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SHORT NOTE

A Scientific Note on a Stingless Bee Hive Model for Ecological and Behavioral Studies and for Environmental Education

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Abstract
Stingless bees (Apidae, Meliponini) occupy a broad range of habitats in the tropical and subtropical regions of the world. They are eusocial and live in sessile colonies. Most meliponini species build their nests in pre-existing cavities, such as tree hollows. Current stingless bee hive models imitate the conditions of natural nests. However, they are not convenient for scientific studies, especially those focusing on ecological and behavioral characteristics. We developed and tested a hive model that ensures clear visibility of the interior of the hive, facilitating ecological and behavioral studies and environmental education. Our new model was successfully used to house and maintain ten stingless bee species and one semi-social orchid bee species.

Introduction

Stingless bees are among the most important pollinators in the South American tropics (Duarte et al., 2016). They occupy a wide variety of habitats and are remarkably diverse in hot tropical-subtropical regions. All known meliponini bee species are eusocial and live in sessile colonies. Most species build their nests in tree hollows, though some build exposed nests or occupy hollows in the ground or within abandoned ant or termite nests (Nogueira-Neto, 1997; Camargo, 2007). Suitable nesting sites and building resources are crucial and limiting factors for stingless bees occurrence, especially in habitats that have been altered by man (Sakagami, 1982; Roubik, 1989).

The most widely used hive models in Brazil and Mesoamerica can be categorized into horizontal and vertical models (Leão et al., 2016). The horizontal model, the most traditional, is usually non-modular, without any internal divisions, although more elaborate options that have internal divisions to separate the food storage pots from the brood (Nogueira-Neto, 1997; Sommeijer, 1999). This kind of model allows one to view the inner part of the hive. The vertical models follow the natural nest organization of most meliponini species. Their popularity is growing among stingless bee beekeepers (Venturieri, 2008). They usually have detachable modules, such as the Fernando Oliveira model (Oliveira & Kerr, 2000). This model type has many derivations created according to personal preferences; it is organized to separate the base chamber, which contains the brood cells, from the management modules above the nest, where the food storage pots usually are placed. Most experienced meliponists build and test various hive models, and they adapt their management practices according to their observations (Jaffé et al., 2015).

Unfortunately, the most widespread hive models are not convenient for scientific studies. Here, we present a hive model that allows behavioral and ecological studies, developed by Gerson Luiz Pinheiro, co-author of this paper and member of the NGO SOS Abelhas sem Ferrão (Stingless Bees).

This hive model was developed in 2014 for environmental education purposes. The most relevant aspect of this model is its concept; the dimensions vary since each species needs different cavity sizes (Table 1).

Table 1. Bee species raised in the SOS stingless bee Hive Model.

Bee species	Time in the hive (months)	Colonies (n)	Hive internal measurements (cm)
Friesella schrottkyi	39	4	10 x 10 x 10
Frieseomelitta varia	36	3	15 x 15 x 15
Leurotrigona muelleri	4	3	6 x 6 x 8
Melipona marginata	36	2	15 x 15 x 15
Melipona quadrifasciata	25	5	20 x 20 x 20
Plebeia droryana	15	2	15 x 15 x 15
Plebeia nigriceps	42	2	15 x 15 x 15
Plebeia remota	36	6	13 x 13 x 13
Scaptotrigona postica	14	2	20 x 20 x 30
Tetragonisca angustula	24	5	15 x 15 x 15
Euglossa sp. (A communal species)	7	1	15 x 15 x 15

Material and Methods

The materials used to build this hive model are:

1- Wood boards, at least 1 cm thick;
2- Transparent acrylic or Polycarbonate panels, 3 mm thick;
3- EVA (Ethyl Vinyl Acetate) layer, 3mm thick;
4- Bolts;
5- A pressure closure;
6- Wooden knob;
7- Hinges
8- Small wooden strips

The basic structure of the hive model is made with the wood boards and then bolted. The pressure closure, hinges, feet and knob are also bolted. The EVA protection layer is attached to the movable wall and roof cover using PVA (polyvinyl acetate) glue due to its vulcanization properties. The observation window is attached to the beehive by embedding it in a low-relief cutout and keeping the hive closed for a few days. The bees will seal the observation window to the hive themselves, using propolis.

The hive model is composed of 11 main parts: A) Walls; B) Feet; C) Hive entrance; D) Pressure closure; E) Movable wall; F) Protection layer; G) Roof cover; H) Knob; I) Observation window; J) Feeder support; K) Hinges; (Figure 1).

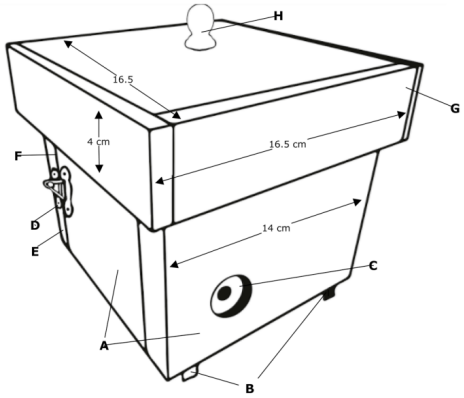

Figure 1.1- Closed hive

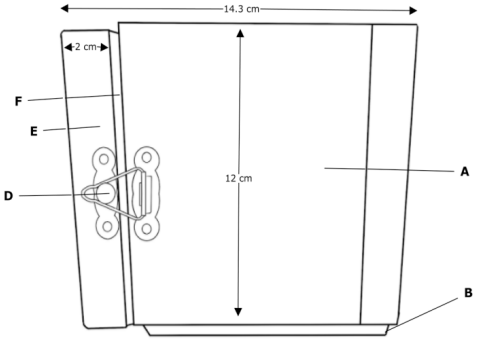

Figure 1.2- Pressure closure

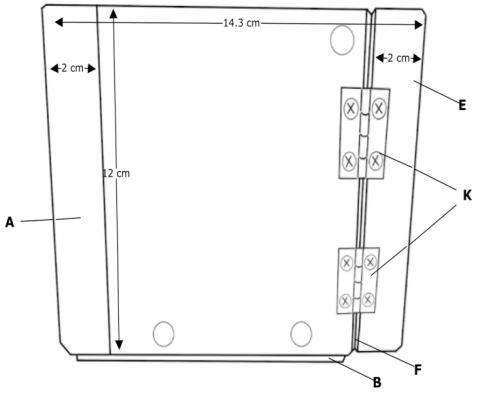

Figure 1.3- Hinges

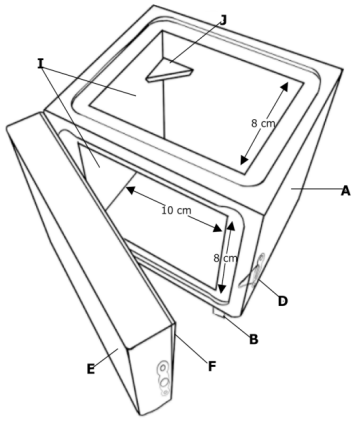

Figure 1.4- Internal view

Fig 1. SOS Abelhas sem Ferrão (Stingless bees) Hive Model (Illustrations by Paula Drago).

The choice of materials was based on various trials and practical observations. Explanations on the use of materials and the functions of the parts:

A) Walls (and the basic structure): we used pine wood. However other untreated wood types can be used.

B) Feet: we used two identical wooden strips below the hive to reduce the contact between the hive and the surface where it is installed.

C) Hive entrance: the central hole allows the bees to enter and exit the hive. The entrance size can be changed to accommodate species of various sizes. The low-relief halo is for attaching protection against ants and lizards, or an exit tunnel made with a plastic tube. The exit tunnel permits the bees to leave the hive to forage outside even when the hive is kept indoors. In order to transport the colonies from place to place, the entrance must be sealed in the previous night.

D) Pressure closure: the pressure closure seals the hive efficiently against light by pressing the movable wall against the observation window. We do not recommend other types of closure, since they may not block the external light entirely even with the protection layer. The pressure closure prevents light from entering the hive. Consequently, the bees do not propolize the observation window, allowing clear visibility of the hive, when the movable wall is hinged open.

E) Movable wall: an articulated wall of the hive connected with hinges and a pressure closure. A protection layer is attached to the movable wall's internal side.

F) Protection layer: the recommended material is EVA, since it protects the observation windows from mechanical shocks; its opacity and flexibility blocks the light when the movable wall is appropriately closed.

G) Roof cover: protects the hive against weather conditions, such as rain, hail and sunlight. The cover's protection layers also reduce mechanical shocks against the upper observation window. Since the roof cover is not in contact with the bees, it is not coated with propolis and therefore not glued to the rest of the hive.

H) Knob: facilitates removal of the roof cover.

I) Observation window: the best materials are transparent acrylic or polycarbonate; they are thinner and more resistant than glass, and easier to clean. When the observation window is excessively covered with propolis, it can be replaced, and the "dirty" window can be cleaned with a prolonged soak in water or alcohol. The bees attach the observation window to the structure of the beehive by themselves, by sealing the sides with propolis.

J) Hive feeder support: made with wooden strips.

K) Hinges: allows the movable wall to open and close when necessary.

Measurements: we adopted various measurements for the hive model, according to bee species particularities (Table 1). The most relevant measurements are the internal size and wood thickness. The internal size changes according the requirement of each species, such as brood chamber volume, the volume of stored food and others. The wood thickness varies according to species thermoregulation and humidity necessities. We recommend thicker wood in regions with larger temperature variation or lower average temperatures.

We transferred all the meliponini colonies from trap-nests or other hive models. The only one that was spontaneously colonized was the hive with *Euglossa* sp.

Fig 2. Closed Hive (Photo by André Matos).

Results

We successfully used this hive model for ten meliponini species and one communal euglossini species (Table 1). All the colonies developed well and successfully occupied the hives without problems. All the colonies were used in environmental education activities about once a week, and no damage to colony health was noticed. This hive model allows excellent visibility of the interior of the hive (Figures 2 and 3).

Fig 3. Internal view (Photo by André Matos).

This hive model has an alternative version with two movable walls and three observation windows. This variation allows other observation angles and use of light for photography and studies (Figure 4). It is a good option for entomological studies, bee behavior and ecological research and environmental education.

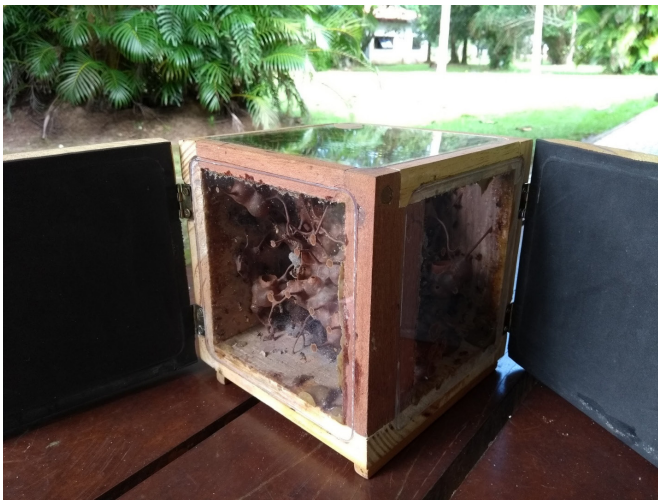

Fig 4. Two Movable Walls Version (Photo by Celso Barbieri).

Discussion

Our new hive model offers a good view of the interior of the nest and does not interfere with the natural development of the colonies. Current horizontal models allow clear visualization of the interior of the nest; however, they result in unnatural colony component placement for most species, which may affect colony biology and behavior. Some species, such as *Melipona marginata* and *Melipona subnitida* develop well in the horizontal models (Celso Barbieri & Gerson Luiz Pinheiro, personal observations), but the concept of our model can easily be adapted for these particular cases. In addition to the advantages for scientific and educational use, our model facilitates colony management as it gives access to the inter area of the nest from two or more sides, which is not possible with traditional models.

Acknowledgements

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Rights of use

Commercialization of this hive model is reserved for the non-profit organization SOS Abelhas sem Ferrão (SOS Stingless Bees). It can be produced for private use, research and education, except if it involves profit interests.

Contribution of authors

CelsoBarbieri Jr: Collected data, wrote the paper
Paula Marques Drago: Made the illustrations, wrote the paper
Gerson Luiz Pinheiro: Developed and built the hives
Tiago Mauricio Francoy: Helped detail the concept and wrote the paper

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