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An overview on the diversity, nesting behaviour and importance of stingless bees (Hymenoptera; Apidae)

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Abstract
Stingless bees belong to the family Apidae and sub family Meliponinae are social insect found in colonies ranging from a few dozen to 100,000 or more workers. They can be found in most tropical and subtropical regions of the World. Recent accounts report more than 400 species of the stingless bees belonging to two important genera Melipona and Trigona all over the world. They make contribution to pollination in agricultural and natural landscapes. Stingless bees are also very important for their role in primary health care through production of medicinal hive products such as honey, propolis and small beebread. Their honey fetches more price than honey extracted from honeybee due to its high medicinal values. Facets of their diversity are evident in their social organization, system of communication, nest architecture and reproductive behaviour. They build the nest in hollow trunks, tree branches, underground cavities, rock crevices or wall cavities using various natural materials like gums, resins and wax. The development of traditional meliponiculture provides new opportunities for people in rural areas, women in particular, and it can improve the economics of many households.

Keywords: Stingless bees, diversity, pollination, social organization, meliponiculture

Introduction
Stingless bees are the smallest of the honey producing bees belong to the super family Apoidea, family Apidae and sub family Meliponinae. Meliponinae consists of two important genera *Melipona* and *Trigona* which belong to the tribe Meliponini and Trigonini, respectively. Meliponinae includes eight genera, having 15 sub-genera and more than 500 species [1]. *Trigona* is the largest and most widely distributed genus, which includes 130 species under ten sub-genera. *Melipona* consists of 50 species and is confined to the neotropics. All Asian and African species of stingless bees belong to the tribe Trigonini. The various genera in this tribe include *Trigona, Plebeia, Tetragona and Nanotrigona* [2]. Stingless bees are closely related to the honeybees, bumblebees and orchid bees. Unlike most bee species that live solitary lives, the stingless bees and are highly social (‘eusocial’) and have complex and long-lasting colonies [3]. The smallest species of stingless bees measure only about 3 mm and their very small nest fits into a cigarette packet. The largest stingless bees are as big as the honeybee (*Apis mellifera*) and the total volume of the nest of certain stingless bee species may be more than 200 litres.
Stingless bees developed before the continents drifted apart from each other. Therefore, they are present in all tropical parts of the world. The group of stingless bees differs in several respects from the honeybee. The morphological characteristics of stingless bees include wing venation, rudimentary structure of the sting, strong mandibular musculature and the dorsal position of the wax glands (ventral in Apini). Since the sting is greatly reduced without an effective tip, hence, the defence behaviour is by chasing the intruders by biting, becoming entangled in the intruder’s hairs and getting into the nose, ears and eyes.
Although stingless bees and honey bees both exhibit highly eusocial behaviour, including perennial colonies of workers and a single queen, the two tribes have likely evolved their particular kind of sociality independently [3, 4]. Stingless bees are the only group of social bees to have left an imprint in the fossil record spanning most of the Cenozoic. Hence, they offer an unusual opportunity to examine the early biogeographic history and colonization pattern of a highly eusocial bee. A Gondwanan origin appears possible because they are an old group with a worldwide distribution restricted to tropical regions.

Distribution of stingless bees
Stingless bees are monophyletic (halophyletic) groups which are principally found in tropical and subtropical areas of Americas, Africa, Australia, and parts of Asia [5].

Meliponini extends up to 28°S - 35°S and 23.3°N. Unlike honeybees (*Apis*) with approximately 11 species in one genus, stingless bees consist of several hundred species distributed into 26 genera worldwide [6]. The highest distribution of these bees is found in tropical America. Various species have their preferred habitats and climatic conditions. Some species are present in the rain forest, Savanna and also transitions between forest and Savanna vegetation zones. Stingless bees are most abundant in the southern parts of India and along the coast in the Bay of Bengal but can also be locally common elsewhere. The interior plains of India are the least favourable areas for stingless bees. Apparently stingless bees are also to be expected in the southern parts of Pakistan, Nepal, Bhutan, and most of Bangladesh. Stingless bees of the Indian subcontinent represent the northernmost distributed stingless bees, globally, although the precise distribution in the region is only fragmentarily known. Recent accounts report six species namely *Tetragonula iridipennis, Tetragonula bengalensis, Tetragonula praeterita, Tetragonula laeviceps, Tetragonula ruficornis, Lepidotrigona arcifera* from Indian subcontinent [7].

Biogeographic Hypotheses

Stingless bees have limited dispersal ability because of their gradual and progressive colony establishment and a short flight range making successful transport across water highly unlikely by individual reproductive or swarms [8, 9]. This leads to the questions of when and how the stingless bees achieved their disjunct global distribution

Wille proposed that stingless bees originated in Africa during the Late Cretaceous or Early Tertiary and then dispersed to southern Europe during the Eocene, when land bridges formed between the two continents; later, he argued, they dispersed to their current range [1].

Fossil origins

A good fossil record is important in the estimation of divergence times. Several fossils can be brought to bear on estimating the divergence times of Meliponini that they are an ancient lineage is evident from Cretotrigona prisca, a Nearctic meliponine fossil that dates at least to the Late Cretaceous (approximately 65 MYA) and is the oldest known Apidae [10]. The age of the stingless bees must therefore be older than 65 MYA.

The early stingless bees occurred throughout the range they currently occupy (Neotropical, Afrotropical, Indo-Malay/Australasia) or maybe the bees were initially restricted to the Afrotropical region followed by range-expansion to the Neotropical and Indo-Malay/Australasia regions.It is possible that as the continental plates moved and topographic barriers appeared, the ancestral fauna split into subgroups. The first major split occurred between the Old and New Worlds, followed by the isolation and diversification of the Afrotropical and the Indo-Malay/Australasian faunas. Based on the fossil records, the Old World clade diverged 73 Million years ago (MYA), the Afrotropical clade diverged 61 MYA, and the Indo-Malayan/ Australasian clade diverged 49 MYA. The New World clade began to diverge 71 MYA [11].

Communication

Stingless bees are connected with tropical and subtropical forest areas. Here navigation by means of the sun, as used by honeybees, is not as easy as in open habitats. Stingless bees use different ways of communicating to each other the way to food sources. There are three main methods, depending on the different species. One method is that the scout bee returns and makes a special sound in the nest that gets other bees to fly out and search for the flowers at random. Another method is that the scout bee lays out an odour trail by marking stones and plants on the route with a special scent. Inside the colony, she makes a sound and a zigzag dance. When leaving the nest again, she leads a group of recruits to the source by following the trail. The third method is like the second, but instead of the odour trail, the scout bee guides a group of recruits by means of a pheromone emitted during her flight back to the flowers.

Division of labour among workers of stingless bees

The social life of stingless bees can be characterized by two kind of division of labor: Division of castes (reproductive system) and division of labor among workers (productive system). The females of stingless bees are divided into two castes: queens and workers. Queens are much larger than the workers and lack corbiculae and wax glands. As workers grow older, their tasks changes. The sequence of activities can be divided into stages. In stingless bees, there can be two or more queens laying eggs in the same nest. New queens are produced regularly, but most of them are killed and never allowed to produce eggs. Some queens may remain imprisoned in special cells as reserves [12].

Reproductive behaviour

Reproductive behaviour in the nest is typical. Whereas the Apini are progressive provisioners of their larvae, the Meliponini have a system of mass-provisioning brood cells. This means that all food needed for the complete larval development is brought into the cell prior to oviposition. New bees are reared from eggs that are oviposited in brood cells immediately after the cell has been provided with larval food. During very short periods of high activity, a small number of bees deposit liuid food in the brood cell; immediately after this, an egg is laid on top of the food. Colony reproduction takes place through swarming. In stingless bees this process is still poorly understood. A few observations of species other than Melipona indicate that there is long-lasting contact between the mother nest and the filial nest [13, 14]. This implies that daughter colonies can only be established within the flight range of the mother nest

Nesting site and architecture

Most species build their nests in existing cavities like hollow trees or in the ground. A few species build their nests in exposed positions. The narrow and often elaborate entrance to the Melipona nest lets the nest to be defended by one or more guards positioned in the outside opening of the tubeshaped entrance. Within the nest there is a clear separation between the brood chamber and the food storage area. Storage pots are several times larger than brood cells. In general pots with different contents are not kept separate: pots containing honey intermingle with those containing pollen. In most species brood cells are arranged in horizontal combs but they may also be built in clusters

Species vary considerably in their nest architecture, which ranges in design from brood cells arranged in horizontal combs or clusters, constructed within crevices in trees or in the ground), and occasionally within the active colonies of other social insects [11, 5,16, 17, 18]. The substantial elaboration of their nest entrance is generally species specific.

Many stingless bee species nest in cavities. These cavities could be found in the following:

- Stem and branches of living trees including bamboo.
- Dead logs (either standing or lying on the ground).
- Old and abandoned ant hills.
- Cracks in walls of houses.
- Cavities in unused panel doors of buildings (accessed by cracks and key holes).

However one species of stingless bee (*Dactylurina staudingeri*) builds its own nest in the form of a ball attached to a stem or branch of a tree.

Table 1: Diversity in nesting site and arrangement of brood chamber important genera of stingless bees

Sl.no	Genus	Brood chamber	Nesting site
1.	*Geotrigona*	Horizontal spiral combs	underground cavities
2.	*Meliplebia*	Horizontal concentric combs	open farm areas, secondary forests
3.	*Dactylurina*	vertically arranged with double layers	exposed nests
4.	*Meliponula*	Clustered	tree trunks and in empty traditional hive
5.	*Trigona*	Horizontal spiral combs	around the manmade structures

Economic importance of stingless bees

Stingless bees are important in a number of ways. These include; their role in plant reproduction through pollination, production of medicinal honey and other hive products as well as their value in aesthetics. Stingless bees can be used in research as well as for ecotourism

1. **Pollination:** Stingless bees visit flowers of plants including crops and forest trees as well as shrubs and herbs to collect nectar, pollen, wax, resins, oils and other plant substances. Bees in general carry out most of the pollination services. However, as a result of their small size and large diversity, stingless bees are found to be one of the most effective and efficient pollinators. Stingless bees are pan tropical and in all their regions their principal function is to pollinate the tropical forest. Because they are natural pollinators and vary so much in size and foraging behaviour, these bees have recently received much attention as possible pollinators of agricultural crops, particularly in crops grown in greenhouses [19].

2. **Hive Products:** Stingless bees are also important to man in the production of honey, propolis, wax and pollen or Beebread.
   a) **Honey:** Stingless bee honey is popular for its antioxidant and antibiotic properties, hence its effectiveness in healing wound and fighting both internal and external infections.
   b) **Pollen:** Pollen is rich in proteins, vitamins and minerals and provides these nutrients to the bees. Pollen may be packaged and used as food supplements and also added to infant food. It is also used in many cosmetic preparations.
   c) **Propolis**: Propolis has been scientifically tested and proven to be effective against many health disorders. It is a natural antibiotic that is effective in healing wounds and infections in the body. Ulcers (internal and external), skin infection and rashes are known to be treated with propolis. Regular intake of propolis is known to regulate blood pressure and also boosts the body's immune system.
   d) **Beeswax:** Stingless beeswax can be used in cosmetics products to boost the skin and body health. Body and facial creams as well as lip balms can be prepared from beeswax. In addition to these health products, industrial items such as textiles, polishes (wood, floor, leather) and candles can be produced from beeswax. In the pharmaceuticals, industrials beeswax is used to coat tablets and capsules.

3. **Nucleus Colonies:** Many species of stingless bees have been found to continuously produce many queen cells. The beekeeper can take advantage of this colony behaviour and raise baby colonies from the queen cells. When a number of workers and queen cells are placed in a small hive, a young colony (nucleus colony) can developed. This nucleus colony can be used for multiplication of a beekeeper's stock or could be sold to other beekeepers

Conclusion and future strategies

Improve agricultural practices has increased food supply over the past 50 years but a depopulation in both number and species of bee pollinators within agricultural environment has resulted from land clearing, cultivation, irrigation and pesticide use. The population of honeybees presently is not sufficient to meet the huge demand of pollination above this the honey bees cannot pollinate all the crops. Honey bee population may also fluctuate naturally in response to climatic calamity, the attack of parasites and diseases. Reliance on single agricultural pollinator is always prone to such crises. Therefore, there is immediate need of diversification and conservation of pollinators. Efforts are therefore needed to explore manage conserve and multiply the alternative pollinators

Stingless bees are natural pollinators and vary so much in size and foraging behaviour and due to their compact colonies and safety for farmers and visitors; these bees have recently received much attention as possible pollinators of agricultural crops, particularly in crops grown in greenhouses.

The development of traditional meliponiculture provides new opportunities for people in rural areas, women in particular, and it can improve the economics of many households. Many people who have opted out of beekeeping because of the highly defensive behaviour of Africanized honey bees may be persuaded to take up meliponiculture, particularly if floral resources are abundant. lmproved and rationalized management of domesticated colonies, based on the biology of the bees, is necessary to increase honey production, although the amount of honey produced by stingless bees will always be much less than the amount produced by honey bees. It should be possible to improve many aspects of traditional meliponiculture, e.g. the housing of colonies, multiplication and harvest procedures. Furthermore, the antibiotic activity of stingless bee honeys' may lead to the use of these honeys in medicinal products. Certainly stingless bee honey, with its delicate taste, does fit very well in the present development of niche (export) markets for speciality honeys.

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