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Rescue of Stingless bee (Hymenoptera: Apidae: Meliponini) nests: an important form of mitigating impacts caused by deforestation

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Abstract

As stingless bees are important pollinators of wild and cultivated plants, their preservation is of vital importance to sustain the global ecosystem and to safeguard human food resources. The construction of large dams for the production of energy involves the removal of wide extents of riparian vegetation, where many species of bees, especially Meliponini, build their nests. The rescue of bee colonies is essential, not only in the conservation of pollinators, but also in the use of these colonies in meliponiculture and biological research. The aim of this work was to describe the procedures used in the rescue of stingless bee colonies at the time of deforestation, prior to initiating construction of a large dam in the Madeira River (Amazon Basin, Brazil). With simple equipment and widely known methods of meliponiculture 287 stingless bee nests were rescued, of which 15.7% were reallocated and 26.5% perished. The remaining 57.8% recovered well and were donated to local stingless beekeepers. The rescue of Meliponini nests during deforestation, besides resulting in the conservation of numerous colonies of various species, also contributes to the generation of environmental and social benefits.

Introduction

Pollinators, and especially bees, are responsible for the production of fruits and seed crops that are essential to guarantee human food resources, as well as in the maintenance of worldwide economy (Tepedino, 1979; Slaa et al., 2006; Klein et al., 2007). Unfortunately, pollinator diversity and abundance has decreased worldwide, due to deforestation, habitat fragmentation and the use of pesticides in agriculture (Garibaldi et al., 2011; González-Varo et al., 2013). In natural habitats, the lack of pollinators detrimentally affects wild plant reproducibility, thereby causing local extinction, and adversely affecting other dependent species (Allen-Wandell et al., 1998; Biesmeijer et al., 2006; Steffan-Dewenter et al., 2006; Ramírez et al., 2011).

Stingless bees (Meliponini) have been identified as important pollinators in both natural environments and crops (Imperatriz-Fonseca et al., 2006; Slaa et al., 2006). Hence their preservation is of the utmost importance for the sustenance of ecosystems and food resources worldwide. Many species of Meliponini are especially vulnerable to environmental degradation. In *Melipona* Illiger bees, for example, inbreeding can lead to decline or even the extinction of native bee populations through the presence of diploid males (Kerr, 1987; Carvalho, 2001; Alves et al., 2011; Francini et al., 2012).

Meliponini bees inhabit tropical and subtropical regions of the world, their diversity and abundance reaching the highest expression in the Amazon Basin (Michener, 2007; Camargo & Pedro, 2012). Thus, this region has become an essential area for research and conservation.

In Brazil, as in other tropical countries worldwide, economic growth has given rise to the construction of large infrastructure projects, especially power plants. The construction of large dams for the production of energy involves the removal of wide extents of riparian vegetation prior to the formation of reservoirs, thereby causing damage to the entire aquatic and riparian environment (Junk & Mello, 1990). Riparian

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environments are especially important ecosystems for wildlife, where many bee species, especially Meliponini, find the appropriate conditions for nesting (Roubik, 1989, 2006; Camargo, 1994).

In this context, the inclusion of stingless bee rescue programs in infrastructure projects, such as power plant construction, is an effective way of mitigating environmental damage caused by deforestation. Furthermore, the rescue of stingless bees nests, besides providing an unusual opportunity of data sampling for research in various aspects of Meliponini biology, can be a source of colonies appropriate for meliponiculture, an important activity in sustainable land use and environmental education (Kerr et al., 1996; Souza et al., 2012).

The aim of this study was to describe plausible procedures for rescuing stingless bee nests, and to discuss the possibilities for improvements in deforestation activities. Data was also presented on the various bee-species found during deforestation, prior to building the Santo Antonio hydroelectric power plant on the margin of the Madeira River, Rondonia State, Brazil.

Material and Methods

Study area and equipment used

The rescue of stingless bee nests was undertaken within the south-western Amazon Basin in the state of Rondonia, northern Brazil, on the left margin of the Madeira River (8° 47′ 29.49″ S and 63° 58′ 58.5″ W). This area was undergoing intense deforestation prior to construction of the Santo Antonio hydroelectric power plant. The area consists of 1,620ha of preserved riparian forest. The regional climate is equatorial Af (Köppen, 1948), with an average annual rainfall of 2,300mm, and an average annual temperature of 26°C. The intense dry season lasts from May to August.

Rescue was carried out between August 2010 and October 2011. The rescue teams consisted of a specialist in stingless beekeeping (meliponiculture) and two field assistants with experience of working in forest environments. One of the field assistants latter was a chainsaw operator. All the members used personal protective equipment for fauna rescue. The tools used were those traditionally employed in meliponiculture for handling colonies (Nogueira-Neto, 1997) (Table 1). Beekeeper suits were also used for protection against defensive species. A four-wheel-drive pickup was the means of access to areas of deforestation and the transportation of rescued colonies.

Table 1. List of basic material for one stingless bees rescue team (three people).

Basic tool for the rescue of Meliponini bees	
Description	Quantity
Chainsaw	1
Bucksaw	1
Hatchet	1
Metal wedges	2
Crowbar	1
sledgehammer	1
Stone chisel	1
Machete	1
Knife	1
Painting spatula	1
3” Paintbrush	1
Syringe >20ml	Material of continuous use
Plastic bottles 500ml	Material of continuous use
Plastic bag >1l	Material of continuous use
Plastic tray	2
Insect aspirator	1
Samples containers	Material of continuous use
Alcohol 96%	Material of continuous use
5L bottle with water	2
Beekeeper suit	3
Wood stapler	1
Metal net of fine mesh	Material of continuous use
Strong scissors	1
Stingless bees’ hives	Material of continuous use
Striped warning tape	Material of continuous use
Adhesive tape	Material of continuous use
Rope	>10 m
Binoculars	1
Camera	1
GPS	1

Search and rescue of nests

The search lasted eight hours a day in four distinct situations: coincident with deforestation (forefront) during cutting; lugging to storage; log stacking; and the final stage, loading for transportation out. In all of the situations, active search went ahead.

Binoculars were used in the search for nests, while simultaneously everybody was on the look out for bees among logs and branches. On coming across a nest, the surrounding area was taped off. GPS data of the located colonies, photos and samples of worker bees (n~10) in alcohol 96%, were collected for species identification.

After localizing and signalizing the colonies, in accordance with nesting biology, a decision was taken as to whether to transfer to a beehive or to leave wherever the colony had been originally found, in the original tree trunk or branch, in a termite nest, or an external nest.

Vertical modular hives, adapted from Venturieri (2004) and Carvalho-Zilse et al. (2005) were used. These came in two sizes: inner space 12x12x7 cm, for small colonies, and inner space 20 x 20 x 7cm, for larger ones. Cube-shaped boxes, inner space 40 x 40 x 40cm, were used for species in which nest architecture was not adjustable to vertical boxes.

If the decision was to do the transference to a beehive, the trunk or branch was opened with a chain saw, according to instructions by Nogueira-Neto (1997) and Coletto-Silva (2005), but with adaptations. The transference of colonies associated with termitaria and external nests was with stone chisels, hammers, matches and knives.

Pollen and honey pots were not transferred to beehives, so as to avoid parasites. Only the light colored, mature brood combs (pupal stage and the last larval stage) and cerumen were transferred. Food storage pots were placed in plastic bags or boxes and stored in a refrigerator. Pollen and honey were used for feeding the colonies later on. Brood combs containing larval food were discarded.

After an interval of approximately 24 hours, usually on the following day, the colonies that had been transferred to beehives were sealed in, by closing the entrance, and then transported to our field base, which was 3 to 32km from the rescue areas, for a period of observation and care. This was done at the end of the day, in order to capture the maximum number of forager workers in transit. During the observation and care period (c. one month), the colonies were nourished with sugar syrup (or their own honey) and their own pollen. Internal and external feeders were used for sugar syrup (Kerr et al., 1996; Nogueira-Neto, 1997), whereas only internal ones were for pollen. Cerumen, i.e., a mixture of bee wax and resin used for building nest structures, was collected, washed and returned to the nests for reutilization by the workers. Vinegar traps were employed against Phoridae fly infestation (see Nogueira-Neto (1997) for details of parasite control methods).

In the case of colonies to be left within their original log, the nest size was first estimated according to the species in question, whereupon the log was trimmed at both ends with a chainsaw. Afterwards, these were sealed by way of a thin metal mesh, to so avoid the entrance of Phoridae flies and the exit of bees. In cases of species associated with termites or those with external nests, and depending on the possibility, the entire structure was detached from the tree.

These colonies were transported to our field base or re-allocated in the nearby forest at a level higher than the final water level of the reservoir. The decision for the right procedure depended on the biology of the species found, or in another words, nesting habits, behavior, chances of survival in a bee hive, and the size of the trunk or external nest.

The colonies transported to the field base after the recuperation period, were donated to those local, experienced stingless beekeepers who presented the necessary conditions for giving special care. Bee samples were later identified by Dr. Silvia R. M. Pedro (FFCLRP, Universidade de São Paulo, Brazil).

Results and Discussion

Throughout the deforestation process, 416 colonies of stingless bees were found. From these, bee-specimens were collected from 118 nests (28% of the total found), comprising 36 species of 15 of the 33 known Neotropical genera of Meliponini (Table 2). It shows that the number of species in the area is certainly higher and the rescue of Meliponini is essential during deforestation activities, not only in the Amazon region, but also in other tropical forests.

Being present at the forefront of deforestation was an important step in the rescue of stingless bees, since the impact of large trees falling to the ground often resulted in cracks in the hollow branches or trunks where nests were located. Most of the Meliponini nests found were in branches (up to 20m high). Since brood combs, as well as honey and pollen pots, were seriously damaged after the fall, colonies had to be quickly transferred to beehives. As external nests (*Trigona* Jurine) and those in termitaria (mainly *Partamona* Schwarz) were also often severely damaged with the fall, there was no other choice, but to attempt transferring them to a beehive, as well.

A special problem in the forefront of deforestation, especially in the case of *Melipona* bees, was the destruction of colonies by deforestation workers to collect honey. The workers knew from tradition that *Melipona* bees are harmless and produce good honey. In this case, the presence and orientation given by the rescue team were fundamental in preserving colonies of a harmless species. There was also evidence of colonies of *Melipona* in cracked branches, some days after felling, having fallen prey to *Eira barbara* Linnaeus (Mustelidae) and *Potos flavus* Schreber (Procyonidae), mammal species common in the area, but of minor problem. The attacks of these animals were also recorded by Nogueira-Neto (1997).

At the second stage in the deforestation process, during lugging to storage, colonies, which were not evident at the time of cutting, were discovered, whereupon machine operators usually gave aid in signalizing. However, upon removal from one place to another, a further mishap appeared. Several colonies presented problems with strong insolation, honey fermentation and infestation by Phoridae and *Hermetia* Latreille. In this case, transfer to a beehive was considered to be the best, immediate, option.

During the process of stacking, the rescue team was able to avoid loosing species with cryptic behavior, such as *Plebeia* Schwarz. In the final stage, when the logs were being loaded for transportation, colonies, such as of *Tetragonisca* Moure, *Nannotrigona* Cockerell, *Scaptotrigona* Moure, *Frieseomelitta* Ihering, and *Trigona* Jurine, were still found.

Considering all the stages in the deforestation process, 416 stingless bee nests were found. However, 31% of these had been destroyed (n = 129) either during felling, in attempts to abstract honey, or by parasites. However, the remainder (69%, n = 287) presented mature brood combs and queens and could consequently be recuperated.

As regards species of the genera *Melipona*, *Scaptotrigona*, *Tetragona* Lepeletier & Serville, *Frieseomelitta, Nannotrigona,* and *Tetragonisca*, there were no relevant problems for most following rescue with the methods used for transference to beehives. The importance of the non-transference of brood

Table 2. Species identified during the Meliponini rescue at Santo Antônio Dam, Madeira River, Brazil.

Species	N. nests	Substratum
Cephalotrigona femorata (Smith, 1854)	9	trunk/branch
Frieseomelitta silvestrii (Friese, 1902)	1	trunk/branch
Frieseomelitta trichocerata Moure, 1990	7	trunk/branch
Melipona (*Michmelia*) *brachychaeta* Moure, 1950	2	trunk/branch
Melipona (*Michmelia*) *seminigra abunensis* Cockerell, 1912	5	trunk/branch
Melipona (*Michmelia*) sp. 1 (gr. *rufiventris*)	1	trunk/branch
Melipona (*Michmelia*) sp. 2 (gr. *melanoventer*)	1	trunk/branch
Nannotrigona melanocera (Schwarz, 1938)	3	trunk/branch
Oxytrigona cf. *flaveola* (Friese, 1900)	3	trunk/branch
Oxytrigona obscura (Friese, 1900)	1	trunk/branch
Partamona ailyae Camargo, 1980	7	termitaria/trunk
Partamona batesi Pedro & Camargo, 2003	5	termitaria
Partamona sp.	1	termitaria
Partamona testacea (Klug, 1807)	4	termitaria
Partamona vicina Camargo, 1980	1	termitaria
Plebeia alvarengai Moure, 1994	1	trunk/branch
Ptilotrigona lurida (Smith, 1854)	8	trunk/branch
Scaptotrigona polysticta Moure, 1950	1	trunk/branch
Scaptotrigona sp. 1	1	trunk/branch
Scaptotrigona sp. 2	1	trunk/branch
Scaptotrigona sp. 3	3	trunk/branch
Scaptotrigona sp. 4 (gr. *bipunctata*)	1	trunk/branch
Tetragona clavipes (Fabricius, 1804)	9	trunk/branch
Tetragona essequiboensis (Schwarz, 1940)	1	trunk/branch
Tetragona goettei (Friese, 1900)	4	trunk/branch
Tetragona truncata Moure, 1971	1	trunk/branch
Tetragonisca angustula (Latreille, 1811)	14	trunk/branch
Trichotrigona sp. n	1	*
Trigona branneri Cockerell, 1912	2	external
Trigona chanchamayoensis Schwarz, 1948	1	external
Trigona crassipes (Fabricius, 1793)	5	trunk/branch
Trigona dallatorreana Friese, 1900	1	external
Trigona guianae Cockerell, 1910	5	trunk/branch
Trigona pallens (Fabricius, 1798)	1	trunk/branch
Trigona truculenta Almeida, 1984	1	trunk
Trigona williana Friese, 1900	5	trunk/branch

combs containing larval food and storage pots to the beehives becomes evident, since the problem of parasite infestation, especially by Phoridae flies, was thus avoided. Most species recovered well, when transferred to beehives and brought to our field base for the period of observation and care. In the case of the presence of Phoridae or *Hermetia* flies, the problem was solved by using vinegar traps. This technique is widely known in meliponiculture (Nogueira-Neto, 1997). As 166 colonies, 57.8% of all those rescued, were considered to be in good condition, these were donated to local stingless beekeepers.

In the case of some species, transfer to beehives compensated little, due to hardy defense and sensitivity to rescue, leading to perishing after disturbance. This occurred in the case of *Ptilotrigona lurida* Smith, *Trigona truculenta* Almeida and other species of *Trigona*, mainly those with external nests. In the case of these species, *Oxytrigona* spp., due to their defensiveness, and colonies attached to or inside very large logs, they were considered preferable to reallocate the entire colony, as it was, to the nearby forest with the aid of deforestation machinery, up to the very margin of the future reservoir. We reallocated 15.7% of the rescued colonies (n = 45), including mainly *P. lurida*, *Trigona* spp., *Partamona* spp. and *Oxytrigona* spp.

However, attention is called to the difficulty in finding a safe place to leave the colonies, since besides the possibility of exceptional flooding, there is the lack of adequate and appropriate programs to monitor colony survival. Furthermore, as already pointed out, most colonies were severely damaged during felling, with frequent parasite infestation. As regards colonies brought to the field base for care and observation, 26.5% (n = 76), among species with external nests, colonies left inside logs and termitaria, perished, most after one to two months due to Phoridae fly infestation. These factors led to suppose that the probability of reallocated colony survival would be low.

Thus, apart from the destiny chosen for rescued colonies (re-allocation or donation to stingless beekeepers or research centers), a monitoring program is called for as a way of evaluating colony survival and guiding future rescue action. As part of this monitoring process, and in the case of donations to beekeepers, it is also important to promote training courses for updating knowledge (Fig 1). Furthermore, it is necessary to have a larger number of available rescue teams, at least one per forefront of deforestation, for improving results. Stingless-bee rescue, concomitant with deforestation, is imperative as a means of aiding in the conservation of pollinators, for providing singular opportunities for data sampling on stingless bee biology, and in support of meliponiculture. By using the simple methods employed in meliponiculture, the rescue of Meliponini can mitigate the various environmental impacts caused by deforestation, besides generating social and cultural benefits.

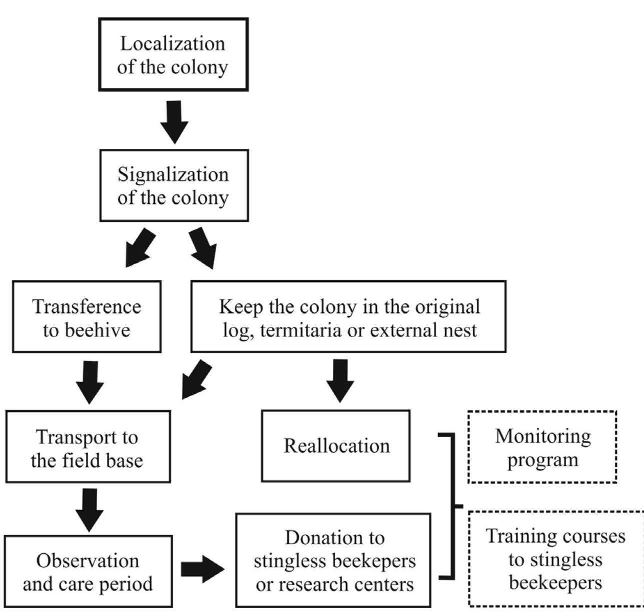

Fig 1. Diagram of steps adopted for the rescue of stingless bees during the deforestation to build the Santo Antonio hydroelectric power plant on the margin of the Madeira River and suggested post rescue actions (squares surrounded by dotted line).

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