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Prospects and challenges in Meliponiculture in India

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Abstract: *Meliponiculture is the scientific keeping and managing of stingless bees. It is widely known as "dammer bees (or) dammar bees" (dammar = resin formed among the dipterocarp trees). It is highly diverse and abundant group of eusocial bees that occupy the Tropical and Subtropical parts of the world, originated from Africa. More than 500 species of stingless bees in worldwide belonging to 18 genera. Trigona is the most widely disturbed genus, which includes 130 species and under 10 sub – genera and Melipona consists of 50 species. Eight species of stingless bees are known from the Indian Sub – Continent: Lepidotrigona arcifera (Cockerell), Lisotrigona cacciae (Nurse), L. mohandasi (Jobiraj and Narendra), Tetragonula aff. laveiceps (Smith), T. bengalensis (Cameron), T. gressitti (Sakagmi), T. iridipennis (Smith), T. praeterita (Walker) and T. ruficormis (Smith). Nests of stingless bee mostly found on cavities tree trunk, old walls, inside the termite mound and subterranean cavities. Nests are built using wax secreted from the metastomal terga, mixed with plant resin and gums. A variety of crops are pollinated by stingless bee viz., guava, mango, citrus, cucumber and sunflower etc. It is effectively used for green house pollination because of their limited foraging distance and foraging activity of T. iridipennis peak time is 10.00 am to 12.00 pm. In India, the dry fruit mite, Carphoglyphus lactis infestation on T. iridipennis colonies and also parasitic mites (Pyemotes sp.) affect the colonies. Propolis of stingless bee has wide spectrum of pharmacological properties such as antibacterial, antimicrobial, antioxidant, anti – herpes, antiulcer, antihypertensive and anticancer activity.*

Keywords: *Trigona irridipennis, Nesting sites, Pollination, Resin, Propolis, Pests*

1. INTRODUCTION

Bee species in the world account to around 30,000. Bees generally come under the Class: Insecta and Order: Hymenoptera to involve some of the commercially important groups like solitary bees, sub – social and social bee species. Among these, social bees belongs to three tribes namely Apini, Bombini and Meliponini (Michener, 2000). Stingless bees are amongst the longest evolved bees and have been found preserved inside pieces of 80 million years old amber. Honey bees and stingless bees belong to the family Apidae and assigned to separate subfamilies, Apinae and Meliponinae, respectively (Culliney, 1983). Most recent classification of stingless bees, the Meliponini comprises of 23 genera and 18 sub – generic names consisting of 374 recognized species. Worldwide, there are records of 120 species of genus *Trigona* placed under 10 subgenera, of which *Homotrigona*, *Lepidotrigona* and *Heterotrigona* are quoted as endemic sub – genera for tropical and sub – tropical regions of Asia (Michener, 2000). The generic name *Trigona* refers to its triangle shaped abdomen while the species name shown its refers to its iridescent wings (Devanesan *et al*., 2009). Stingless bees are widely known in the Indian subcontinent as "dammer bees" or "dammar bees" (dammar = resin formed among dipterocarp trees). Many local names are applied with reference to the pattern of storage of pollen and honey as "Cherutheneecha" and "Arakki" in Kerala. " Tenetigalu" in Andhra Pradesh; and "Mulijenu" (Kodagu), "Mujanatejenu", " Misrijenu", "Nasarujenu", "Kirujenu" in Karnataka (Nair, 2003). The stingless are eusocial and corbiculate in nature inhabiting tropical and southern subtropical regions on the earth (Leonhardt *et al*., 2007). These are found to have a distinguished of reduction and weakness of wing venation, presence of the penicillum (a brush of long setae on the outer apical surface of the hind tibia) and vestigial sting (Wille, 1983). Stingless bees are known to be generalists with regard to selection of nesting sites (Roubik, 1983). Like honey bees, stingless bees nests in hollows of tree trunks, stone walls, mud walls, corners of walls, crevices, termite mounds and other such concealed places. One major component of the stingless bee's nests is the excellent insulation,

especially with the exposed nests. Nests in large trunks or in soils are particularly well insulated. Stingless bees keep their honey in ellipsoidal pots made with cerumen which is a mixture of wax, resin, propolis and mud. Beekeeping with stingless bees is called as meliponiculture, which has been practiced for many centuries in various parts of the world (Michener, 2000). During foraging, *Trigona* shows preferences for different plants. Their small size allows them to have access to many kinds of flowers whose openings are too narrow to permit penetration by other bees and they are common visitors to flowering plants in the tropics (Heard, 1999). Stingless bees are appreciated for their medicinal values in honey along with their utilities for pollen, wax and propolis; which are commercially exploited nowadays (Nogueira – Neto, 1997).

Stingless bee in Indian sub- continent

The species of stingless bees are known from the Indian subcontinent: *Lepidotrigona arcifera* (Cockerell), *Lisotrigona cacciae* (Nurse), *Lisotrigona mohandasi* Jobiraj and Narendran, *Tetragonula* aff. *laeviceps* (Smith), *Tetragonula bengalensis* (Cameron), *Tetragonul agressitt i*(Sakagami), *Tetragonula iridipennis* (Smith), *Tetragonula praeterita* (Walker), and *Tetragonula ruficornis* (Smith). Lectotypes are newly designated for *T. bengalensis* and *T. ruficornis* (Rasmuseen, 2013).

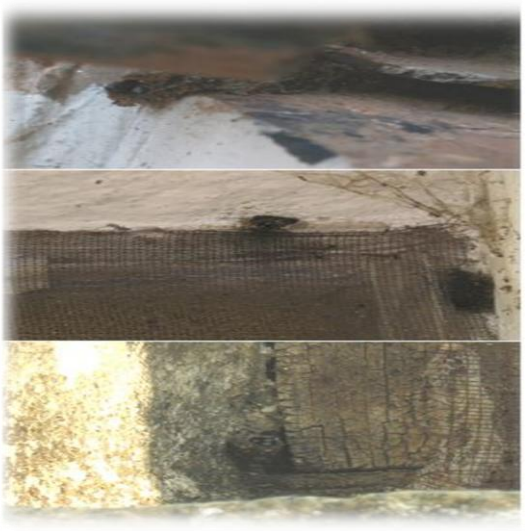
Nesting habitats of *Trigona iridipennis*

A diverse range of nesting habitats were chosen by *Trigona* spp. (*Tetragonula* spp.) corresponding to the equally varied climatic and geographic conditions prevailing in the southern regions of India. Because, nests were detected at different ecological zones involving tropical evergreen, semi evergreen, grassland, moist deciduous, dry deciduous, shrub lands, freshwater wetland, subtropical secondary scrub, grassy slopes and thorny scrub type of forest vegetation.

Selection and preferences of habitats

Stingless bees have commonly received with a tag of true generalist; exhibiting a range of selection habitats to build their nest around human dwelling spaces by using human constructed materials for nesting. These bees showed specialization in making their nests at different places and opted for diverse form of substrates like crevices of building walls made from mud and cement bricks, stone pillars, underneath the metallic and cement sheaths, crevices and staircases and heavy rocks; water pipes made from iron, plastic cement materials intended for supply of water channels and passages of waste water drainages; electric poles made from iron, plastic, cement materials meant for communication wires of telephones and lamp post; hallow iron rods used as a support for construction of buildings; crevices of wooden rim meant for door and window of the houses; crevices of wooden electric meter board; inside the hollow spaces of very old fragile mud

Stone walls



Windows

Underground cavities **Plastered walls** **Electric pipes**

Plate 1. *Different nesting sites of Trigona iridipennis*

Table 1. *Different nesting attributes of the Trigona iridipennis at Bangalore (Pavithra et al., 2013)*

Sl. No.	Attributes	Observation / Criteria's	Most preferred
	I. Nest characters		
1.	Size of nest opening	Small, medium, large	Medium sized
2.	Shape of nest opening	Circular, oval, irregular	Oval
3.	Nest measurements	1. Nest depth (0.1 – 35 cm) 2. Nest opening – circumference (0.15 – 2.2 cm)	03. – 4 cm (small projection) 0.8 – 1.4 cm (medium openin)
4.	Colour of nest	Red, black, grey, brown, cream, light green, orange, yellow (amber), black	Greenish, black
5.	Nest orientation	North, south, east, west, northeast, northwest, south east, southwest	
6.	Nest enclosure material	Petroleum products such grease, resin, wax, wooden pieces, sand, mud, tar, blue paint, pollen, stones, cow dung, animal feces.	Resin, mud, wax
7.	Nest height from round	Reading in feet (0 – 18 ft)	Middle elevation (1.1 – 15 ft)
8.	Surface	Smooth, rough	Rough
	II. Nesting habitat		
1.	Places visited	Residential quarters, Educational buildings, hostel, office, road side, parks	Educational buildings
2.	Colony location	Interior, exterior	Interior regions
3.	Substratum (Habitat)		
	a. Wall	Stone, mud brick, pillars, metallic sheath	Wall of mud brick
	b. Water pipes	Iron, cemented, plastic	
	c. Electrical pipes	Electric box, lamp post, telephone wires	
	d. Wood	Wooden, Door rim, Window's	
	e. Stare cases	Cemented plastering's	
	f. Floor	Mud	

Table 2. *Different nesting sites of T. iridipennis in Peninsular India (Shwetha, 2013)*

Sl. No.	Nesting sites	Number of nests	Percentage
1.	Cavities in buildings	213	83.84
	a. Stone walls	147	57.87
	b. Plastered walls	56	22.04
	c. Corner of windows	10	3.93
2.	Cavities in tree trunks	15	5.90
3.	Cavities in termite mounds	9	3.54
4.	Electric pipes	11	4.33
5.	Soil / Underground cavities	6	2.36
Total		**254**	

Meliponiculture

Meliponoculture is the science of keeping and managing stingless bees. It is practiced as backyard bee keeping mainly for honey production where stingless bees are kept either in bamboo nodes or mud pots or box hives **(**Muthuraman e*t al*., 2012**).**

2. DIFFERENT TYPES OF HIVE FOR DOMESTICATION OF *T. IRIDIPENNIS*

Mango wood hives

Three types of wooden hives *viz*., long cylindrical hive with longitudinal two parts (29 cm length, 11 cm breadth, 12 cm height and 2 cm thickness) and entrance, (ii) small cylindrical hive with longitudinal two parts (14 cm length, 11 cm breadth 10 cm height and 1 cm thickness) and entrance, and (iii) cuboid (19 cm length, 19 cm breadth, 19 cm height and 2 cm thickness) hives with entrance and upper lid were used for hiving and rearing of *T. iridipennis* (Singh, 2013).

Plate 2. *Long cylindrical hive with longitudinal two parts and entrance*

a) Brood nest of stingless bees *T. iridipennis* Smith in long cylindrical hive, b) Storage cells with pollen and honey adjacent to the brood nest of *T. iridipennis* within long cylindrical hive, c) Funnel shaped entrance of long cylindrical hive of *T. iridipennis* and d) Long cylindrical hive with longitudinal two parts and brood along with honey and pollen stored cells in both parts, and brood nest of *T. iridipennis*,

Plate 3 and 4. *Small cylindrical hive and Cuboids bee hive*

Domestication of *T. iridipennis*in the long cylindrical with longitudinal two parts hive is successful for extraction of honey, multiplication and seasonal management of colony. No any hive is designed for its hiving of this species and its comb nest consists of the bee space or space between cells provided the passage, probably used by worker bees for larval food supply, nourishment and care of larva, aeration and thermo regulation of brood nest.

Bamboo stem hive

The stingless bee, *T. iridipennis* reared in hollow trunks of bamboo tree. Bamboo stem with a diameter of 30 – 35 cm were chosen. The length of the bamboo hive is 80 – 85 cm. The stem of the bamboo is split into two halves and the two halves are tightly joined with the help of ropes. The joined stem has narrow gap in the middle for the entry of the bees. Both ends of the bamboo stem are sealed. The tied log is opened into two halves then transfers the brood chamber into bamboo log. After 2 hrs, the colony settled completely inside the bamboo pole well. Bamboo log is closed and tied with ropes in both edges and the openings at the end are sealed. The bamboo pole with the bees are taken to the home and tied below the roof of the hut. The bees inside the bamboo poles start moving outside through the narrow gap left in the middle. The bees make the entrance smooth by depositing resins (propolis) collected from trees and their wax. They live in complex colonies (Suresh Kumar *et al*., 2012).

Plate 4. *Indigenous method of bamboo bee hive*

A colony generally contains a queen bee, drone bees and worker bees. In the month of June to July (South West monsoon season), the bees store honey to the maximum. A single colony produces 600 – 700 g/ yr. When the bamboo hive loaded with honey open the pole. In the bee hive three chambers (brood rearing chamber, pollen storage chamber (food chamber) and honey storage chamber) are interconnected. From the hives, remove the honey storage pots only (not like hexagonal combs) crushed in a white cloth, filtered and then bottled. This honey has different colour, odour and taste (Suresh Kumar *et al*., 2012).

Pollination of stingless bee

Stingless bees are found in the holes of tree trunks (Michener, 2000). Over 130 species of stingless bee's world over have been identified as potential pollinators of crop and can be managed for this purpose (Heard, 1999). Only the non-infurious species are managed e.g. 40 species of *Trigona*, 40 species *Scaptotrigona*, 4 species *Cepholotrigona* and *Melipona* can utilize artificial domiciles and can be kept in hives. *Trigona* may nest in hollows of varied habitats whereas; *Cephalotrigona* and *Melipona* can be managed in section of tree trunks close to their forest habitat. Most of the species which can be managed are distributed in tropical America and Asia. The size of the nest may vary from 3-30 cm. Stingless bees possess many characteristics that enhance their importance as crop pollinators like perenniality, polylecty, floral constancy, recruitment, harmlessness and resistant to diseases and parasites of honey bees suit them for pollination.

Table 3. *Desirable attributes (Heard, 1999)*

1	Polylecty	The workers from a colony can visit many different types of plants. This behaviour, called polylecty, enables a colony to potentially pollinate many types of plants.
2	Floral Constancy	Each individual worker on a trip usually visits only one plant species. This behaviour, called floral constancy, makes these bees efficient pollinators because each bee only carriers pollen between the flowers of one plant species.
3	Domestication	Stingless bee colonies can be domesticated. The potential of stingless bees for crop pollination is enhanced by the ability to transfer colonies into artificial hive. These hives can be propagated so that growers do not to depend on natural populations. Hives can also be transported wherever needed for pollination.
4	Perennial nature	Stingless bee colonies live for a long time. They do not have to be restarted.
5	Adaptability	Stingless bee colonies are active over a wide range of climatic conditions and if the climatic conditions become unsuitable, the colonies can be moved to better area.
6	Hoarding food	Large food reserves are stored in stingless bee nests so the bees can survive for long periods when food is scarce. The workers will also collect more nectar and pollen than their current need.
7	Shorter foraging distance	Stingless bees have short flight range. Hence, their importance is increased in using them for green house pollination.
8	Forager recruitment	Scout bees in a colony find new flowers for the colony to use. Middle aged foragers function as scout bees. They return to the hive and communicate the location of the flowers to other worker bees. If the flowers continue to be productive, allows large numbers of worker bees to quickly find a good food source and this behaviour is called forager recruitment,
9	Communication mechanisms	Different communication strategies are used by the scout bees for sharing the information about the discovery of a floral patch to the nest mates. The returning foragers may produce a weak or strong sound and run in a zigzag manner while passing the nectar to the hive bee which make the nearby bees to repeat their sounds and the whole colony buzzes and the responsive bees leave out for foraging due to mass sound production.

Floral choice of stingless bees

Stingless bees are generalist flower visitors. They visit a broad range of plant species. They prefer small flowers, dense inflorescence, flowers with long corolla tubes that are wide enough for the bees to enter and white or yellow coloured flowers.

Different crops pollinated by Stingless bee

More than 1000 plant species are cultivated in the tropics for food, beverages, fibre, spices, and medicines. The breeding system and pollinators of many of these crops have been catalogued. Nearly half of the species of economically significant tropical crops originated in areas where honey bee species do not occur naturally, i.e. the neotropics, South Pacific, and Australia. Approximately half of these plants are pollinated by bees. Many of these 250 species may be adapted to pollination by stingless bees. All crops recorded as having been visited by stingless bees are reviewed here. They are divided into sections depending on the importance of the bees. This division is preliminary, as information is lacking for many crop species. Difficulties in assessment included the lack of information on the need for pollination, e.g. the need for pollination of most mango varieties is unknown and geographic variability, e.g. stingless bees are visitors to flowers of crop species in many parts of India but not in the Punjab, which is outside of their geographic range (Muthuraman e*t al*., 2012).

Foraging activity of stingless bee

Foraging activity in bees is a routine and essential task for survival of colony, although no foraging activity was observed during cloudy or rainy days. Foraging activity also decreases to greater extent in months of Nov-Feb in northern parts of India. Like *Apis* species pollen and nectar are the essential food for stingless bees. In case of stingless bees, strength, development and quantity of honey stored in a colony are highly dependent on the collection of nectar and pollen by the worker bees. Information on the foraging behaviour of stingless bees will be of much use for meliponiculture (rearing of stingless bees) and in management of stingless bees Managanvi *et al.* (2012) reported peak activity of outgoing and incoming forager bees of *Trigona laeviceps* at 11am i.e. 44.4 bees/5min and 43.8bees/5min, respectively. Maximum pollen collector bees were observed at 10 am i.e. 19.6 bees/5min and maximum nectar collector bees at 12 pm i.e. 25.8 bees/5min.

Table 4. *Group-wise distribution of bee flora of* T. iridipennis *in Peninsular India* ***(Shwetha, 2013)***

S. No.	Common name	Scientific name	Family	Flowering period (months)	Source abundance
Field crops					
1	Groundnut	*Arachis hypogea* Willd.	Fabaceae	Aug - Sep	N_2P_2
2	Black mustard	*Brassica nigra* Konch.	Brassicaceae	Aug – Sep	N_3P_3
3	Safflower	*Carthamus tinctorius* L.	Asteraceae	Dec - Jan	N_1P_1
4	Soyabean	*Glycine max* Merr.	Fabaceae	Aug - Sep	N_1P_2
5	Sunflower	*Heliantus annus* L.	Asteraceae	June - Nov	N_3P_3
Vegetable crops					
1	Onion	*Allium cepa* L.	Liliaceae	May – July	N_3P_3
2	Chilli	*Capsicum annum* L.	Solanaceae	Jan - Dec	P_1
3	Carrot	*Daucus carrota* L.	Apiaceae	Feb – Apr	N_1P_1
4	Tomato	*Lycopersicon esculentum* Mill	Solanaceae	Jan - Dec	P_1
5	Drum stick	*Moringa oleifera* Lamk.	Moringaceae	Dec - Apr	N_1P_1
6	Chow chow	*Sechium edule* (Jacq.)Swartz.	Cucurbitaceae	Apr - Aug	N_3P_2
Fruits and Plantation crops					
1	Cashew nut	*Anacardium occidentale* L.	Anacardiaceae	Dec - Feb	N_2P_1
2	Custard apple	*Annona squamosa* L.	Annonaceae	Mar - May	N_1P_1
3	Jack fruit	*Artocarpus heterophyllus* Lam.	Moraceae	Jan - Mar	P_1
4	Lemon	*Citrus medica* L.var *acida*	Rutaceae	Apr - May	N_1P_1
5	Coconut	*Cocos nucifera* L.	Arecaceae	Jan - Dec	N_2P_3
6	Coffee	*Coffea arabica* L.	Rubiaceae	Apr - May	N_3P_1
7	Cardamom	*Elettaria cardamomum Maton & Var.*	Zingiberaceae	Jan - Feb	N_1P_1
8	Rubber	*Heva brasilinensis* Muell. & Agr.	Euphorbiaceae	Jan - Apr	N_3P_1
9	Mango	*Mangifera indica* L.	Anacardiaceae	Dec - Mar	N_1P_1
10	Pomegranate	*Punica granatum* L.	Punicaceae	Apr - July	N_1P_2
Weeds					
1	Amaranthus	*Amaranthus viridis* L.	Amaranthaceae	Jan - Dec	N_1
2	Celosia	*Celosia argentea* L. var *spicata*	Amaranthace	Jan - Aug	N_1
3	Railway creeper	*Ipomoea pulchella* Roth.	Convolvulaceae	Aug - Sep	N_1P_2
4	Alternenthera	*Alternenthera sessilis* L.	Amaranthaceae	Apr - July	N_1

5	Crown flower	*Calotropis gigantea* L.	Asclepidaceae	Jan - Dec	N_1P_1
Medicinal and Aromatic plants					
1	Alfa alfa	*Medicago sativa* L.	Fabaceae	May – Aug	P_2
2	Indian gooseberry	*Emblica officinalis* Gaertn.	Euphorbiaceae	Mar – Nov	N_1P_1
3	Wild cumin	*Centratherum* sp.	Asteraceae	May – Sep	N_2P_1
4	Lavender	*Lavandula stoechas* L.	Labiatae	June - Nov	P_2
5	Spreading hogweed	*Boerhavia diffusa* L.	Nyctaginaceae	Sep - Dec	N_2
Ornamental plants					
1	Chrysanthemum	*Chrysanthemum coronarium* L.	Asteraceae	July - Oct	N_1P_1
2	Jasmine	*Jasminum* sp.	Oleaceae	Oct - Mar	N_1
3	African marigold	*Tagetes minuta* L.	Asteraceae	Jan - Dec	N_2P_2
4	Neem	*Azadirachta indica* L.	Meliaceae	Mar - May	N_3P_2
5	Ashoka tree	*Polyalthia longifolia* (Sonn.)	Annonaceae	Mar – May	N_1
6	Tamarind	*Tamarindus indica* L.	Caesalpinaceae	May - June	N_1P_1

P=Pollen, N= Nectar, 1= Major source, 2= Medium source, 3= Minor source
Jan- January Feb-February Mar- March Apr-April Aug-August
Sep- September Oct-October Nov- November Dec- December

Table 5. *Melissopalynology of T. iridipennis honey samples from Tamil Nadu (Shwetha, 2013)*

Month of sampling	Predominant pollen type (>45 %)	Secondary pollen type (16 – 45%)	Important minor pollen type (3-15 %)	Minor pollen type (< 3 %)
August	*Cocos nucifera Heliantus annus*	*Anacardium occidentale Cucumis sativus*	*Antigonan leptopus Arachis hypogaea Canthium parviflorum*	*Aster thomsonii Spathodea campanulata*
September	*Pterospermum personatum*	*Anacardium occidentale Heliantus annus*	*Bidens pilosa Manilkera achras Sesamum indicum Psidium guajava*	*Citrus medica Coccinia indica Tagetes minuta*
October	*Eucalyptus* sp. *Cocos nucifera*	*Heliantus annus Sesamum indicum*	*Bauhinia purpurea Cottea arabtca Santalum album Tridax procumbens*	*Bombax malabaricum Tagetes minuta Terminalia arjuna*
November	*Eucalyptus* sp.	*Mimosa pudica Cocos nucitera*	*Cajanus cajan Euphorbia pulcherrima Heliantus annus*	*Celosia argentea Jasminum* sp. *Tagetes minuta*
December	*Areca catechu Laginaria siceraria*	*Antigonon leptopus Mangifera indica*	*Bidens pilosa Euphorbia pulcherrima*	*Chenopodium album Spathodea campanulata*
January	*Bombax malabaricum Butea monosperma*	*Eucalyptus* sp. *Helianthus annuus*	*Brassica nigra Mangifera indica*	*Tabebuia avellande*
February	*Persea Americana Psidium guajava*	*Brassica nigra Pithecollobium dulce Pongamia pinnata*	*Abelmoschus esculentus Anacardium occidentale Pongamia pinnata*	*Citrus mediea var.acida Mangifera indica Rosa indica*
March	*Pterospermum personatum Persea Americana Psidium guajava*	*Pongamia pinnata Azadirachta indica Salmalia malabarica*	*Citrus medica var.acida Gliricidia sepium Peltophorum pterocarpum*	*Mangifera indica Crossandra infundibuliformis*
April	*Pterospermum personatum Pongamia pinnata*	*Azadirachta indica Terminalia arjuna*	*Dalbergia sissoo Madhuca indica Salmalia malabarica*	*Gliricidia sepium Parthenium hysterophorus*
May	*Peltophorum pterocarpum Pongamia pinnata*	*Antegonon leptopus Syzygium cumini Terminalia arjuna*	*Azadirachta indica Madhuca indica Terminalia alata*	*Feronia limonia Polyalthia longifolia*
June	*Heliantus annus Syzigium cumini*	*Artocarpus heterophyllus Callistemon lanceolus Terminalia arjuna*	*Artocarpus heterophyllus Canthium parviflorum Delonix regia*	*Bauhinia purpurea Zizyphus jujuba*
July	*Callistemon lanceolus Heliantus annus Syzigium cumini*	*Ageratum conyzoides Callistemon lanceolus Cocos nucifera*	*Antegonon leptopus Bauhinia purpurea Canthium parviflorum*	*Tridax procumbens Zinnia elegans*

Patnaik and Prasad (2006) reported that the number of incoming pollen foragers of *Trigona iridipennis* ranged from 0.07 to 2.92/min, while that of non-pollen foragers varied from 0.34 to 6.94/min. However, nectar and resin collection was evenly distributed throughout the day. Collection of nectar and pollen accounted for more than 90% of flights. The workers performed relatively more number of flights for collection of nectar rather than pollen and resin.

Stingless bees and their forage resources

Stingless bees forage to collect resources needed for their daily survival and these includes nectar for energy requirements, pollen for protein and other nutritional needs, water for cooling hives and for metabolic processes, resins and other plant materials for nest-building, soil and sand particles for nest building and twigs and plant materials for nest building.

Properties of honeybee

Stingless bee honey in different contexts, such as antimicrobial, antioxidant, and cataract studies and anti-inflammatory activity. Twenty-four chemical compounds were identified from the Indian stingless bee propolis by GC–MS analysis. They were of several classes, viz. alkanes, thiophilic acids, aromatic acids, aliphatic acids, sugars, esters, and terpines. Out of these, 15 compounds are being reported for the first time in Indian stingless bee propolis (Choudhari *et al*., 2012).

Table 6. *Physicochemical properties of stingless bee honey (Souza et al., 2006)*

S. No.	Physiochemical	Honey
1	Appearance	Amber brown
2	Moisture content	25.02
3	pH	3.05–4.55
4	Total reducing sugars	55.00–86.00%
5	Glucose	8.20–30.98
6	Fructose	31.11–40.20
7	Sucrose	0.31–1.26%
8	Electrical conductivity (mS/cm)	0.49–8.77
9	Hydroxylmethylfufural HMF (mg/kg)	8.80–69.00
10	Ash content (g/100 g)	0.01–0.12

Pests of stingless bees

Stingless bees seem to be relatively disease-free and no reports of brood disease have been seen. They do, however, suffer from predation, parasitism and colony infestation. There are many general predators such as flies, ants, spiders, mites, wasps, birds, lizards, toads and, of course, humans, which are common pests of social bees worldwide.

Syrphid fly

One of the most serious pests of stingless bee colonies is the syrphid fly, *Ceriana ornata australis* Macquar. *Ceriana ornata* is 12mm long, with bright orange-yellow and black markings and is frequently observed hovering near nests during summer. This fly has been observed in all regions where stingless bee colonies are present and is seldom observed in areas where stingless bees do not occur (Klumpp, 2007).

Phorid fly

The phorid fly, *Dohrniphora trigonae* Disney can also cause problems in Australian stingless bees, especially *Trigona* species (Disney and Bartareau, 1995).Stingless bee predators that are unique to include *Bembix flavipes* Smith and *Bembix musca* Handlirsch (Crabronidae). These *Bembix* hunt singly and hover outside the entrance, waiting for bees to exit. Once a bee leaves the nest the wasp swoops from behind the unsuspecting worker and drags it to its own nest.

Dry fruit mite

Vijayakumar *et al.* (2013) reported the infestation of dry fruit mite *Carphoglyphus lactis* on *T. iridipennis* colonies in India. The infestation of *C. lactis* initiate the pollen store and subsequently spread over the brood cells and declining worker strength attracted the more predators and carry away all food store and young ones.

Management of stingless bee colonies

- Keep the colonies in shade to protect the nest components against the scorching effect of sun.
- Prevent entry of rain water into the hives to avoid mould growth and subsequent colony desertion.
- Use a mylar film sheet of suitable size as an inner cover for the box hive to facilitate easy hive inspection.
- Provide artificial feeding with honey bee honey or sugar syrup (1:1) in mud lamp feeder during dearth period especially when adequate honey reserve is not present in the hive which is needed for proper growth of the colony.
- Provide ready to emerge pupal brood and artificial feeding to strengthen weak colonies.
- Provide either ripe queen cells or honey smeared queen/gyne to orphan colonies for requeening

- Provide either advancing front having egg\larval brood and pupal brood or advancing front having larval and pupal brood for requeening queenless colonies
- Remove the spider webs found in or near the hive to protect the colony against spiders
- Seal the inner lid tightly with resin to deny access for ants
- Remove affected pollen pots and brood cells to prevent the spread of storage mites infesting pollen pots.

3. CONCLUSIONS

Stingless bee mostly found on cavities tree trunk, old walls, inside the termite mound and subterranean cavities. Nests are built using wax secreted from the metastomal terga, mixed with plant resin and gums. Now day's stingless bees are used as domestication process for pollinating crops *viz*., guava, mango, citrus, cucumber and sunflower etc. Stingless alone pollinated crops are mango, strawberry and cashew. It is effectively used for green house pollination because of their limited foraging distance and foraging activity of *T. iridipennis* peak time is 10.00 am to 12.00 pm. Propolis of stingless bee has wide spectrum of pharmacological properties such as antibacterial, antimicrobial, antioxidant, anti – herpes, antiulcer, antihypertensive and anticancer activity. In India, the dry fruit mite, *Carphoglyphus lactis* infestation on *T. iridipennis* colonies and also parasitic mites (*Pyemotes sp.*) affect the colonies. *Pyemotes* sp. also affect the stingless bee queen and brood cells.

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