1) abundance of pollen and nectar sources for the bees; 2) presence of the canopies which serve as barriers and shelter for the bee colonies; 3) absence of pollutants such as smoke (burning of plant refuge) and pesticide sprays ; 4) minimal access to people who might disturb the colonies ; and 5) absence of pests which adversely affects the population of the colonies. Mostoles and Ruiz (2010) stated that stingless bees are indicators of pollution and indirectly promote biodiversity conservation.

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Performance of the stingless bees in selected meliponaries in the Bicol region was evaluated by determining the productivity and adaptability in the different ecosystems. Colonies hived in the traditional method using coco shells and colonies in boxes were compared in terms of brood development and production of pollen and honey pots. The bee bread was examined to identify the plant pollens utilized by the bees. Pests of stingless bees were identified.

Brood developed faster and with more brood layers in colonies hived in coco shells (traditional) at MTB's and Barcelona's meliponaries. More pollen pots were produced in colonies hived in coco shells at the Rafael's meliponary in Ligao. Honey pots produced by colonies were higher in boxes at Rafael's' meliponary and coco shells at Barcelona's meliponary.

Pollen sources at the Rafael's, MTB's and PHI's meliponaries were abundant having coconut, fruit trees, flowering plants and fruit-bearing crops in the agroecosystem Sources of pollen at Abad's and Barcelona's meliponaries were forest trees, fruit crops and palms while those at Servilla's meliponary mangrove plant species such as nipa, bakawang lalaki and babae, and coconut.

Small hive beetles, metallic beetles, wax moth, reduviid bugs, vespid wasps, frog, cockroaches, lizards are the pests of stingless bee colonies which made them abscond, propolize or die.

Ecological adaptability of the stingless bee technology under different ecosystems significantly differed, with technical knowhow of the beekeeper and the environmental conditions as contributory factors for success of beekeeping. Highly significant differences among the ecosystems were influenced by factors such as abundance of pollen and nectar sources for the bees, presence of canopies which serve as barriers and shelter for the bee colonies, absence of pollutants and human disturbance, and absence of pests which affect the population of the colonies.

For productivity of stingless beekeeping in the ecosystem, the traditional hive is recommended for success in producing starter colonies and by products. Keeping colonies in boxes is recommended for chunk honey and pollen production as well as protection from pests. Stingless bees in traditional hive is more adapted in ecosystems with sufficient nectar and pollen sources, less disturbance, clean and unpolluted surroundings. Managing the pests of the stingless bees is recommended. An individual who intends to venture on meliponiculture must first conduct an environmental assessment of the prospective area. Technical know-how as well as the viability and marketability of the technology must also be considered.

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