ICAR

KERALA AGRICULTURAL UNIVERSITY

STATUS PAPER ON

# STINGLESS BEE

## *TRIGONA IRIDIPENNIS* Smith

To. Dr. D. Alexander
With respectful regards



S. DEVANESAN
PROFESSOR & PRINCIPAL INVESTIGATOR
AICRP ON HONEY BEES AND POLLINATORS
KERALA AGRICULTURAL UNIVERSITY
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## FOREWORD

Stingless bees are a class of hymenopteran insects under Sub-family Meliponinae. These bees are looked at for their efficiency in pollination of those plants having very small flowers that cannot be accessed by larger bees such as honey bees and others.

*Trigona* spp., of stingless bees has a wide distribution in the country, particularly around the elevated plains of Western and Eastern Ghats as well as in North-Eastern hill regions. Different species have been described from these locations and have been utilized by humans for harvesting their role as pollinators as well as harvest the honey that has proven medicinal value. These insects have, in their habitat, fringing forests and agro-ecosystems that are exploited for their pollen and nectar requirements. Exploitation of these bees for harnessing useful products is important and suitable research in this area has been introduced under the All India Coordinated Research Project on Honey bees and Pollinators during the Eleventh plan Period.

I am sure that this book would provide suitable impetus to researchers to fortify their ideas into suitable action plans and develop domestication techniques so as to result in economic management of stingless bee colonies, as part of rural enterprise, for women and unemployed youths. The current decade of this century has significant opportunity to take off such promising areas of research through organized programmes. I congratulate Dr. S. Devanesan and his excellent team for this initiative and for this wonderfully informative collection of facts on *Trigona spp.*

The various researchable issues that are raised through this book could be the beacon for future researchers.

**Dr. T.P. RAJENDRAN**
ASSISTANT DIRECTOR GENERAL (PP)
INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI, INDIA

## MESSAGE

The Kerala Agricultural University has initiated apicultural research with the outbreak of viral disease on Indian honey bee (*Apis cerana indica*) used for commercial beekeeping in the State during nineties. Under the aegis of Indian Council of Agricultural Research, New Delhi a centre of All India Co-ordinated Project on Honey bee Research and Training was started at the Regional Agricultural Research Station (Southern Zone), College of Agriculture, Vellayani during 1994. This helped to standardize scientific technologies suited to beekeeping under Kerala conditions and rejuvenating the ruined beekeeping industry in the State due to the devastating "Thai Sacbrood Virus" disease.

I am happy to note that the centre has done commendable work to study the small sized stingless bee *Trigona irridipennis* Smith available in the domicile like crevices in wall, hollow blocks, tree cavities etc. and standardized its domestication and management technologies. The importance of this species to human by enhancing crop productivity through pollination and supply of medicinal honey is well known. It is ideal for beekeeping in homesteads. Popularization of meliponiculture will help for rural upliftment and supplementary income generation especially to women.

I appreciate the effort made by Dr. S. Devanesan, Professor and Principal Scientist of the All India Co-ordinated Research Project on Honey bees and Pollinators, Vellayani and his team Dr. K.S Premila and Smt. K.K. Shailaja in documenting the findings through the publication of the book **"Status Paper on Stingless bee *Trigona irridipennis* Smith"** with the support of Indian Council of Agricultural Research (ICAR), New Delhi. The publications on meliponiculture in Kerala are quite scanty, I am sure that his book with attractive photographs and valuable information will generate awareness and provide basic knowledge on stingless bee to researchers, students and farmers who are interested in meliponiculture and initiate more effective exploitation.

**K.R. VISWAMBHARAN, I.A.S**
VICE CHANCELLOR
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, THRISSUR.

## MESSAGE

Honey bees belong to the family of eusocial insects which also includes bumble bees and the tropical stingless bees. The true honey bees, bumble bees and stingless bees constitute the family Apidae and come under the sub-families Apinae, Bombinae, and Meliponinae respectively. The honey bee is one of the few insects that are directly beneficial to mankind. Human's association with honey bees, dates back to several thousands of years. Honey is the oldest sweetner known from animal source. India is fortunately endowed with all four species of true honey bees, of these three species are indigenous. The giant honey bee *Apis dorsata*, little bee *Apis florea*, Indian bee *Apis cerana* and exotic Italian bee *Apis mellifera* are the common honey bees coming under the Genus *Apis*. In addition to that the stingless bee *Trigona iridipennis* is also abundant in the country which is a very good pollinator to a vast majority of the crops.

Dr. Devanesan and his team conducted basic studies on stingless bees with the help of ICAR ad-hoc scheme and succeeded in domestication, hiving and management of *T.iridipennis*. I am happy that the team is documenting the results of the studies entitled "Status paper on Stingless bees" with the support of Indian Council of Agricultural Research (ICAR). I hope the status paper will serve as a basic publication on stingless bees benefitting to beekeepers as well as researchers. I congratulate the team for putting their effort in the publication and wish all success.

**DR. R.K. LAKRA**
PROJECT CO-ORDINATOR
AICRP ON HONEY BEES AND POLLINATORS (ICAR)
HARYANA AGRICULTURAL UNIVERSITY, HISAR, INDIA

## MESSAGE

The Kerala Agricultural University has been sanctioned a centre of All India Co-ordinated Project on Honey bee Research and Training in 1994 by the Indian Council of Agricultural Research (ICAR), New Delhi consequent to the outbreak of the dreadful disease to honey bees during nineties. The centre has identified the causal agent as Thai sacbrood Virus (TSBV) and contributed for rejuvenation of ruined beekeeping industry in the Kerala State by evolving nucleus colonies of TSBV tolerant strains of Indian bee by selective breeding.

Along with other apicultural research, the centre under the leadership of Dr.S.Devanesan, Professor and Principal Scientist has conducted basic studies on the stingless bees with the support of ICAR through the ad-hoc scheme "Bio ecology, domestication and management of stingless bees in Kerala". Dr. Roubik, Smithsonian Tropical Research Station, USA, identified the species available in different districts of Kerala as *Trigona iridipennis* Smith. The technologies for the domestication, hiving and management in different seasons have been standardized. The bee biology, biometry and bee botany have been worked out which is the first successful work in India. I am happy that Dr.S.Devanesan and his team have taken effort to document the information gathered in the book 'Status Paper on Stingless bee *Trigona iridipennis* Smith with the support of ICAR.

I hope the information in the book will be of much use to the science of meliponiculture, beekeepers and researchers not only in Kerala but throughout the country. I wish all success to the endeavour.


**DR.D. ALEXANDER**
DIRECTOR OF RESEARCH
KERALA AGRICULTURAL UNIVERSITY
VELLANIKKARA, TRICHUR

# PREFACE

Honey bees are the fascinating insects that live in almost all parts of the world except the polar region. About 20,000 species of bees are known in the world. In India, though special efforts were made after independence to develop various agro-based industries, beekeeping industry received inadequate attention resulting in its slow development. Till 1962, beekeeping was slowly practiced with native honey bee *Apis cerana indica* when exotic species *Apis mellifera* was introduced in the country. Beekeeping industry is still in infancy compared to neighbouring country China where beekeeping has been established as a commercial enterprise. In Kerala there are four species of true honey bees *viz.,* rock bee *A. dorsata,* little bee *A. florea,* Indian bee *A. cerana indica* and Italian bee *A. mellifera*. In addition to these the stingless bee, a close relative of honey bee, *Trigona iridipennis* Smith is also common in Kerala.

Not much scientific information is available on this species. Considering the importance of stingless bee in pollination and high price to its honey, the Kerala Agricultural University , All India Co-ordinated Research Project on Honey bees and Pollinators; Regional Agricultural Research Station (Southern Zone), College of Agriculture, Vellayani , Kerala, India conducted detailed studies on the domestication, hiving and management of stingless bees with the support of the Indian Council of Agricultural Research (ICAR) through the adhoc-project " Bio-ecology, domestication, and management of stingless bees in Kerala." Even though, 500 species of stingless bee are distributed world wide, only one species is identified in the State. The natural domicile of this small bee is in crevices of empty trunks, hollow blocks, walls etc. We have attempted to domesticate, hive and standardize the management of this species. The findings of the studies covering basic information and knowledge gathered along with photographs of the species are documented in this book.

Dr. K.S. Premila, Associate Profesor & Senior Scientist and Smt.K.K. Shailaja, Research Associate have contributed for the compilation of this status paper. We earnestly hope that, this basic knowledge and information on stingless bees will be useful reading and reference material to those who are connected with meliponiculture especially unemployed women, youth and researchers.

The authors profusely thank the Indian Council of Agricultural Research (ICAR) and Kerala Agricultural University (KAU) for the support in the conduct of investigations and compilation of this book.

**DR. S. DEVANESAN**
PROFESSOR AND PRINCIPAL SCIENTIST
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# CONTENTS

# INTRODUCTION

Bees of all kinds belong to the order of insects Hymenoptera; literally mean "membrane wings". Honey bees belong to the family of eusocial insects which also include bumble bees and the tropical stingless bees. The true honey bees, bumble bees and stingless bees constitute the family Apidae and come under the sub-families Apinae, Bombinae, and Meliponinae respectively.

Honey bees are a group of polymorphic colonial insects. It is one of the few insects that are directly beneficial to mankind. Human's association with Honey bees, dates back to several thousands of years. Honey was one of the natural foods that the early man had tasted.

Apinae consists of single genus, *Apis*, which is characterized by the building of vertical combs of hexagonal cells constructed bilaterally on either side of a midrib, using the wax secreted by the worker bees. The cells are multipurpose, being repeatedly used for rearing the larvae and for the storage of honey and pollen. Each colony is headed by a single fertile female, the queen, which is the only egg layer. The workers gather nectar; make and store honey; build the cells, ventilate the hive (by fanning with wings), protect the colony and feed the queen and the larvae and clean the hive by removing debris. About 20,000 species of bees are known in the world (Michener, 2000). (Fig 1, Fig 2)

Bumble bees belong to the genus *Bombus.* They are similar to their close relatives, the honey bees, in that their colonies are headed by a queen, who is the main egg-layer, and many workers, who are the daughters of the queen, and the drones (males) are produced during the mating season. However, the colonies of bumble bees, unlike those of honey bees, only survive during the warm season. In addition, there are usually fewer individuals in a bumble bee colony than in a honey bee colony and bumble bees do not use a dance to communicate the location of food to other members of the colony, as honey bees do. Moreover, although bumble bees collect nectar and store it as honey, they do not hoard large amounts of it, as do honey bees. In the tropics, bumble bee colonies continue for many years, but in temperate regions the workers and the drones die in the fall. Only the young, fertilized queens live through the winter, in hibernation to begin another colony in the following spring. Bumble bees are important pollinators of many plants (Fig 3).

Stingless bees are small in size and the natural domicile is the crevices in walls, hollow blocks etc. The stingless bee with more than 500 species, exhibit larger bio-diversity than Honey bees (Crane, 1992). Along with the true Honey bees they form an excellent example of social evolution (Fig 4).

# 2 HISTORY OF BEEKEEPING

The method of care and management of Honey bees is called beekeeping (apiculture) and that of stingless bees is known as meliponiculture.

Beekeeping is a farmer and ecofriendly enterprise with special advantage that it can be practiced where majority of people are small or marginal landholders or even land-less, which provide supplementary income and employment to the rural people. In ancient times Honey bees were kept in a crude manner. The discovery of the principle of 'bee space' by L.L. Langstroth in the West during the second half of the nineteenth century paved way for improved/scientific methods of beekeeping and subsequent refinement.

In India, beekeeping has been practiced from time immemorial. References are available in Bible, Koran and ancient vedic literature such as Ayurveda, Rigveda, Charaka samhita wherein honey had been praised as a nutritious food and valuable medicine. Honey became essential part of the life and culture of the Indian people that honey and Honey bees were even incorporated in their religions. The recommendations of the Royal Commission on Agriculture(1928) for developing cottage industries gave a fillip to beekeeping. Beekeepers of India organized themselves into an All India Beekeepers Association during 1938-39. The Indian Council of Agricultural Research (ICAR) co-ordinates the activities of research works in beekeeping. In addition to that from 1980, an All India Co-ordinated Project on Honey bees Research and Training had been started. During the past four decades the State Agricultural Universities, Village and Khadi Industries Commission, State designated agencies for beekeeping are also contributing to the development of beekeeping.

European bee *Apis mellifera* (Fig 5) is found all over Europe and has spread to other continents also during the last five centuries. In Asia there is greater diversity of Honey bees *viz.*, the Asian honeybee, *Apis cerana indica* (Fig 6), the rock bee *Apis dorsata* (Fig 7), the little bee *Apis florae* (Fig 8).

Kerala "the God's own country" with rich floral diversity and congenial climatic conditions offers immense scope for beekeeping in the State. Beekeeping is being practiced in the State since 1924 and it made rapid strides during the second half of the twentieth century. Now beekeeping is developing as a major industry and many entrepreneurs are taking it on commercial basis. Besides honey, bee industry also market beeswax, pollen, royal jelly, propolis and bee venom as byproducts. The Honey bees enrich agro horticultural crops by its pollination services. In India over 80 per cent of crops *viz.*, oil seeds, pulses, vegetables, fruits and commercial crops are benefited by bees.

Detection of rubber (*Hevea brasiliensis*) as a rich source of extrafloral nectar during seventies gave a big boost to the beekeeping industry in the State. Migratory beekeeping with Indian bees, *A. cerana indica* forms the basis of the apiculture industry of the State. Kerala was contributing 70 per cent of the annual production of honey in India till 1991 (Jacob *et al.*, 1992). But the beekeeping industry in the State got a set back during 1991-1992 due to the severe outbreak of Thai Sacbrood Virus (TSBV) disease. European bee, *A. mellifera*, which is resistant to TSBV was introduced in the State to rebuild the declining beekeeping industry.

Among the four species, only the indigenous species *A. cerana* and exotic species *A. mellifera* are being utilized for commercial beekeeping in Kerala. *A. dorsata* and *A. florea* are two wild species of Honey bees seen in the State, which could not be domesticated. In addition to these true Honey bees, the stingless bee species *Trigona iridipennis* Smith is also very common with the beekeepers.

# 3 STINGLESS BEES AND THEIR IMPORTANCE

Stingless bees are highly eu-social, sharing several specialized features including existence in large perennial colonies showing extreme caste differentiation, storage of large quantities of food and highly effective thermo-regulation. The stingless bees are so called because they have no venom apparatus and cannot sting. They are small to medium sized, having a vestigial sting, which is greatly reduced without an effective tip. However, they do have well-developed mandibles by which they bite when an intruder disturbs the colony.

Three distinct characters recognized for the identification of stingless bees *viz.,* reduction of sting, presence of penicillium (a bunch of curved hairs on the outer corner of hind tibia) and reduction and weakness of wing venation.

*Trigona iridipennis* is the common stingless bee in India, which is small to medium sized. They are sometimes called 'dammer bee' as they collect a kind of resin for constructing their nest along with wax produced from their body. The generic name *Trigona* refers to their triangle shaped abdomen and *iridipennis* refers to their iridescent wings. Most *Trigona* species are relatively small, and long winged, while *Melipona* species are short winged and tend to be larger and some even attaining the size of Honey bees.

in several regions, the technique of stingless beekeeping is adopted by using hollow logs and pottery vessels as bee hives (Nordenskjaeld, 1934). The most sophisticated meliponiculture was developed by Mayas in Yucatan, Latin America, with ritual dating from pre–Columbian times (Weaver, 1981). The art of meliponiculture has been practised traditionally in Asia especially Indonesia (Crane, 1992).

Stingless bee products are used world wide as food and medicine. The honey of stingless bees is more acidic than commercial honey but it has unique taste and medicinal properties. This may be due to the fact that the bees collect nectar and pollen from many medicinal plants with small flowers which are not visited by *Apis* spp. The only limitation is the low quantity of honey produced, bulk of which is utilised for its own use. Despite the small amount of honey produced per hive, the honey is in great demand and fetches comparatively higher price due to its medicinal value.

Ecologically too the stingless bees are important because of their role in pollination of tropical flora. The abundance combined with their bio-diversity make them a key factor in pollination of natural tropical plants and crops. Over 130 species of stingless bees world over have been identified as potential pollinators of crops (Roubik, 1995). Stingless bees are undoubtedly the most important natural pollinators of the tropical crops (Heard, 1999). Due to their small size, they have an easy access to differently oriented flowers. More than 250 plant species are adapted to pollination by stingless bees. The foraging range is shorter than *Apis* spp. and hence they can very well be utilized in planned pollination.

The feral colonies found in tree and wall cavities (Fig 9) can be transferred to hives and easily domesticated compared to other Honey bees. Meliponiculture is suitable for women because it does not involve heavy physical work and provides an additional means of income for the rural homesteads. It can modestly contribute to the economy of peasant households, as a single component or integrated with conventional beekeeping. However, lack of systematic studies about the species and its management practices is a limiting factor in popularizing meliponiculture. The present honey production is far short of the current demand and hence with adequate research and extension support, meliponiculture industry has a bright future in India.

In Kerala stingless bees are reared as backyard beekeeping practice mainly for honey production. They are kept in mud pots (Fig 10), bamboo bits (Fig 11) or coconut shells, wooden box (Fig 12, Fig 13). The stingless bees are hardy and easy to handle. In view of the diversity of flora in Kerala considerable quantity of stingless bee honey can be produced from the State (Devanesan *et al.*, 2003). A large number of colonies are being destroyed due to the unscientific method of honey harvest. The honey produced is mainly obtained from the feral colonies. If concerted attempts are made for improving the hiving, domestication, conservation and management of stingless bee it would result in the increase in adequate number of colonies for producing sufficient honey for meeting the current demand. The potentialities of Meliponiculture *viz.,* rural employment, nutrition and supplementary income generation, especially to women who can easily handle it, is substantial in the homesteads of Kerala. Augmentation, conservation and management of *T. iridipennis* should be intensified for ensuring sustainable agriculture and the conservation of biological diversity.

# 4 ORIGIN AND GEOGRAPHICAL RANGE OF MELIPONINAE

The oldest known specimen of social bee is a stingless bee found in Amber in New Jersey, USA. It lived in cretaceous period, 80 million years ago and had been named as *Trigona prisca* (Crane, 1992). Stingless bees were probably the first social bees to branch off from less social ancestors and this occurred before the new world continents of America and Australia were separated from the old world land mass of Africa, Asia and Europe. As a result, the bees are present in both old and new world.

Based on paleantological and bio-geographic data, stingless bees are considered to have their center of origin in Africa with subsequent dispersal to other tropical and subtropical parts of the world. This hypothesis is also supported by the fact that their primitive species with a well-developed sting system lived in Africa.

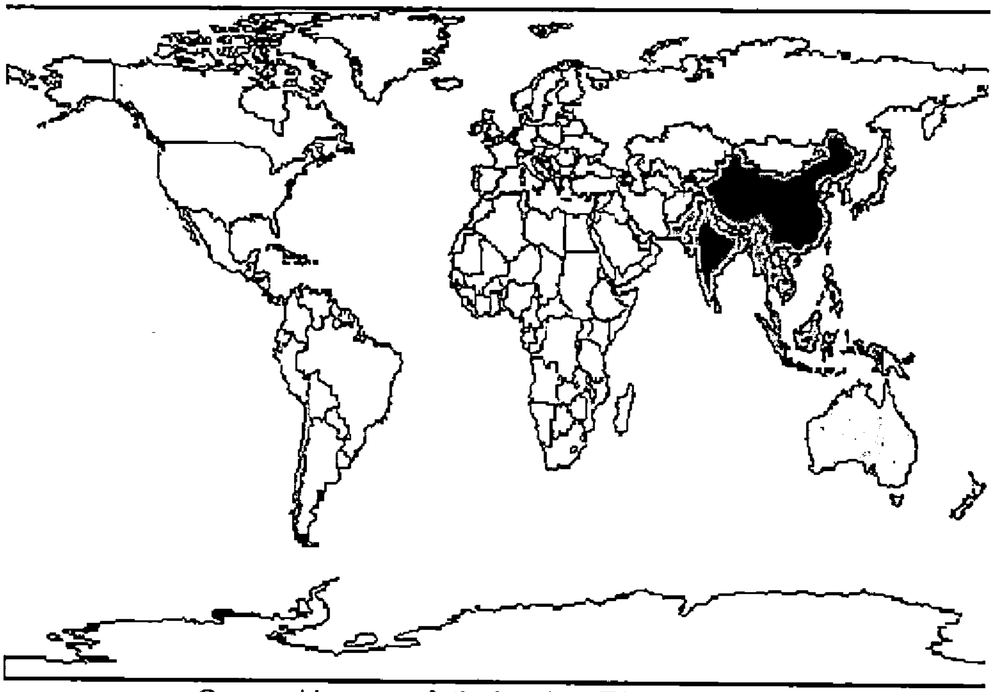
Different species are adapted to different tropical habitats but mostly they live at low altitudes. However, because of their predominance in the tropics, the biology of stingless bees has been far less explored in temperate regions (Sakagami,1982).

**Taxonomic hierarchy of stingless bees**

| | | |
|---|---|---|
| Phylum | : | Arthropoda |
| Class | : | Insecta |
| Order | : | Hymenoptera |
| Family | : | Apidae |
| Sub family | : | Meliponinae |

Meliponinae are a fairly large group with diverse morphology and biology. About 500 species of stingless bees are recognized, of which majority are found in South America (Roubik, 1992). At least 250 species have been described in South and Central America where research has been most advanced. About 50 species live in South Asia and Malaysia, 20 in Australia, Papua New Guinea, the Philippines and as many as 40 are native to Africa. Since the forests in the tropical areas mostly consist of entomophilous plants, stingless bees are of great importance for the pollination of many wild plants in addition to crops.

The important genera of stingless bees are *Melipona* and *Trigona*. Crane (1992) listed 14 species of *Melipona* and 21 species of *Trigona* that have been used for



Geographic range of stingless bee *Trigona iridipennis*

traditional beekeeping. *Trigona* species are present in all the tropical countries while *Melipona* are restricted to Central and South America and occasionally in Asia. *T. iridipennis* Smith is found all over India.

# 5 DIVISION OF LABOUR AND CASTE DIMORPHISM

A stingless bee colony consists of a queen,(Fig 14) a few drones (Fig 15) and a large number of workers (Fig 16) as in *Apis* sp. Social life in stingless bees, as in other social insects involves division of labour. The females are divided into two castes, which include queen and workers (Neto, 1953). According to Bassindale (1955) the different tasks performed by the workers are not rigidly established but show a tendency to do some specific tasks at different ages. Simons (1974) observed that the number of guards increased in weak colonies. The relation between age sequence to worker polyergism and some morpho-functional features in *Scaptotrigona postica* was described by Sakagami (1975). The task sequence is more pronounced in colonies containing virgin queens. The sequence identified are self grooming, incubation, repair of brood chamber, construction and provisioning of cells, feeding of young ones, reconstruction of involucrum, guard duty and collection of nectar and pollen (Dollin, 2001).

Caste dimorphism is strongly developed in *T. iridipennis*. Female bees have two sets of chromosomes (*diploid*), one set from the queen and another from one of the male bees or drones. Drones have only one set of chromosomes (*haploid*) and are the result of unfertilised eggs. In stingless bees, sex is determined by a single complementary sex-determining locus. This method of sex determination imposes a severe cost of inbreeding because an egg fertilized by sperm carrying the same sex allele as the egg results in a sterile diploid male. Females become workers or queens depending on the nutrition they receive during larval stage. Queen cells can be distinguished from others by their large size as they are stocked with more food than the worker and drone cells. When the queens emerge they are killed or evicted. But if the ruling queen is weak or dying the hive will select a new virgin queen.

Queens are much larger than workers, lack corbiculae and wax glands. it has longer scape, shorter tongue, smaller mandibles, wings partially covering the swollen abdomen, absence of corbicula and less distinct glabrous streaks on mesonotum. Sakagami (1982). The sole activity of the queen in the colony is egg laying. The gravid stingless bee queens are far more physogastric than honey bee queens, but the number of ovarioles per ovary is four as in the case of workers and never as numerous as in honey bee queens. Instead, each ovariole of the stingless bee

Fig. 1 Honey bee worker

Fig. 2 Honey bee queen

Fig. 3 Bumble bee

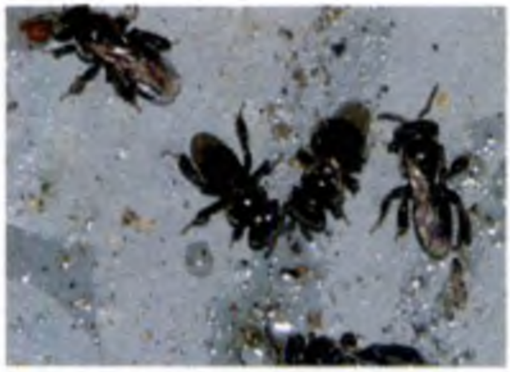


Fig. 4 Stingless bee workers

Fig. 5 Italian bee *Apis mellifera*

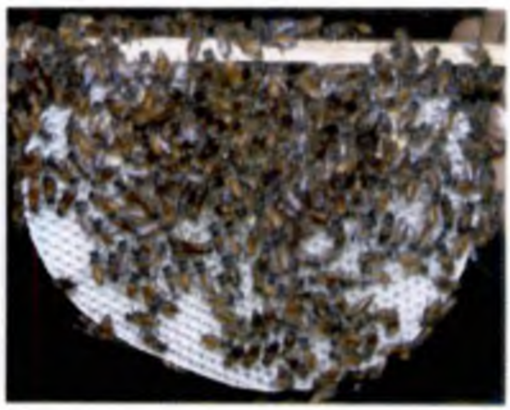


Fig. 6 Indian bee *Apis cerana indica*

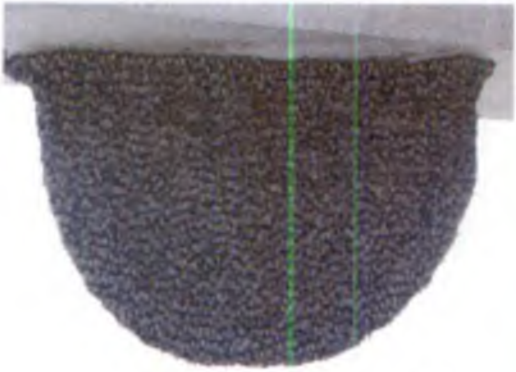


Fig. 7 Rock bee *Apis dorsata*

Fig. 8 Little bee *Apis florea*

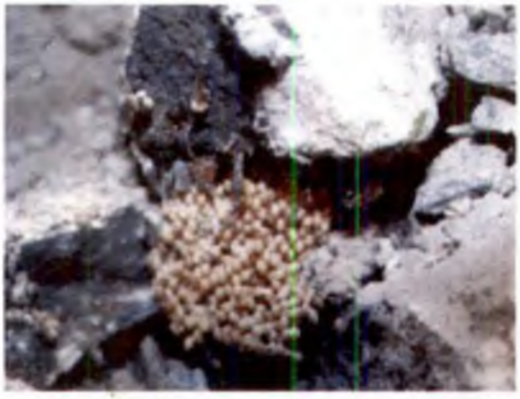


Fig. 9 Feral colony of *T. iridipennis* in rock wall

Fig. 10 Stingless bee colony in earthen pot

Fig. 11 Stingless bee colony in bamboo bit

Fig. 12 Stingless bee colony in coconut shell


Fig. 13 Stingless bee colony in a wooden box


Fig. 14 Queen bee of stingless bee


Fig. 15 Drone of stingless bee


Fig. 16 Workers of stingless bee


Fig. 17 Antenna of stingless bee worker


Fig. 18 Mandible of stingless bee worker

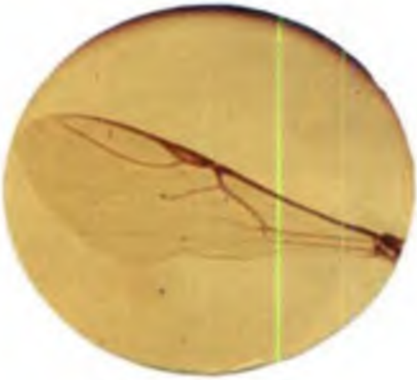


Fig. 19 Fore wing

Fig. 20 Hind wing

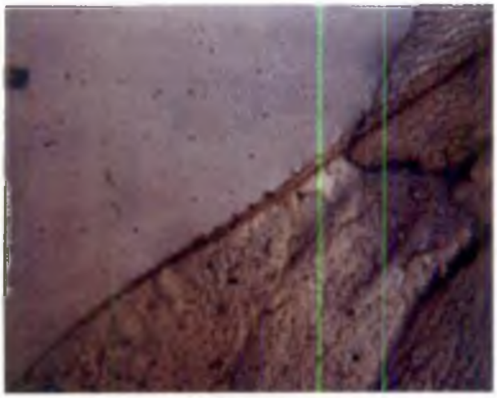


Fig. 21 Hamuli on wing

Fig. 22 Fore leg

Fig. 23 Middle leg

Fig. 24 Hind leg

Fig. 25 Legs of stingless bee

queen is extremely long and coiled within the abdomen. The new queen makes her nuptial flight, where she is mated by only one male. The sperm is stored in a special sac in her body for her entire life. The virgin queen will mate only once. The queen's ovaries initiate egg development, enlarging the abdomen so that she cannot fly anymore. Egg laying commences soon after mating. She can choose whether or not to fertilize each egg with the sperm. If she fertilizes the egg, it will develop into a worker or a queen. If she does not fertilize the egg, it will develop into a drone. The queen will live for up to 5 years, although her stamina for egg laying will reduce over time (Raakhee, 2000; AICRP, 2003).

Workers and queens of *Apis mellifera and Apis cerana* are so similar that beginner beekeepers have difficulty in distinguishing one from the other, but males are very different from both of them. On the contrary, males and workers of meliponine bees are very similar, and difficult to differentiate. Worker bees are females developed from fertilized eggs. The worker bees are smaller in size than the queen with small abdomen. The activities of the workers change as the age advances. When the young worker bees emerge from their cells, they tend to remain inside the hive pursuing different jobs. It starts with self-grooming just after emergence from the pupae, followed by preparation and repairs of the brood chamber, construction of the involucrum and provisioning of cells. Some will become nurse bees, producing royal jelly to feed the larvae, young adults and the queen. As they get older, they become guards at the entrance or foragers for collecting pollen, nectar and propolis. Life span of workers is around 80 days although some may live to become scouts, responsible for finding food and alerting other bees in the hive to its source.

The drones are male bees which are few in a colony (Fig. 15). The males and workers extraordinarily resemble each other meanwhile both differ very much from the fertile females (virgin queens). The drones can be identified by straightly arranged ocelli, laterally enlarged compound eyes, smallest scape, longest antennae, smallest mandibles, less distinct glabrous streaks on mesonotum, rudimentary corbicula, wings projecting slightly beyond the blunt abdomen and genitalia. They do not have any work in the colony except mating with the queen bee.

# 6 MORPHOMETRY

The morphological characteristics of the stingless bee, *T. iridipennis* studied at All India Co-ordinated Project on Honey bee Research and Training Centre, Vellayani showed that a queen has golden brown colour and a pointed abdomen and it has a mean body length of 10.07 mm. The adult workers are highly black pigmented compared to young worker bees which are pale yellow in colour. The body length of the worker is 4.07 mm (Devanesan *et al.*, 2004).

The mean total length of the antennae of queen is 3.72 mm and that of worker is 2.57 mm (Fig 17). The flagellum has ten segments in both. The mandibles of workers are modified and differ from those of the true Honey bees and the mandible in the workers is smaller than that of the queen (Fig 18). The length and breadth of the fore wing are 3.56 mm and 1.30 mm respectively in queen and that of workers are 3.60 mm and 1.36 mm respectively (Fig 19). In queen the hind wing has a length of 2.25 mm and breadth of 0.64 mm and in workers it has a length of 2.46 mm and breadth of 0.63 mm (Fig 20). The number of hamuli on the hind wing is five in both workers and queen but the extent of hamuli had slight difference in both queen and workers (0.24 mm and 0.22 mm) (Fig 21). Wing venation in *Trigona* was found to be reduced (AICRP, 2004).

The fore, middle and hind legs have a total length of 4.03 and 4.58 and 5.22 mm respectively and that of workers are 3.05 mm, 3.74 mm and 4.56 mm. A pollen basket is seen on the hind leg of the worker bees of *Trigona* as in true Honey bees (Fig 22,23,24,25). There is a row of stiff spine like setae at the inner apical margin of tibia and those are not found in the queen (Fig 26) (Devanesan *et al.*, 2004).

Table 1. Morphometric characters of the queen and worker of *T. iridipennis*

| Characters | Queen (mm) | | | Worker (mm) | | |
|---|---|---|---|---|---|---|
| Length of proboscis | 1.30 | | | 1.38 | | |
| **Antenna** | | | | | | |
| Length of Scape | 0.72 | | | 0.54 | | |
| Length of pedicel | 1.62 | | | 0.13 | | |
| Length of flagella | 1.38 | | | 1.90 | | |
| No. of segments of flagellum | 10 Nos. | | | 10 nos. | | |
| Size of mandible | 0.625 | | | 0.6 | | |
| **Fore wing** | | | | | | |
| Length of fore wing | 3.56 | | | 3.6 | | |
| Breadth of fore wing | 1.30 | | | 1.36 | | |
| **Hind wing** | | | | | | |
| Length of hind wing | 2.25 | | | 2.46 | | |
| Breadth of hind wing | 0.64 | | | 0.63 | | |
| No. of Hamuli | 5 Nos. | | | 5 nos. | | |
| Extent of hamuli | 0.24 | | | 0.22 | | |
| **Legs** | Fore leg (mm) | mid.leg (mm) | Hind leg (mm) | Fore leg (mm) | Mid.leg (mm) | Hind leg (mm) |
| Length of Coxa | 0.43 | 0.67 | 0.72 | 0.35 | 0.53 | 0.53 |
| Length of trochanter | 0.48 | 0.48 | 0.53 | 0.29 | 0.32 | 0.36 |
| Length of femur | 0.96 | 1.03 | 1.25 | 0.75 | 0.86 | 1.03 |
| Length of tibia | 0.91 | 0.96 | 1.26 | 0.72 | 0.91 | 1.43 |
| Length of tarsus | 1.25 | 1.44 | 1.46 | 0.94 | 1.12 | 1.21 |
| **Total length of legs** | 4.03 | 4.58 | 5.22 | 3.05 | 3.74 | 4.56 |
| **Total length of body** | 10.07 mm | | | 4.07mm | | |

# 7 LONGEVITY OF COLONY

Little is known about the longevity of the colonies of stingless bees. The known reported duration is 10 years (Willie, 1963).The colony of stingless bees can be prolonged by replacing the queen successively as long as lethal disaster does not occur. Generally, the longevity of the queen seems to be longer than that of the honey bees which is 3-5 years. There is a report from Thailand in 1995 stating that a 12 year old colony of *T. fuscovartiata* could be located which is being maintained under controlled conditions without exchange of queen. The workers of stingless bees also seem to live considerably longer (around 80 days) than those of *Apis* species. *T. xanthotricha* workers spend about six weeks in the nest and then about the same length of time in the field, a life span about double to that of *Apis*.

# 8 LIFE CYCLE OF STINGLESS BEE

## Provisioning and oviposition

The brood rearing in stingless bee is different from that of *Apis* species. In *Apis* species same comb cells may be used for storage of food *i.e.*, either pollen or honey and also used for brood rearing, all the cells in a comb are of the same size and shape and are constructed on either side of a comb and reused according to the need and season. While in stingless bee, pollen and honey are stored in separate cells which are larger in size and placed separately. The brood cells are smaller and oval in shape and are exclusively used for brood rearing which will be used only once. First of all, the worker bees construct pillars of wax, in the hive that provide base for the brood cells (Fig 27). On these pillars, the worker bees start construction of brood cells in groups. The cells will be either spherical or oval in shape (Fig 28, 29, 30) (AICRP, 2004).

Mass provisioning is observed in stingless bees (Fig 31). Before provisioning the queen walks over the brood comb cells and inspects them. After the walking she settles down near a cell that has been collared for egg laying. Several workers are seen around the queen and they fill the selected cell with food. When the workers provision the cell, the queen inserts her abdomen into the cell and lays an egg in it.

The egg is kept in the centre of the liquid food in a perpendicular direction (Fig 32). The queen leaves the cell immediately after oviposition. The workers engage in provisioning and a single worker is involved in closing the cell that was oviposited. The steps involved in oviposition could be depicted as follows:

Construction of cell

↓

Arrival of queen

↓

Queen drums the workers

↓

Provisioning of food into cell

↓

Cell inspection by queen

↓

Food consumption by queen

↓

Egg laying by queen

↓

Departure of queen

↓

Operculation by workers

Sakagami (1982) observed that in stingless bees, about 2 hrs is required to build one cell and 1-2 minutes for provisioning alone and about 10 minutes was required for provisioning, oviposition and cell closure. According to Bentham *et al* (1995), provisioning and operculation of all cells occurred simultaneously and 4-9 workers get involved in the process (Fig 33,34).

## Biology

George (1934) found that a period of 21 to 25 days was required for the completion of development of egg to adult in the case of *T. iridipennis*. According to Salmah *et al* (1996) the time required for oviposition to adult emergence of workers was 46.5 days (egg 4.3 days, larva 10.4 days, pupa 31.8 days) in *Trigona itama*.

A detailed study was conducted at the AICRP Centre, Vellayani, to work out the biology of stingless bee with the help of observation hives fitted with glass doors on the sides. The activities of the bees inside the hive were observed through the glass. The cells oviposited were daily marked with Indian ink as separate lots. From each lot, one cell was opened up daily and the development stages were recorded. Five such hives were maintained as replication. The procedure facilitated the observations on the developmental stages (egg, larva, and pupa) and the time of hatching and adult emergence and to record the egg, larval and pupal durations. This procedure was continued until the hatching of eggs. The cells with one day old larvae were selected in five colonies and they were marked for observing the larval changes inside the cell. One such cell from each colony was opened every day to observe the changes till the remaining larvae pupated. One day old pupae were selected, marked and observed in the five colonies for determining the pupal duration (Raakhee, 2000).

Table 2. Developmental period of *T. iridipennis*

| Sl. No | Stages | Days (Mean) |
|---|---|---|
| 1 | Egg | 4.7 |
| 2 | Larva | 18.5 |
| 3 | Pupa | 21.3 |
| Total | | 44.5 days |

The mean length and breadth of egg were 1.07 and 0.9mm respectively. The average incubation period was 4.7 days.

Soon after hatching the larva assumes a horizontal position in the cell. During the later stages, the 'C' shape of the larvae becomes obvious. The larva takes 18.5 days to pupate (Fig 35,36). The pupa remains in the cocoon with head directed upwards. One week prior to the emergence of adults, black eyes can be seen prominently through the pupal cover (Fig 37). Average pupal period is 21.3 days. Thus the life cycle of *Trigona* is completed in 44.5 days under Kerala conditions.

## 9 FLIGHT RANGE AND COMMUNICATION

The flight range of stingless bees is comparatively lower than those of honey bees. The workers of stingless bees show compact flight range of over 1 km while, *Apis* spp forage about 2 - 3 km.

Kerr (1959) and Willie (1983) reported the flight range of stingless bees: *Plebeia* sp., (300 m), medium sized bee *Torigona* sp. (around 800 m) and large bee *Melipona fuliginosa* (about 2,000 m). The flight range of *T. iridipennis* was reported as 120 m (Lindauer, 1957).

Flight activity of stingless bees is highly influenced by the weather conditions. In *Melipona marginata* Moure, the flight activity is correlated positively with the temperature and negatively with relative humidity, but the behavior indicates a flexible response to other weather parameters.

The stingless bee uses a wide range of communication skills, from simply watching where other bees go, to encoding information in sounds. Like *Apis*. many species of stingless bees are able to communicate the location of a food source. They use a chemical secreted from the mandibular giand and sunlight for orienteering. Foraging workers leave scented spots at regular intervals on the way back to the colony from a good source of food. Other bees leave the nest and follow the odour trail outward. In *Trigona postica,* the foraging workers act as guide bees by leading others in a group to the foraging spot, back and forth, several times. Some species of stingless bees such as *T. angustula* communicate using sound signals and zigzag running. In *M. quadrifasciata* and *M. merillae,* returning foragers produce sound impulses in proportion to the distance of the food source. In *T carbonaria,* a foraging bee that has located a good food source marks it with a chemical scent to help other workers visiting the area to locate the spot easily.

Inside the nest, a forager produces pulsed sounds while visibly vibrating her wings after returning from a good food source. She is attended by other bees who cluster and hold their antennae around her, following her as she rapidly spins clockwise and counterclockwise. Locational information may be encoded in this behavior. However, foragers may also directly lead newcomers to the food source.

# 10 BEHAVIOUR OF STINGLESS BEES

## a. Nesting habit

Most parts of the nest in stingless bees are built with cerumen, a mixture of wax secreted by worker bees and propolis made out of resins collected from plants. In general, they build more complex nests than *Apis* spp. with great variety of forms, size and place of construction (Schwarz, 1948). *T. denoiti* builds combs inside the nests of termites (Smith, 1954). The bees that build exposed nests such as *T. spinipes* use leaves and other vegetative parts mixed with resin. Most stingless bees build their nests in empty trunks or in hollow branches or even in soft or hard soil (Pooley and Michener, 1969). *T. oryani* builds its nest within ant nest of *Crematogaster* spp. using cavities produced by depredation of the diurnal pangolin (Darchen, 1971). Generally stingless bees prefer darkness. *T. iridipennis* is seen nesting inside the compound walls, hollow blocks etc preferring darkness. When nest is exposed they laminate it with a thin layer of propolis, the batumen (Sakagami, 1982) (Fig 38,39). Even though the great majority of species use closed cavities to build their nests some build completely exposed nests in large cavities, bushes and bird nests. Certain species like *Schwarziana quadripunctata, Paratrigona* spp., *Melipona quinquifasciata* and *Geotrigona* spp. construct nests in root cavities. Still others use man made structures such as cavities in masonry walls (Bruijin, 1996).

The stingless bee nest usually consists of five parts; an entrance, brood comb, involucrum, store pots and batumen. In the construction of the brood comb, storage pot and involucrum they use cerumen (Raakhee and Devanesan, 2000).

Openings to the nest of *T iridipennis* are through resin tubes of varying shapes, lengths and sizes, normally built of wax and mud, sometimes sticky in nature

(Fig 40, 41). The form of the entrance varies from species to species and it helps in the orientation of the bees moving out and in for defence of the nest (Sakagami and Inove, 1989). The flight entrance is lined with propolis or cerumen and some species build a long protruding entrance tube which may be closed every night (Crane, 1992). The shapes of the resin tubes constructed by stingless bees are useful indications of the type of bee species for identification. Resin tubes of *T. collin* are long and tubular, usually with white brown bands. The nests of *T. thoracica* have resin tubes having lips fringed with petal like structures, while the resin tube of *T. apicalis* nest have a slit like opening. The nest cavity is sealed from outside world except for its entrance.

## b. Building of brood combs

The arrangement of brood combs differs among various species. Combs are made of cerumen (Fig 42). Many species build multilayered combs, each expanding concentrically and horizontally. Some species are cluster builders or build imperfect combs (Sakagami, 1982; Crane, 1992). Worker bees at first construct pillars of wax that provide base to the brood cells. On these pillars brood cells are constructed in clusters (Fig 43,44). They are made of wax and oval or elliptical in shape. Cell construction starts from the bottom of the pillars and proceeds in an upward direction. The cells are seen growing through successive and intermittent contributions of workers. They build multi-layered combs one over the other and each expanding concentrically and horizontally (Fig 45). The arrangement of their brood cells in clusters is different from that of double-sided combs in *Apis*. At a time, a batch of cells is constructed by several worker bees.

Raakhee, 2000 and AICRP, 2004 reported that the brood comb consists of brood cells, in each of which a single young one is reared. In the construction of brood comb, each cell is fully built and provisioned before oviposition by the queen, after which the workers close the cell. Once the first set of brood cells are provisioned and oviposited, newer cells are constructed above it. Within a set of brood cells, some of them are connected to each other by means of wax connectives while others are not. The newly constructed cells are attached to the point of contact, and sometimes three to four cells are broadly attached together. The very significant specific character of *T. iridipennis* is that the species adapt itself to limited space possibly because the cells are usually seen crowded into crevices.

George (1934) opined that the queen cells of *M. iridipennis* were larger than that of worker cells. Queen cells could be seen in stingless bee colonies from November to March. The queen cells (4.00 mm) are larger in size than worker brood cells (0.22 mm) (AICRP, 2003). They are intermixed with worker cells in the comb or seen at the periphery of the brood cluster. Brood cells are dark brown in colour in the early stages (Fig 46) and as the pupae mature, the cell walls are removed, so that the cocoons get exposed and became creamy in colour (Fig 47). The brood clusters are very delicate and should be handled with care (Fig 48).

According to Darchen (1972) the bees remove wax from the cells as soon as the cocoon is spun by the larvae occupying the cell. Traces of wax remained on cocoons which were yellowish white. He also observed that the uneconomical usage of cerumen for cell construction is compensated by the efficient usage of removed cerumen for various purposes. Bruijin (1993) found that during the development of a bee, the cerumen from which the brood cells were built gradually removed from the top of the cell by other workers and they recycled most of the cerumen and used it again to build another brood cell, storage pot or other nest structures.

Kshirsagar and Chauhan (1977) reported that in the colony of *T. iridipennis* brood and food storage pots were connected by columns of wax. The height and diameter of brood cells were reported to be 4.08 mm and 3.12 mm respectively. According to Sakagami (1982) and Bruijin (1993) brood cells were used only once in stingless bees.

### c. Food storage pots

Honey and pollen storing nature of stingless bee *T. iridipennis* is different from that of *Apis* sp. In *Apis* species the pollen and nectar, the food of bees, are stored in the hexagonal comb cells build by the bees which are also used for oviposition and brood rearing. In the case of stingless bees pollen and honey are stored in specialized separate cells built of cerumen. The food chamber of both *Melipona* and *Trigona* lay outside the brood comb and consisted of pollen and honey pots which were many times larger than the brood cells (Lindauer, 1957).

The food chambers are normally oval in shape and larger than the brood cells (Fig 49, 50). The pollen and honey pots are found either separate or intermixed and they are of almost the same size. In *T. irridipennis,* the storage pots are seen very close to brood cells or separated from brood cells (Kshirsagar and Chauhan, 1977; Crane, 1992). New pots are built adjacent to older pots, hence pots look like a bunch of grapes (Dollin,1996).

The density of honey pots and pollen pots in the hive and the size of storage pots and quantity of honey and pollen per pot were studied. (Fig 51,52,53,54). The average number of pollen and honey pots present in an area with a volume of 2 $cm^3$ was eight each. The height of the honey pot ranged from 0.5 cm to 1.1 cm with an average of 0.96 cm. The height of pollen pot ranged from 0.8 cm to 1.2 with an average of 0.97 cm. The average diameter of honey pot was 0.89 cm with a range of 0.6cm to 1.1 cm and pollen pots varied from 0.6 to 0.8 cm with a mean of 0.73 cm. The perimeter of honey pot ranged from 1.9 to 3.0 cm with an average of 2.09cm and that of pollen pot ranged between 1.6 and 2.2 cm with an average of 1.98 cm . The quantity of honey stored in a single pot ranged from 0.5 ml to 0.6 ml with an average of 0.5 ml. The average weight of individual pollen per pot was 0.23 g with a range of 0.15 g to 0.37g (Devanesan *et al.*, 2002; AICRP, 2003).

## d. Waste and resin dumps

Lindauer (1957) recorded that *T. iridipennis* placed scattered droplets of sticky matter in the hive and fresh resinous matter at the mouth of the entrance tube. Further the bees engaged in removing the pupae from damaged cells, dropped them outside the nest. He also observed that the stingless bees deposit irregular rows of pointed lumps of resin in front of the colony entrance which help to prevent the invasion of ants. The stingless bees void their excreta in the hive on the top of the waste heap, in contrast to *Apis* colonies in which workers always defecate outside the nest (Bruijin, 1993).

When a hive is disturbed the bees are seen depositing resin at several parts of the hive and even among brood cells. In many hives piles of yellowish brown coloured matter could be seen at a distance from the brood cells, bees were found flying out with small cakes of this material. These waste dumps were seen to contain dead bees or part of them, remains of brood, cocoons as well as faecal material. Resin in the form of creamy droplets could also be observed in the hive. Small lumps of resin were also found to be attached near to the hive entrance and to other parts of the hive (AICRP, 2004) (Fig 55,56,57).

# 11 DEFENCE MECHANISM

Unlike the true honey bees, the stingless bee *T. iridipennis* do not have sting as the defence mechanism, but developed an equally effective biting behaviour, in defending their nest. While biting they eject a caustic fluid and also cause annoyance by crawling into the nose, eyes and ears and entangling in hairs. The most common strategy of defence is to make their nests and the entrance invisible to intruders (Bruijin, 1996).

According to Lindauer (1957) the stingless bees have no means of defence. But Willie (1983) reported that stingless bees possess efficient means of defence. Bees of the genus *Trigona* possess volatile materials in their mandibular glands used as alarm substances and as marking pheromones. Some species use unpleasant odours as a means of defence. *Trigona* (*Oxytrigona) tataira* and its relatives have enlarged mandibular glands capable of producing a caustic fluid which causes blisters when they bite. Most species do not harm people or animals. *T. iridipennis* is a gentle species and can be manipulated with ease. The insects defend the nest by sealing up all openings and sometimes crawl over persons and give tiny nips with their mandibles when their nest is disturbed (Dollin *et al.*, 1997).

When disturbed the bees attack the enemy in large numbers, usually selecting sensitive organs like eyes, nose and ears as their target. Biting with the mandibles (Fig 58) is quite irritating for several of the enemies of dammar bees, but can be easily protected against by man. Covering the head and body of the beekeeper with wet cloth while handling the bees will keep the bees away from biting (AICRP, 2004).

Fig. 26 Pollen basket on hind ieg

Fig. 27 Wax pillars - foundation for brood

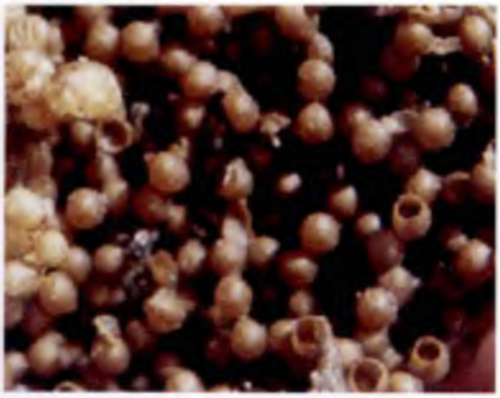


Fig. 28 Brood cells in different stages

Fig. 29 Collared brood cells on construction

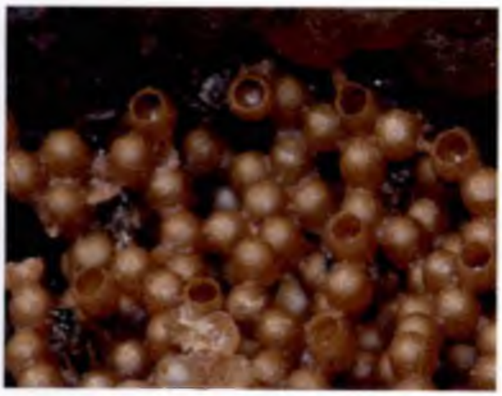


Fig. 30 Brood cells - before provisioning

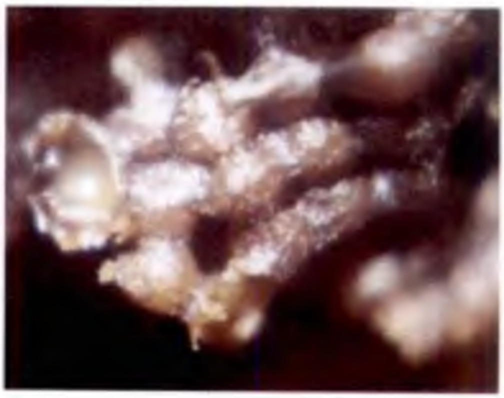


Fig. 31 Food provisioned in a brood cell

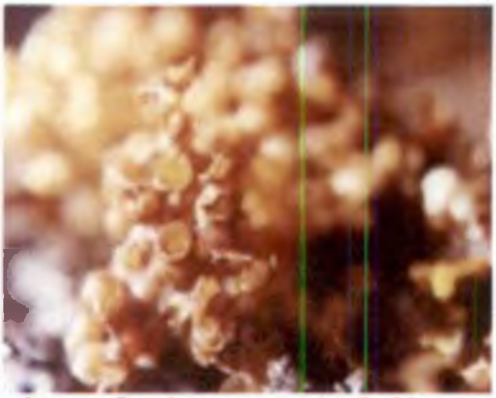


Fig. 32 Provisioned brood cell with egg

Fig. 33 Young brood cells with dark propolis covering

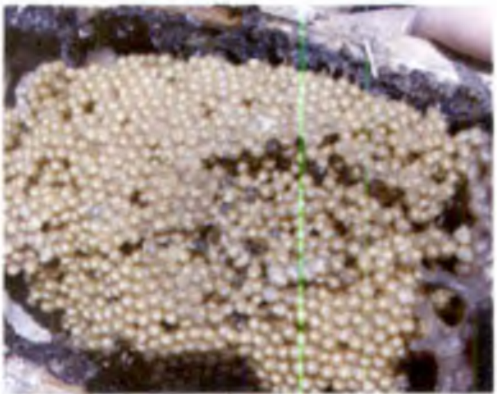


Fig. 34 Brood about to emerge

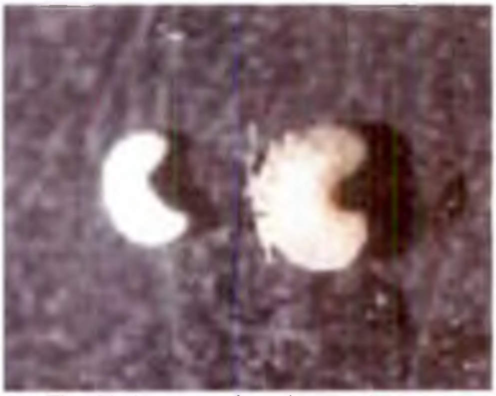


Fig. 35 Larvae of worker and queen

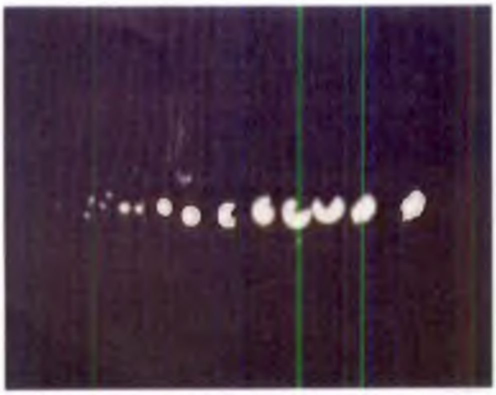


Fig. 36 Different development stages of *Trigona iridipennis* worker

Fig. 37 Pupated brood shows the eyes of young one

Fig. 38 Brood in a feral colony

Fig. 39 Involucrum in a stingless colony

Fig. 40 Entrance tube in a masonary wall

Fig. 41 Opening of the entrance tube

Fig. 42 Resin deposit in a hive

Fig. 43 Foundation of wax pillars for construction of brood layers


Fig. 44 Brood comb of *T. iridipennis* on wax pillars

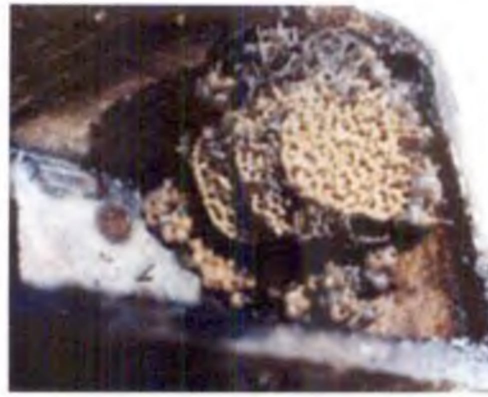


Fig. 45 Brood layers in a hive

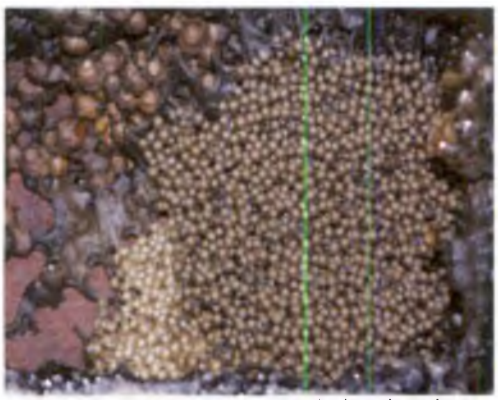


Fig. 46 Young brood with dark colour in a hive


Fig. 47 Workers removing wax from oval shaped brood cells


Fig. 48 Young brood at the left and cells ready to emerge at the right side


Fig. 49 Pollen pots with pollen

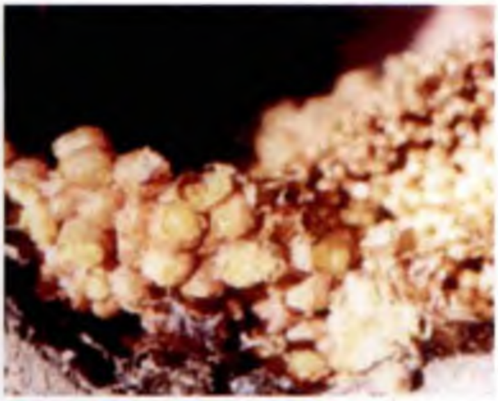


Fig. 50 Pollen storage in stingless bee hive

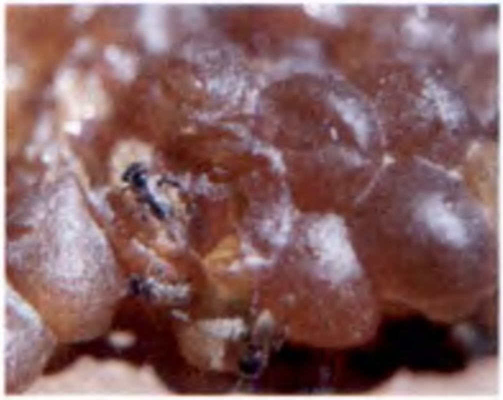


Fig. 51 Honey storage pots


Fig. 52 Honey storage pots enlarged view


Fig. 53 Honey storage inside stingless bee hive

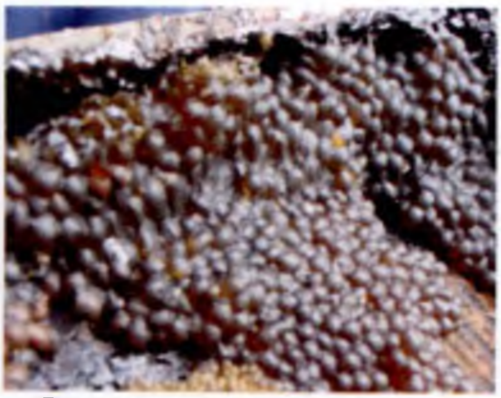


Fig. 54 Honey storage in a bee hive

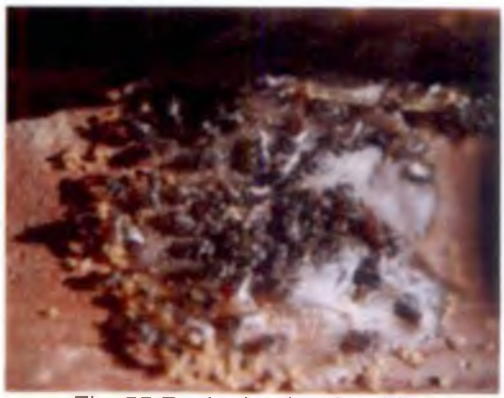


Fig. 55 Resin droplets in a hive

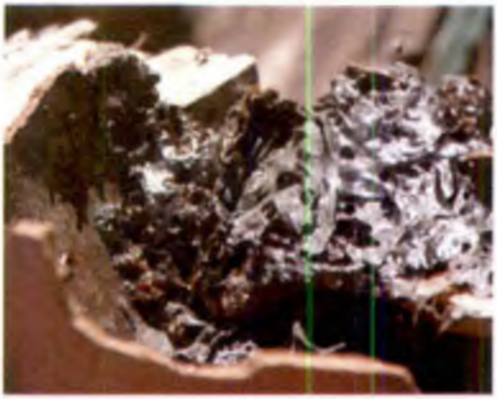


Fig. 56 Bulky serumen storage

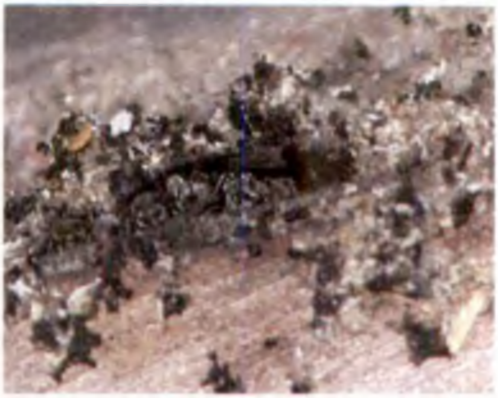


Fig. 57 Waste dumps around hive entrance


Fig. 58 Worker bees on defence by biting


Fig. 59 Worker bee with pollen

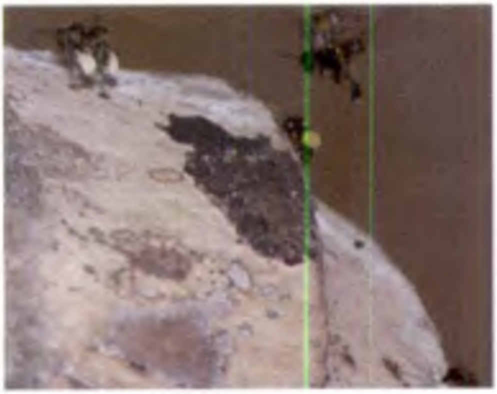


Fig. 60 Worker bee with pollen


Fig. 61 Worker bees collecting pollen

# 12 THERMOREGULATION

Generally, stingless bees are not as efficient as other Honey bees in controlling the nest temperature, especially when the temperature falls lower than the optimum. This may be a factor limiting the occurrence of stingless bees in tropical and subtropical areas. Only a few species, *Torigona spinipes* and *T. duckei* are known to have the ability to regulate the nest temperature within certain limits. Studies showed that *T. carbonaria* do not control the temperature in the hive. The Indian honeybee *A. cerana indica* maintain the temperature around the brood at 34-36°C. The temperature is raised with their own body heat, generated by shivering the wing muscles and lowered, if necessary, by fanning the hive with wings at the nest entrance to draw cooler air into the nest and when necessary by spreading water over the comb.

# 13 FORAGING BEHAVIOUR

Like *Apis* spp. pollen and nectar are the essential food for stingless bees. The bee strength, development and quantity of honey stored in a stingless bee colony are highly dependent on the collection of nectar and pollen by the worker bees, which is regulated by the availability of flora in the surroundings (Fig 59,60,61). Most of the stingless bee species are polylecty, foraging on wide variety of crops. It is observed that the stingless bees visit and forage from almost all the plants visited by other *Apis* species. They also collect nectar and pollen from low lying herbs and weeds having comparatively smaller flowers, which are not commonly visited by *Apis* spp. including medicinal plants (Premila, *et al.*, 2007).

Information on the foraging behaviour of stingless bees will be of much use for meliponiculture. Experiments conducted at College of Agriculture, Vellayani, Thiruvananthapuram showed that the bee started activity from 0700 hrs reaching the first peak at 1200hrs and second peak at 1500hrs. Activity ceased after 1800 hrs. Maximum number of pollen foragers was noticed in the morning hours and nectar foragers at midday. Resin collection remained throughout the day. The incoming foragers were observed to collect more pollen than nectar. The average number of incoming foragers with pollen was found to be 17.9 when compared to nectar collectors (11.5) during the first peak period of activity at 1200hr. During the second peak at 1500hrs, the average incoming foragers with pollen were 13.9 while nectar foragers accounted 10.8. This difference in the pollen and nectar load collected by *Trigona* reflects the availability of pollen yielding flora in the experimental area. Flight activity is highly influenced by the light intensity, which resulted in the reduction of activity in the evening. Maximum foraging activity was recorded during the month of July coinciding with the blooming season of the State. According to Pande and Bandyopadhyay (1985) the reduction in the foraging activity during cloudy season suggests that foraging insects have built-in mechanism to protect themselves against bad weather. The prevalent temperature could be an important factor.

## Diurnal variation in foraging activity

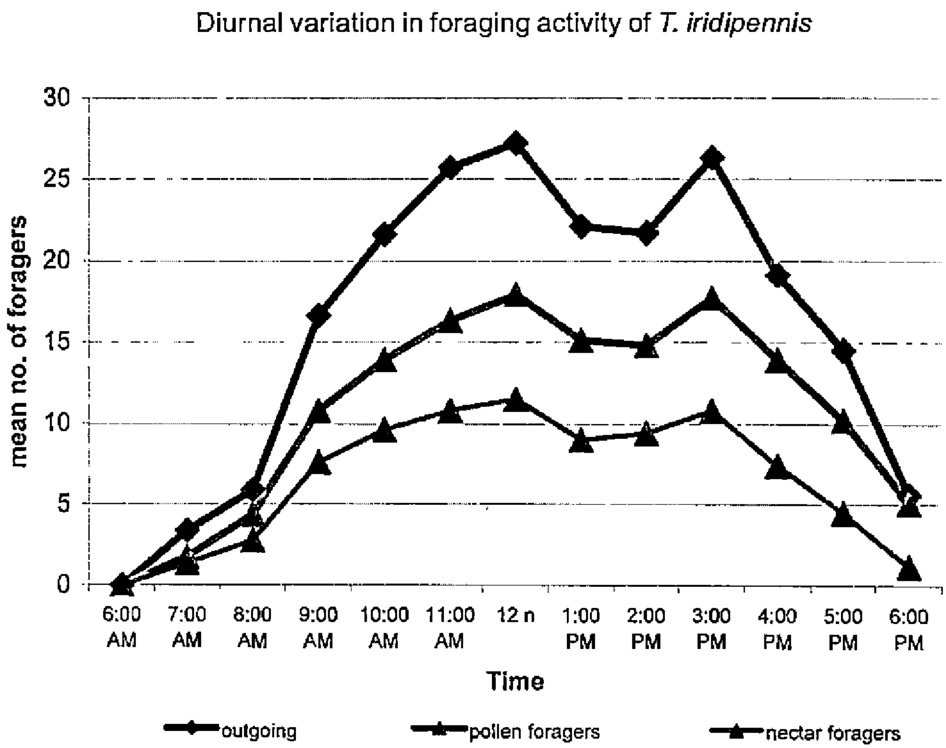
The foraging activity of *T. iridipennis* observed from 0600 h in the morning till 1800 h in the evening for a period of one year revealed that the bees started foraging activity by 0700 h in the morning and gradually increased the activity reaching the first peak at 1200 h and second peak at 1500 h, then again declined. The activity was almost nil after 1800 h. (Devanesan *et al.*, 2002).

Table 3. Diurnal variation in foraging activity of *Trigona iridipennis*

| Time | Mean number of foragers/colony | | |
|---|---|---|---|
| | Outgoing | Incoming with pollen | Incoming with nectar |
| 0600 | 0 | 0 | 0 |
| 0700 | 3.4 | 1.8 | 1.4 |
| 0800 | 5.9 | 4.4 | 2.8 |
| 0900 | 16.6 | 10.8 | 7.6 |
| 1000 | 21.6 | 13.9 | 9.6 |
| 1100 | 25.7 | 16.3 | 10.8 |
| 1200 | 27.2 | 17.9 | 11.5 |
| 1300 | 22.1 | 15.1 | 9.0 |
| 1400 | 21.7 | 14.8 | 9.4 |
| 1500 | 26.3 | 17.7 | 10.8 |
| 1600 | 19.1 | 13.9 | 7.4 |
| 1700 | 14.5 | 10.2 | 4.5 |
| 1800 | 5.6 | 5.1 | 1.2 |

Incoming bees with pollen were easily recognized by yellow colour pollen grains hanging on to their legs within the pollen baskets. The bees started collecting pollen from 0700 h but the activity was comparatively low till 0800 h. The activity increased gradually reaching the first peak at 1200 h. A decline in pollen collection by bees was observed after 1200 h. A gradual increase in pollen collection was noticed reaching the second peak activity at 1500 h.

The incoming foraging bees without pollen load were considered as bees with nectar. The bees started collecting nectar from flowers around 0700 h. A gradual increase in the activity occurred from 0900 h. The first peak activity was seen around 1200 h and the next peak at 1500 h.



## Monthly variation in foraging activity

Foraging activity was observed for a period of one year. Peak foraging activity was observed during July with maximum foraging bees. Lowest foraging activity was observed during the month of December and January. The number of incoming foragers with pollen was more during July, August and October and less during December and January (Devanesan *et al.*, 2002).

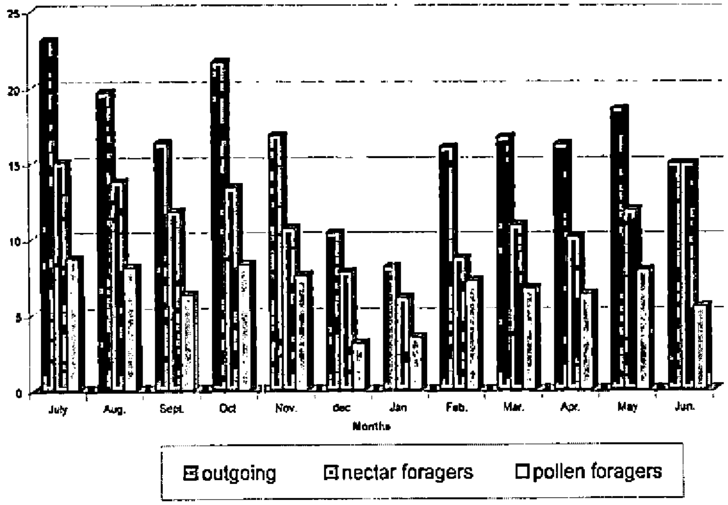
Table 4. Monthly variation in the foraging activity (nectar and pollen) of *T. iridipennis*

| Month | Mean number of foragers | | |
|---|---|---|---|
| | Outgoing ( mean ) | Incoming (mean) | |
| | | Nectar | Pollen |
| July • | 23.1 | 15.1 | 8.7 |
| August | 19.7 | 13.8 | 8.1 |
| September | 16.4 | 11.8 | 6.3 |
| October | 21.7 | 13.4 | 8.3 |
| November | 16.9 | 10.7 | 7.6 |
| December◈ | 10.4 | 7.8 | 3.1 |
| January◈ | 8.1 | 6.1 | 3.5 |
| February | 16.1 | 8.7 | 7.2 |
| March | 16.8 | 10.9 | 6.7 |
| April | 16.3 | 10.1 | 6.3 |
| May | 18.6 | 11.9 | 7.9 |
| June | 15.0 | 15.0 | 5.5 |

• Peak activity

◈ least activity

Monthly variation in foraging activity of *T. iridipennis*



# 14 FLORA VISITED BY STINGLESS BEES

Stingless bees are ecologically important because of their role in pollination of tropical flora. The Centre had documented the plants visited by stingless bees in the State. Before starting meliponiculture care should be taken to select areas with sufficient foraging plants. Observation on the flower visitation by the stingless bees was recorded from 6 am to 6 pm during the blooming period of different plants in different districts of the State, either for honey or pollen or both. 77 plants were identified in which stingless bees visited for nectar or pollen or both.

Of these 77 plants, 21 plants (*Cocos nucifera, Anacardium occidentale, Helianthus annus, Couroupita guianensis, Capsicum annum, Antegonon leptopus, Duranta, Moringa oleifera, Psidium guajava, Rosa sp, Mundingia calbura, Tamarindus indica, Manihot esculenta, Ixora coccinea, Ricinus communis, Caesalpinia pulcherima, Manihot glaziovii, Eucalyptus globulus, Santalum album, Raphanus sativus, Solanum melongena, Euginea jambosa*) provided both nectar and pollen, 37 plants (*Hevea brasiliensis, Impatiens balsaminae, Musa sp., Duranta goldiana, Euphorbia hirta, Hamelia patens, Tagetes erecta, Phyllanthus niruri, Indigofera tinctoria, Brassica juncea, Burmese coriander, Cajanus cajan, Brassica pekinensis, Crotalaria variteoss, Vigna mungo, Dolichos lablab, Coffea arabica, C.robusta., Crotalaria macronata., Aerva lanata, Duranta plumieri, Baliospermum monatanum , Canna indica, Sesbania rostrata, Sesamum indicum, Euphorbia pulcherima, Glyricida maculata, Vinca rosea, Jetropha* sp., *Boerhaavia diffusa, Heliconia rostrata, Cassia alata, Justicia simplex, Oxalis carniculata, Zizipus nummularia, Gladiolus grandiflorus, Ocimum sanctum*) provided nectar only and 19 plants (*Mangifera indica, Pennisetum typhoides, Cinnamomum zeylanicum, Anthurium andreanum, Luffa cylindrica, Mimosa pudica, Gossypium hirsutum, Talinum triangulare, Corchorus olitorlus, Averrhoa bilimbi, Solidago canadensis, Salvia splendens, Carica papya, Momordica cochinchinensis, Haemanthus cinnabarinus, Allium cepa, Nymphea stellata, Bombax malabarium, Lowsonia alba*) provided pollen only (Fig 62 to 110) (Premila, *et al*., 2007).

Table 5. The stingless bee flora of Kerala

| Common Name | Scientific Name | Family | Source |
|---|---|---|---|
| **Medicinal Plants** | | | |
| Indigofera | *Indigofera tinctoria* | Papilionaceae | N |
| Touch-me-not | *Mimosa pudica* | Mimosaceae | P |
| Ixora | *Ixora coccinea* | Rubiaceae | N+P |
| Phyllanthus | *Phyllanthus niruri* | Euphorbiaceae | N |
| Castor | *Ricinus communis* | Euphorbiaceae | N+P |
| Javanese wool plant | *Aerva lanata* | Amaranthaceae | N |
| Nagadandi | *Baliospermum monatanum* | Euphorbiaceae | N |
| Periwinkle | *Vinca rosea* | Apocynaceae | N |
| Boerhavia | *Boerhaavia diffusa* | Nyctaginaceae | N |
| Puliyarala | *Oxalis carniculata* | Oxalidaceae | N |
| Henna | *Lowsonia alba* | Lythraceae | P |
| Holybasil(Thulsi) | *Ocimum sanctum* | Laminaceae | N |
| **Plantation crops** | | | |
| Rubber | *Hevea brasiliensis* | Euphorbiaceae | N |
| Coconut | *Cocos nucifera* | Palmaceae | N+P |
| Cashew | *Anacardium occidentale* | Anacardiaceae | N+P |
| Coffee | *Coffea arabica* | Rubiaceae | N |
| Coffee | *Coffea robusta* | Rubiaceae | N |
| **Condiments and spices** | | | |
| Chilly | *Capsicum annum* | Solanaceae | N+P |
| Tamarind | *Tamarindus indica* | Caesalpinaceae | N+P |
| Cinnamon | *Cinnamomum zeylanicum* | Lauraceae | P |
| Mustard | *Brassica juncea* | Umbelliferae | N |
| **Vegetable crops** | | | |
| Sponge gourd | *Luffa cylindrica* | Cucurbitaceae | P |
| Drumstick | *Moringa oleifera* | Moringaceae | N+P |
| Chinese cabbage | *Brassica pekinensis* | Umbelliferae | N |
| Dolichos | *Dolichos lablab* | Papilionaceae | N |
| Waterleaf | *Talinum triangulare* | Portulacaceae | P |
| Radish | *Raphanus sativus* | Cruciferae | N+P |
| Bilimbi | *Averrhoa bilimbi* | Oxalidaceae | P |
| Onion | *Allium cepa* | Liliaceae | P |
| Brinjal | *Solanum melongena* | Solanaceae | N+P |
| Sweet gourd | *Momordica cochinchinensis* | Cucurbitaceae | P |
| Black gram | *Vigna mungo* | Fabaceae | N |
| **Field crops** | | | |
| Bajra | *Pennisetum typhoides* | Poaceae | P |
| Sunflower | *Helianthus annus* | Compositae | N+P |
| Burmese | *Burmese coriander* | Umbelliferae | N |
| Redgram | *Cajanus cajan* | Papilionaceae | N |
| Gingely | *Sesamum indicum* | Pedaliaceae | N |
| **Ornamental plants** | | | |
| Balsam | *Impatiens balsaminae* | Balsaminaceae | N |
| Rose | *Rosa* sp | Rosaceae | N+P |
| Coral creeper | *Antegonon leptopus* | Polygonaceae | N+P |
| Duranta | *Duranta goldiana* | Verbinaceae | N |
| Hamelia | *Hamelia patens* | Rubiaceae | N |
| Anthurium | *Anthurium andreanum* | Areaceae | P |
| Marigold | *Tagetes erecta* | Compositae | N |
| Peacock plant | *Caesalpinia pulcherima* | Caesalpiniaceae | N+P |
| Golden dew drop | *Duranta plumieri* | Verbinaceae | N |
| Canna | *Canna indica* | Cannaceae | N |
| Poinsettia | *Euphorbia pulcherima* | Euphorbiaceae | N |
| Golden rod | *Solidago canadensis* | Compositae | P |
| Ball lilly | *Haemanthus cinnabarinus* | Amaryllidaceae | P |
| Bird of paradise | *Heliconia rostrata* | Zingiberaceae | N |
| Nymphea | *Nymphea stellata* | Nympheaceae | P |
| Sage | *Salvia splendens* | Labiatae | P |
| Gladiolus | *Gladiolus grandiflorus* | Iridaceae | N |

Fig. 62 Stingless bee on *Euphorbia* flowers

Fig. *63 Trigona iridipennis* collecting pollen

Fig. 64 Sunflower (*Helianthus annus*)

Fig. 65 Bajra (*Pennisetum typhoides*)

Fig. 66 Mustard (*Brassica juncea*)

Fig. 67 Thulsi ( *Ocimum sanctum)*

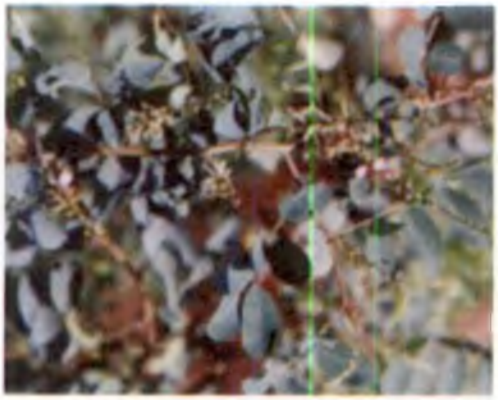


Fig. 68 Indigofera (*Indigofera tinctoria*)

Fig. 69 Birdscherry (*Mundingia calbura*)

Fig. 70 Coral creeper (*Antegonon leptopus*)

Fig. 71 Tapioca (*Manihot esculenta*)

Fig. 72 Hamelia (*Hamelia patens*)

Fig. 73 Peacock plant
(*Caesalpinia pulcherima*)

Fig. 74 Javanese wool plant *(Aerva lanata)*

Fig. 75 Marigold (*Tagetes erecta*)

Fig. 76 Sponge gourd (*Luffa cylindrica*)

Fig. 77 Ixora (*Ixora coccinea*)

Fig. 78 Brinjal (*Solanum melongena*)

Fig. 79 Black gram *(Vigna mungo)*

Fig. 80 Banana (*Musa* sp.)

Fig. 81 Cinnamon
(*Cinnamomum zeylanicum*)

Fig. 82 Drumstick (*Moringa oleifera*)

Fig. 83 Balsam (*Impatieus balsamina*)

Fig. 84 Cannon ball tree
(*Cauropita guinensis*)

Fig. 85 Glyricidia (*Glyricidia maculata*)

Fig. 86 Coffee (*Coffea arabica*)

Fig. 87 Coffee (*Coffea robusta*)

Fig. 88 ~~Golden dew drop~~ *(Canna indica)*
Canna

Fig. 89 Papaya *(Carica papaya)*

Fig. 90 Sage *(Salvia splendens)*

Fig. 91 Sweet gourd
(*Momordica cochinchinensis*)


Fig. 92 Gladiolus (*Gladiolus grandiflorus*)


Fig. 93 Touch me not (*Mimosa pudica)*

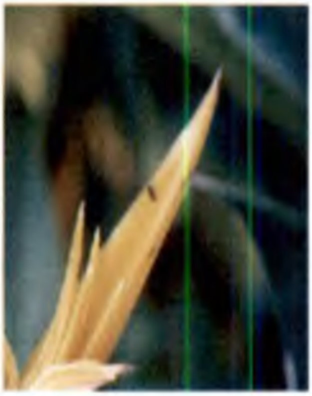


Fig. 94 Bird of paradise
*(Heliconia rostrata)*


Fig. 95 Coconut *(Cocos nucifera)*


Fig. 96 Henna *(Lowsonia alba)*


Fig. 97 Onion *(Allium cepa)*

*98.* Rose apple *(Euginea jambosa)*

Fig. 99 Tuberose *(Poliantha tuberose)*

Fig. 100 Stingless bee foraging from a peacock plant

Fig. 101 Stingless bee collecting pollen

Fig. 102 Stingless bee collecting pollen

Fig. 103 Worker bees foraging from ornamental palm

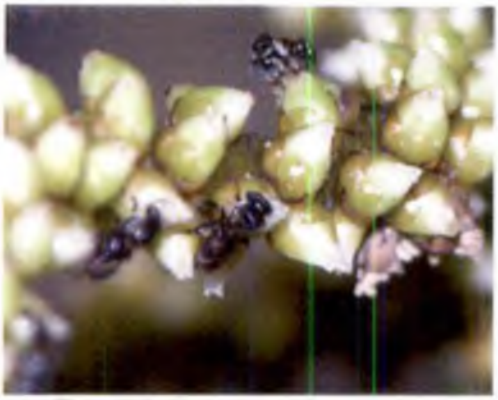


Fig. 104 Worker bees foraging from ornamental palm

Fig. 105 Cashew (*Anacardium occidentale)*

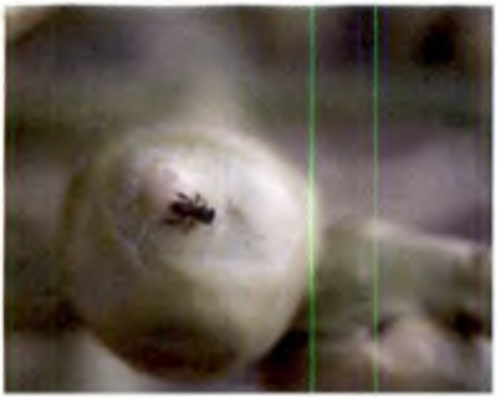


Fig. 106 Stingless bee collecting nectar from female flower of coconut

Fig. 107 Coffee - stingless bee is a good pollinator of coffee plant

Fig. 108 Stingless bee collecting pollen from cucurbit

Fig. 109 Stingless bee collecting nectar/ pollen from winged bean flower

Table 5. The stingless bee flora of Kerala (cont'd)

| | | | |
|---|---|---|---|
| **Fibre crops** | | | |
| Cotton | *Gossypium hirsutum* | Malvaceae | P |
| Jute | *Corchorus olitorlus* | Tiliaceae | P |
| Cotton tree | *Bombax malabarium* | Malvaceae | P |
| **Fruit crops** | | | |
| Mango | *Mangifera indica* | Anacardiaceae | P |
| Banana | *Musa sp.* | Musaceae | N |
| Guava | *Psidium guajava* | Myrtaceae | N+P |
| Papaya | *Carica papaya* | Caricaceae | P |
| Rose apple | *Euginea jambosa* | Myrtaceae | N+P |
| **Herbs, shrubs & bushes** | | | |
| Euphorbia | *Euphorbia hirta* | Euphorbiacea | N |
| Crotolaria | *Crotalaria variteoss* | Papilionaceae | N |
| Crotalaria | *Crotalaria macronata* | Papilionaceae | N |
| Wild tapioca | *Manihot glaziovi* | Euphorbiaceae | N+P |
| Sesbania | *Sesbania rostrata* | Papilionaceae | N |
| Jetropha | *Jetropha sp.* | Euphorbiaceae | N |
| Cassia | *Cassia alata* | Cesalpiniaceae | N |
| Justica | *Justicia simplex* | Acanthaceae | N |
| Zizipus | *Ziziphus nummularia* | Rhamnaceae | N |
| **Tuber crops** | | | |
| Tapioca | *Manihot esculenta* | Euphorbiaceae | N+P |
| **Green manuare crop** | | | |
| Glyricidia | *Glyricidia maculata* | Papilionaceae | N |
| **Forest Trees** | | | |
| Cannon ball tree | *Couroupita guianensis* | Apocynaceae | N+P |
| Birds cherry | *Mundingia calbura* | Verbinaceae | N+P |
| Eucalyptus | *Eucalyptus globulus* | Myrtaceae | N+P |
| Sandal | *Santalum album* | Sandalaceae | N+P |

# 15 HIVING AND MANAGEMENT

## Traditional hives used for meliponiculture

The most commonly described traditional hive for beekeeping with stingless bees, especially *Melipona beecheii* in Yacatau is a horizontal hollowed log, closed at each end with a disc of wood (Crane, 1985). A simple box 1.2 x 0.27 x 0.27 m, with a removable lid is being used for rearing *M.beecheii* in several areas of Guanacaste province and Perez Zeledon (Crane, 1990). Large boxes of 100 x 40 x 40 cm is used for housing *M. trinitatis* in Trinidad and in Costa Rica, the small bee *Tetragonisca angustula* are kept in boxes with average capacity of three litres (Bruijin, 1996). *Trigona carbonaria are* reared in hives consisting of two boxes, an inner box and an outer box. The inner box is designed with three store's to contain a brood space, food storage space and feeding space. The brood space is divisible for propagating the colony. The outer box equipped with heater system keeps the hive at a fixed temperature. He recommends the use of bamboo and wooden box duplication method, as an alternative for propagating *T. carbonaria* (Dollin, 1997 and 2001).

Central Bee Research and Training Institute in Pune recommended wooden boxes of 10 x 12.5 x 10 cm size with a glass top covered by a wooden lid for rearing *T. iridipennis* (Percy, 1989). Coconut shells, small earthen pots, bamboo bits (Fig 111, 112,113) are being used in Kerala for rearing stingless bees from olden times and even now people are using the same. Wooden hives of size 3 x 14 x 15 cm are found superior to bamboo hive and earthen pot for rearing *T. iridipennis* (Raakhee, 2000) (Fig 114).

## Hiving of feral colonies of stingless bees

The natural habitat of *T. iridipennis* is the basements of buildings, compound walls, tree trunks etc. Hiving of feral colonies from the above sites usually damage the buildings and walls and hence the owners hesitate to do it. The transfer of these colonies into artificial hives is very necessary for the success of meliponiculture without damage to the structures. Hence different methods were tried at AICRP Centre, Vellayani in hiving feral colonies and a suitable method standardized (AICRP, 2004).

The mouth of an earthen pot has to be placed in front of the entrance of a feral colony and its rim is to be pasted to the wall using mud. Proper support to the pot should be provided whenever required. An opening is to be given at the opposite side of the pot as the bee entrance is pasted with wax of stingless bee. The worker bees pass through the hole in the pot using it as new entrance. Gradually the bees realize that there is sufficient space inside the pot to accommodate the brood and food material and hence they start construction of pollen and honey pots inside the earthen pot, build the brood combs and start brood rearing. The colony and pot should be left undisturbed for six months for the feral colony to settle. Later the pot with brood, pollen, honey, worker bees and a queen can be detached and shifted to a suitable site to establish as a new colony (Devanesan *et al.*, 2003).

## Hiving

Crane (1992) opined that stingless bees could be kept in hives like *Apis cerana* and *Apis mellifera*. Mishra (1995) also asserted that *Trigona* could be kept in hives. Dollin (2001) reported bamboo as a suitable hive for domestication of *T. carbonaria*. Many people used to rear stingless bee species

Fig. 110 Stingless bee is a good pollinator in winged bean (*Psophocarpus tetragonolobus*)

Fig. 111 Stingless bee colony in coconut shell

Fig. 112 Earthen pot with stingless bee

Fig. 113 Stingless bee colony in a bamboo hive

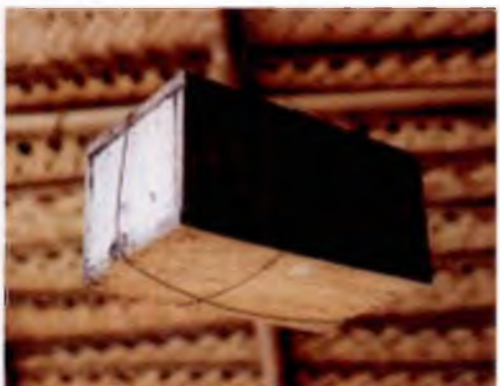


Fig. 114 Stingless bee colony in a wooden hive

Fig. 115 Wooden hives in different size

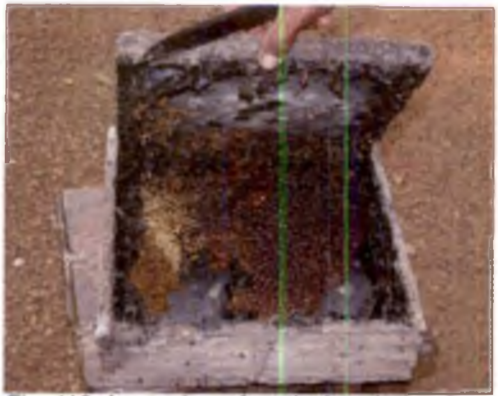


Fig. 116 Inner view of a stingless bee colony in a wooden box hive

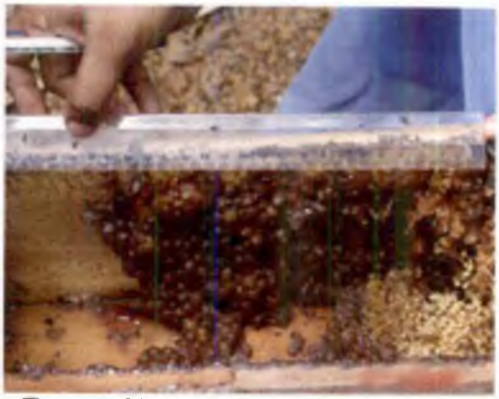


Fig. 117 Measuring brood development in wooden hive

Fig. 118 Bamboo hives in different size


Fig. 119 Bamboo hive

Fig. 120 Inner view of a stingless bee colony in a bamboo hive

Fig. 121 Measuring brood development in bamboo hive

Fig. 122 Brood development in bamboo hive

Fig. 123 Brood – enlarged view

Fig. 124 Earthen pot hives in different size

Fig. 125 Inner view of a stingless bee colony in a earthen pot hive

Fig. 126 Earthen pot hives in an apiary

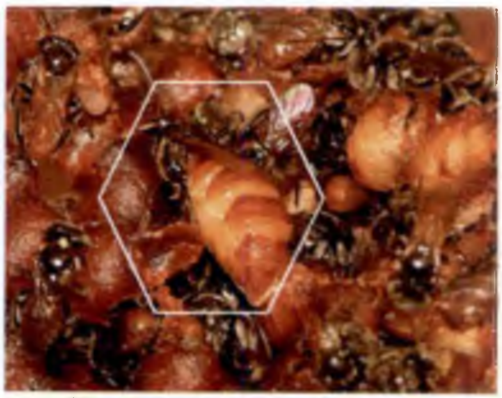


Fig. 127 Queen bee in a colony

Fig. 128 Eggs in provisioned brood cells

Fig. 129 Brood in different stages

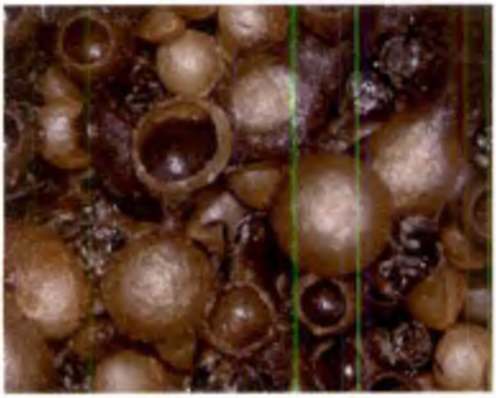


Fig. 130 Developing queen cells

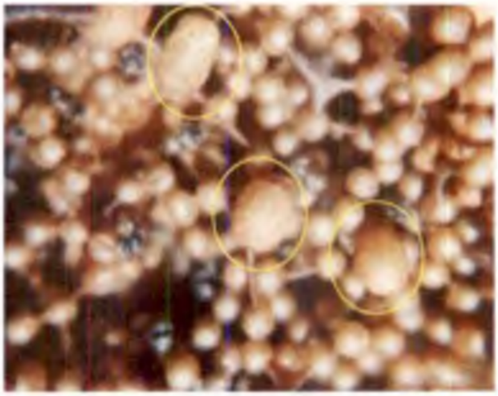


Fig. 131 Royal/ queen cells about to emerge

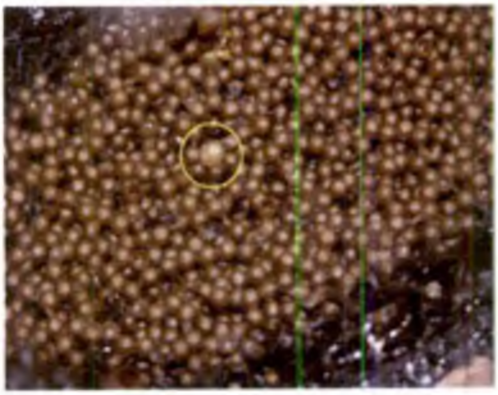


Fig. 132 Brood cells with a single queen cell

Fig. 133 Stingless bee colonies in an apiary

in earthen pots, coconut shells, bamboo bits etc with different size. The local beekeepers are seen using bamboo hives rather than wooden and earthen hives.

Among the different types of hives used for the domestication of *Trigona iridipennis* (wooden box, bamboo and earthen pot) with different volumes, bamboo hive with 1500 cc capacity showed better brood development than hives of 3000, 2250 and 3750 cc capacity. It was also observed that in 3750 cc hives, the colonies occupied only half of the space and in smaller ones it occupied fully.

The storage of pollen was maximum in bamboo hive (1500 cc) followed by earthen pot and wooden hive. This is an indication that *T. iridipennis* prefer bamboo hive for its natural habitat. The present finding also indicated maximum pollen storage by bees during February which coincides with the blooming season in the State while lowest pollen storage during the months of May-June which are the dearth months.

The honey storage also was highest in bamboo hive (1500 cc) compared to wooden and earthen hives (Fig 115 to 126).

Among the different types of hives evaluated, better brood development was observed in bamboo hives and that was least in wooden hives. Considering the monthly brood development, a gradual increase was noticed from November with a peak during February and least during October.

The superiority of bamboo hive may be due to the preference of the species to thrive in narrow / hollow spaces as in feral colonies.

# 16 COLONY MULTIPLICATION

## Swarming

Swarming occurs in stingless bees and the behaviour is preceded by the production of new queens in the colony which later leave the mother colonies for finding new sites (Nogueia-Neto, 1954). Reproductive swarming takes place when colonies become populous with enough drones (Crane,1992). The process of swarming in stingless bees is rather different from the one found in *Apis* sp. A strong colony under favourable conditions will send out scout bees to locate a new nest site. They close all the openings except an entrance with batumen in the selected suitable place. Then start the construction of the new nest, using cerumen from the mother colony. In the beginning, wax pillars are constructed followed by storage pots and stock up honey and pollen. Subsequently the brood cells are constructed. After provisioning the new brood cells, the virgin queen fly across to the new site with some workers. A few workers of the swarm return to the mother colony on the next day and collect construction materials and bring them to the new hive. The males are attracted to the newly formed daughter colony having a virgin queen. The males hover around the entrance. The mating of virgin queen occurs outside the nest (Crane 1992). The queen mate only once and egg laying commences soon after the mating. The queen's abdomen enlarges and she loses the ability to fly. As a result, she remains in the hive throughout. The queen lives up to five years although egg laying rate get reduced over time.

New colonies are formed in a progressive way by transporting necessary material for construction of food and a young queen from the mother nest (Michener, 1972). Division of colony is practiced by transferring about half of the brood cells with queen cells, food stores and bees from parent colonies to new hives (Percy, 1989).

Raakhee (2000) succeeded in division of colony by transferring equal quantity of brood, honey, pollen and a queen from parent colony to a new hive. Duplication of natural colonies by connecting new hive (box or bamboo) with a tube to natural hive and propagating the same was developed by Dollin (2001).

Three methods for division of stingless bee colony were tried at Vellayani Centre of AICRP. Healthy and disease free active colonies having sufficient brood, pollen and honey can be divided. In the first method, colonies with young brood but without queen cells were selected. The queen was transferred along with half the quantity of mature brood, one-fourth quantity of young brood and half the volume of pollen and honey pots to a new hive. The new hive with queen was kept at the original site of the mother colony for two hours and then shifted to a distant site approximately 1000 ft (300 m) away. The mother colony without queen and queen cells was maintained at the original site.

In the second method, colonies with brood and queen cells were selected and were divided as described above. The daughter colony with the transferred queen was kept at the original site of the mother colony for two hours and then shifted to a distant site. The mother colony without queen but with queen cell was kept at the original site.

The colony was divided as described above and the queen was maintained in the mother colony itself and then shifted to a new site. The daughter colony without queen but with queen cells was maintained at the original site itself, in the third method.

The bees in the new hives closed its entrance in a few days and no external activity was observed but internal activities like construction of storage pots, repair of brood cell cups, construction of wax pillars and connectives for fixing of brood cells were continuing. After few days a small orifice was made at one end as bee entrance and a limited number of foragers were seen moving for foraging and for cleaning activity. During this period no guard bees could be observed at the hive entrance. Gradually the small orifice got widened and the entrance changed to the normal size and got guarded by two to five workers. The queen continued to lay eggs.

In mother colony which was kept at the original site show higher foraging activity than in colonies shifted to distant location. In the queenless colonies, 10 to 30 royal cells, with thick cerumen coating, could be observed. Only one queen was allowed to emerge and remaining cells were destroyed by the workers.

In the second method, the mother colony without queen but with queen cell kept at the original site, new queen emerged nearly one month earlier than the colony kept without queen cell and started egg laying. The development in these colonies was also faster than those without queen cells.

The success of the development of colonies in different methods of division was evaluated. The development rate was very high in the colonies divided under second method followed by first method. Both the mother colony as well as the daughter colony showed better performance. Third method of division was found to be least effective when compared to other two methods. The division will be more successful when mature queen cells are present as it reduces the establishment time (Fig 127 to 133).

## Handling of bees

Climatic conditions play an important role in handling of bees. Rainy and cloudy seasons are unsuitable for opening the hive. During unfavorable environmental conditions, the bees tend to remain inside the hive and hence large number of bees may die due to handling during this time. The most preferable time for opening of colonies will be between 0800 h and 1200 h on sunny days. Since the brood combs are very soft, care should be taken to avoid damage of the brood cells.

Division of the colonies can be done during the evening hours. Care should be taken to avoid damage of the honey pots during division. The damaged honey pots during division of the colony cause fermentation of honey. The destruction of brood cells during division should be minimized, otherwise the colony fail to establish. Presence of excess pollen and honey in the colony make them prone to pests and disease incidence and hence, it is desirable to remove excess pollen and honey periodically to maintain healthy colonies.

While handling a hive, the direction of hive opening is to be marked, so that the hive entrance can be retained in the original direction itself to avoid the confusion of foraging bees to find the entry.

Covering of head and body of the beekeeper with wet cloth will help to keep away the bees without biting while handling. It also helps to reduce the destruction of bee population in the hive.

# 17 PESTS AND DISEASES IN STINGLESS BEE COLONY

George (1934) reported a species of *Megachile* which visited the nest of *T. iridipennis* and snatched wax from the entrance. Simoes *et al.* (1980) reported that the endoparasite phorid fly, *Melalonctia sinistia* attacked the bee *Nannatrigona* (*Scaptotrigona*) *postica*. The larvae of phorid fly were found inside the abdomen of worker bees of *N. postica* as a parasite. Hallim and Sommeijer (1994) reported robber bees *Lestrimelitto* sp. as major pest of *Melipona trinitatis*. Disney and Bartareau (1995) reported Dohrniphora (Diptera : phoridae) associated with stingless bee *T. carbonaria* in Queensland which fed on stored pollen provisions of host bees. Ants, phorid, termites and other flies are some

Fig. 134 Larvae of dipteran fly attacking stingless bee colony

Fig. 135 Stingless bee colony destroyed by maggots of *Hermitia illucens*

Fig. 136 Prepupal stage of *Hermitia illucens*

Fig. 137 Dipteran fly *Hermitia illucens* L.

Fig. 138 A megachilid wasp

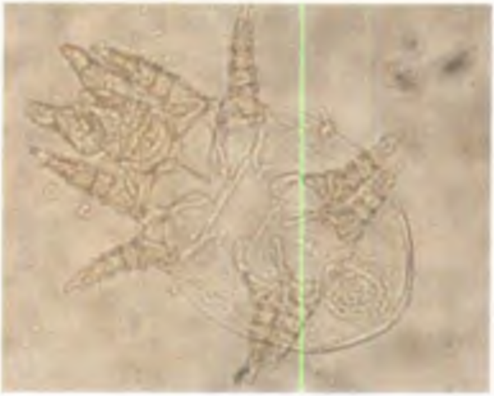


Fig. 139 A mite *Amblyscius* sp.– pest of stingless bee

Fig. 140 A mite *Amblyscius* sp.attacking stingless bee colony in a bamboo bit

Fig. 141 Predatory spider of stingless bee (*Thomisus* sp.)

Fig. 142 Predatory spider catching a stingless bee

Fig. 143 Predatory spider of stingless bee

Fig. 144 Predatory spider of stingless bee

of the natural enemies of stingless bees. Raakhee (2000) observed ants (*Solenopsis geminata*) entering the hives of weak colonies and robbing pollen stock.

Flechtmann *et al.* (1974) reported that a small whitish mite *Neotydeolus therapeutikos* on the comb in nests of *T. postica*. Baker and Delfinado (1985) reported *Neocypholaelaps phooni* a new species of mite found in nests of *T. nritami* and *T. thorasica* in Malaysia. These mites feed on pollen in the nest. A phoretic deutonymph (hypopus) *Meliponopus palpifer* was noticed in *Melipona seminigra* colonies from Brazil (Fain and Flechtman, 1985). Baker and Baker (1988) observed the incidence of two mites belonging to the genus *Eumellipites* in the nests of *Trigona*. Delfinado *et al.* (1989) described a new species of mite *Neocypholaelaps malayensis* found in the nests of *T. itama* and *T. iridipennis.*

Stingless bees (*T. fuscipennis*) learn to avoid webs, but avoidance behaviour is inhibited by daily variations in the decorations of spider *Argiope argentata* (Craig, 1994). it was reported by Craig *et al.* (1996) that a large orb spinning spider *Nephila clavipes* feeds on *T. fluviventris.*

Anderson and Gibbs (1982) reported that *Trigona* pupae were infected by Kashmir bee virus.

Aggressive workers of *Ptilotrigona, Partamona* and *Trigona*, attack predators and large nest aggregation of two to three to several dozens of colonies are often seen in *T. fuscobalteata, T. sapiens, Scaptotrigona luteipennis* and other *Partamona* spp. (Stare and Sakagami, 1987). Large animals like civets, bears, honey badgers, tamandus, tayras, primates, chimpanzees were also reported as important enemies of stingless bees (Roubik, 1995).

The Dipteran fly *Hermetia illucens* L. (Fig 137) which thrive on decaying organic matter was newly identified as a pest of stingless bee *T. iridipennis* AICRP, 2004). The larvae of *H. illucens* massively feed on the pollen honey brood and cerumen deposits of *Trigona.* The colony was completely damaged and sluggish larvae of the fly were seen entangled within a slimy mixture of pollen, honey, brood, cerumen and excreta inside the hive resulting in a foul smell. The adult flies have smoky black wings and a body length of 15-20 mm. Wings are held over the back when at rest. The black coloured fly is easily recognized by two translucent spots on the first abdominal segment. The adult fly entering into the beehive through holes, if any, and laid eggs in masses of 300 – 500 inside the bee hive. The eggs are yellow to cream coloured. Thelarva of the fly is plump, flattened, firm, leathery and with tiny, yellowish black head.

Larval period of it extended upto four weeks undergoing six instars. The larvae feed on mixture of honey, pollen, wax, propolis etc in the bee hive and damaged the entire colony structure and finally the bees deserted. Pupa of the fly enclosed in a puparium emerged as adults within two weeks (Fig 134 to 136)(Devanesan *et al.*, 2003).

A species of wasp *Megachile disjuncta* (Fig 138) was found to snatch the wax at the hive entrance. The mite *Amblyscius* sp.(Fig 139) were found feeding on the pollen but the honey remained uninfected. The mite species multiplied and the whole colony was destroyed. The bees deserted from the hive and as a result the brood development was hindered. The mites were easily visible due to their prominent white coloured body. The pollen was scattered in a powder form entangled with mites inside the hive (Fig 140).

Ant (*Solenopsis geminata*) was seen entering the hive especially in initial stages when the colonies were just divided. In the well established colonies, ants were rarely seen. If present the colony got rid off it by the defending, guarding bees. Different species of spiders (*Thomisus)* were found to predate on bees. They were found attacking the bees at the hive entrance (Fig 141,142,143,144) as well as from foraging sites. No disease incidence was noticed in stingless bee colonies.

## 18 STINGLESS BEE HONEY

Stingless bees are poor honey gatherers. They store only limited quantity of honey. Honey produced by *Melipona* sp. is predominantly from the nectar of flowers. But *Trigona* has broad dietary habits. They feed on fruit juice, honeydew, fungus and liquids from dead animals in addition to nectar (Bruijin, 1993). *Trigona* produce limited quantities of dense, darkish, sour honey up to a maximum of 100 ml / colony (Ramanujam *et al.*, 1993). *Trigona* visits small and poisonous flowers also and produce honey which sometimes causes acidity and this is said to be the reason for its medicinal property (Kamal and Pulak, 1994). Ancient Indians used *Trigona* honey for healing wound, ulcers, kidney disorders and intestinal infection (Bruijin, 1996). Boon (2002) suggested that honey from stingless bees has medicinal property due to resinous chemicals leaching from storage pots within the hive. The honey though sweet, but is strongly acidic and hence sour. The honey fetches a higher price (Rs. 500 per kg) in the market.

Fig. 145 Honey extraction with syringe

Fig. 146 Honey pots in a hive

Fig. 147 Extracting honey with spoon

Fig.148 Extracted honey with spoon

Fig. 149 Honey pots kept in sunlight and sieving through muslin cloth

Fig. 150 Extracted honey pouring into bottle

Fig. 151 Honey samples collected from different locations

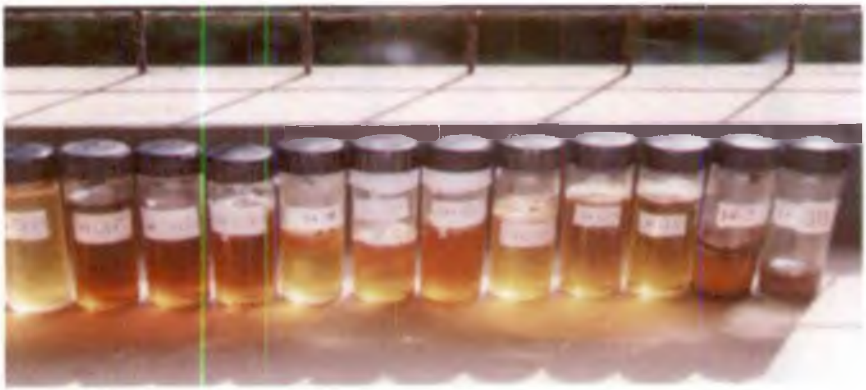


Fig. 152 Honey samples collected from different locations

## Extraction of honey

The traditional method of extraction of honey from stingless bee colonies is by sqeezing honey pots along with pollen pots, brood, bees, wax etc. This results in the destruction of the colony. To avoid this, four different methods of extraction were tried. Squeezing the honey pots was found to be easy but the honey extracted by this method contained large amount of pollen and other extraneous matters, which caused contamination. It also resulted in the destruction of bees, brood and the colony in due course. Extraction of honey with syringe was tried but it was difficult, the needle got clogged with propolis as the storage pots were in cluster (Fig 145,146,147,148). Keeping the entire honey pots on muslin cloth under sunlight yielded clear honey, but the cerumen got melted and the same spreading over the cloth and it caused difficulty in the further filtering of the honey. The honey pots alone were collected by using a clean spoon from the nest and were kept in a tray. The tray was exposed to sunlight in a slanting position. Another tray with muslin cloth over its opening side was kept beneath the above tray. The wax of the honey pots melted due to the heat of the sun and the honey pouring out from it get collected in the tray kept under. This method was relatively simple and yielded clear honey without extraneous matters (Fig 149,150,151,152). (AICRP, 2004).

## Composition

Various ingredients of honey have helped it to become not only a sweet liquid but also a natural product with high nutritional and medicinal value. The medicinal quality, taste, texture, color, aroma of honey differs according to the geographical area and the species of plants from which it has been collected.

The main contents are:

1. Sugars like fructose, glucose, sucrose, maltose, lactose and other disaccharides and trisaccharides.
2. Proteins, fats, vitamins, minerals, enzymes and amino acids.
3. Volatile aromatic substances.
4. Ashes and water etc.

Table 6. Physico chemical composition of stingless bee honey

| Sl. No. | pH | Acidity | Ash (%) | Specific gravity | Total reducing sugar | Refractive index | Moisture (%) | Glucose (%) | Fructose (%) | G/F (%) | Sucrose (%) | Specific heat (calories) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4.00 | 0.29 | 0.19 | 1.3570 | 71.12 | 1.4889 | 19.04 | 32.74 | 38.43 | 1.17 | 1.68 | 60.82 |
| 2 | 3.94 | 0.17 | 0.17 | 1.3570 | 75.44 | 1.4889 | 19.04 | 35.60 | 39.74 | 1.11 | 1.27 | 60.60 |
| 3 | 3.76 | 0.21 | 0.19 | 1.3775 | 70.32 | 1.4869 | 19.88 | 33.02 | 37.96 | 1.14 | 1.60 | 60.90 |
| 4 | 3.96 | 0.18 | 0.19 | 1.3507 | 75.91 | 1.4875 | 19.60 | 36.52 | 39.36 | 1.07 | 1.25 | 60.82 |
| 5 | 3.76 | 0.19 | 0.18 | 1.3532 | 70.60 | 1.4861 | 20.24 | 33.05 | 37.57 | 1.13 | 1.50 | 60.53 |
| 6 | 4.34 | 0.20 | 0.18 | 1.3647 | 74.64 | 1.4871 | 19.80 | 34.96 | 39.66 | 1.13 | 1.74 | 60.53 |
| 7 | 4.22 | 0.27 | 0.18 | 1.3634 | 73.33 | 1.4885 | 19.20 | 35.48 | 37.80 | 1.06 | 1.77 | 60.82 |
| 8 | 4.26 | 0.29 | 0.54 | 1.3775 | 75.63 | 1.4873 | 19.70 | 35.80 | 39.85 | 1.10 | 1.23 | 60.90 |
| 9 | 4.30 | 0.23 | 0.19 | 1.3710 | 76.77 | 1.4867 | 19.90 | 37.20 | 39.85 | 1.06 | 1.27 | 60.60 |
| 10 | 4.16 | 0.27 | 0.18 | 1.3698 | 75.69 | 1.4859 | 20.32 | 36.08 | 39.60 | 1.09 | 1.23 | 60.82 |
| 11 | 4.28 | 0.25 | 0.19 | 1.3646 | 71.88 | 1.4856 | 20.44 | 33.76 | 38.15 | 1.13 | 1.38 | 60.82 |
| 12 | 4.24 | 0.19 | 0.19 | 1.3612 | 69.85 | 1.4856 | 20.44 | 32.46 | 36.59 | 1.12 | 1.37 | 60.90 |
| 13 | 4.38 | 0.26 | 0.18 | 1.3609 | 70.84 | 1.4867 | 19.96 | 32.29 | 38.16 | 1.17 | 1.812 | 60.53 |
| 14 | 4.16 | 0.20 | 0.18 | 1.3621 | 74.95 | 1.4855 | 20.48 | 35.92 | 39.02 | 1.08 | 1.65 | 60.82 |
| 15 | 4.04 | 0.25 | 0.18 | 1.3608 | 74.73 | 1.4860 | 20.28 | 35.36 | 39.16 | 1.10 | 1.79 | 60.90 |
| 16 | 4.20 | 0.28 | 0.18 | 1.3672 | 72.90 | 1.4872 | 19.76 | 35.07 | 37.84 | 1.07 | 1.30 | 60.80 |
| 17 | 4.28 | 0.26 | 0.18 | 1.3608 | 77.10 | 1.4866 | 20.00 | 37.36 | 39.74 | 1.05 | 1.35 | 60.80 |
| 18 | 4.40 | 0.19 | 0.19 | 1.3532 | 72.36 | 1.4864 | 20.08 | 34.37 | 37.99 | 1.10 | 1.26 | 60.60 |
| 19 | 3.84 | 0.29 | 0.19 | 1.3608 | 72.01 | 1.4891 | 18.96 | 33.53 | 38.49 | 1.14 | 1.29 | 60.90 |
| 20 | 4.14 | 0.21 | 0.18 | 1.3698 | 73.70 | 1.4884 | 19.24 | 34.56 | 39.13 | 1.12 | 1.81 | 60.80 |
| 21 | 4.34 | 0.21 | 0.19 | 1.3634 | 75.75 | 1.4862 | 20.20 | 36.00 | 39.75 | 1.10 | 1.32 | 60.50 |
| 22 | 3.86 | 0.20 | 0.19 | 1.3634 | 72.90 | 1.4865 | 20.04 | 34.43 | 38.36 | 1.11 | 1.78 | 60.80 |
| Mean | 4.13 | 0.23 | 0.19 | 1.3632 | 73.57 | 1.4869 | 19.84 | 34.80 | 38.72 | 1.10 | 1.48 | 60.75 |
| F | 25.80** | 25.25** | 0.97 | 4.5273** | 6.3849** | 13.6190** | 5.8634** | 4.0112** | 2.2265** | 1.3467 | 40.44** | 1.34 |
| CD | 0.11 | 0.002 | 0.2184 | 2.4809 | 2.4809 | 0.00010 | 0.5613 | 2.1163 | 1.7016 | 0.0081 | 0.1006 | 0.46 |

## Physico-chemical properties

Antibacterial factor in honey was first identified by White *et al.* (1962) Kallmi and Sohonie (1965) reported that several vitamins *viz.*, thiamine, riboflavin, nicotinic acid, vitamin K, folic acid, biotin, pyridoxine, pantothenic acid, ascorbic acid and carotene are present in honey. Abner and Mary (1966) found that honey possessing significant diastase activity generally contain significant catalase activity. Honey having significant peroxide accumulation show low cataiase activity and vice versa. Phadke (1967) found that difference in nectar source may account for the variations in ash, content, acidity and protein. Phadke (1968) observed that *Trigona* honey do not granulate even after three years inspite of its highly dissolved solids. Neto (1974) discriminate between various types of stingless bee honey on basis of flavour. Gilliam (1979) reported that low pH and high sugar levels are important antibiotic factors. Honey of *T. iridipennis* found to be unifloral in origin and has 75.3 per cent TRS, 0.15 per cent acidity and high positive polarization and dextrose (Mohan *et al.*, 1981). Schutte and Remy (1982) pointed out that there is positive correlation between the depth of colour and ash content. Wakhle and Desai (1983) observed that the level of sucrose is a better indicator of natural honey than the HMF content. Tan *et al.* (1989) reported that organic substances known as degraded carotenoids occur in *Calluna vulgaris* honey and revealed that gas chromatography analysis of organic substances in a honey sample can assist in the identification of its floral source. Oddo *et al.* (1990) found that unifloral honey proved to be characterized by very low diastase values. Wakhle and Desai (1991) reported that *Trigona* honey showed considerably high water per cent and pH values with presence inhibine (0-5) and hydrogen peroxide accumulation (2-380 mg/g).

Vit (1992) asserts that stingless bee honey had higher moisture content and acidity. *Trigona* honey is highly resistant to fermentation (Crane, 1992). Variation in honey enzyme activity has been attributed to the amount of sucrose in food sources, rate of nectar flow and even age of bees (White, 1994). Huidobro *et al.* (1995) reported that the diastase and invertase activity indicates freshness of honey. Specific gravity and refractive index are important physical properties. The most pleasing aroma composition is in honey with low boiling point. Hydroxy methyl furfural is responsible for the aroma which is produced by degradation of honey sugars while fructose/glucose ratio gives an indication of rapidness with which honey granulates (Mishra, 1995). Diastase activity (g starch hydrolysed/100 g honey/hive) was much high in *Trigona* (6.6 – 35.6) and invertase activity (m moles P-nitrophenyl glucopyranoside / kg / honey / minute) varied from 15.9 – 214.3 (Patricia and Patrizio, 1996).

Bruijin (1996) reported that stingless bee honey is more watery but do not spoil and were able to inhibit growth of bacteria. Eupatorium honey is light in colour when fresh and changes to amber colour as it matures with a pleasant aroma and flavour (Thapa and Wongsiri, 1997). Raakhee (2000) reported that the glucose and fructose content of *Trigona* honey are 37.10 per cent and 41.60 per cent respectively. The mean moisture content of *T. iridipennis* honey was reported to be 24.17 per cent (Swaminathan, 2000).

The studies conducted at Vellayani centre indicated that the *Trigona* honey from different tracts of Kerala varied widely in colour from light yellow to dark amber colour with all intermediate shades. This is related to the varied flora in different locations. It also have specific flavour and aroma. Light coloured honey is mild in flavour and darker honey has a more pronounced flavour (Fig 152,153).

The percentage of moisture varied from 18.96 to 20.48 which was significantly lower than *Apis* spp, where the moisture percentage ranged from 19 to 23. The moisture content may even change during storage because honey is hygroscopic. On the contrary, the honey can be saved from absorbing moisture leading to fermentation by proper storage at humid areas (Mishra, 1995).

The pH ranged from 3.76 to 4.40, which is lower than *Apis* honey. Stingless bee honeys were mostly multifloral. Hence variation in nectar quality occurred which influence honey characters like colour and acidity. The pH of stingless bee honey is low and hence was more acidic (De Bruijn and Sommeijer, 1997).

The major sugars in stingless honey are glucose and fructose, which account to 37.1 and 41.6 per cent respectively. Sucrose content varied from 1.2 to 1.8 per cent. All the honey samples contain lesser amount of glucose, which is the main reason for high F/G ratio and this gives an indication of rapidness with which the honey granulates. The honey, which has higher ratio of F/G, will granulate slowly. Mean total reducing sugars ranged from 77.10 to 69.85 and the mean glucose content ranged from 37.36 to 32.29. Glucose has the tendency to crystallize and because of this, honey has a natural tendency to crystallize. Fructose is more soluble in water than glucose therefore moisture content of honey also contributes to granulation of honey. Percentage of fructose ranged from 39.85 to 37.57 in stingless bee honey samples (Table 6).

The percentage of ash content in *Apis cerana* honey is 0.187 (Phadke, 1967) while that of *Trigona* honey is 1.1. The present finding indicated that ash percentage in the *Trigona* honey is ranged from 0.178 to 0.196.

The specific heat of *Apis cerana* honey was 60.82 calories while that of *Trigona* honey ranged from 60.5 to 60.9 calories.

Specific gravity and refractive index are important properties. The specific gravity of *Apis cerana indica* honey ranged from 1.392 to 1.400 (Phadke, 1967), while that of *Trigona* honey ranged from 1.350 to 1.377. The refractive index was in the range of 1.4891-1.4855.

The honey samples from different districts exhibited significant variation with regard to their properties and this may be due to the variability of the flora available in different districts (AICRP, 2004).

## Quality standards

Although several *Apis* species and stingless bees produce honey widely relished by humans as a food, the official definition of 'honey' is restricted to *Apis mellifera* by the Codex Alimentarius Commission. Imitations of Meliponinae honey have been found in local markets in Mexico, Guatemala and Venezuela (unpublished data). Honey standards have been modified according to the botanical origin but not according to the species origin. It is important that these factors are taken into account and quality standards set for other types of stingless bee honey. A proposal of quality standards for three genera of Meliponinae (*Melipona, Scaptotrigona, Trigona*) honey is suggested and they are compared with the accepted standards for *Apis mellifera.* These three genera have been chosen as representatives for the wider subfamily because previous work found statistical multivariate differences between these three groups. However, this is not attempting to condense the characteristics of honey produced by different genera, as in the honey standards accepted for only one species, the commercial *A. mellifera.* With this non-exclusive approach, it is suggested three genera to be considered for the proposal of further standards for stingless bee honey. Official methods for honey quality control have been developed for *A. mellifera* honey standards, and these are periodically reviewed by the Codex Alimentarius, the International Honey Commission (IHC) and country health authorities. The IHC works with researchers from 18 countries and has published two technical reports with inter-laboratory data of honey analyses. Water content, reducing sugars, sucrose, acidity, ash, hydroxyl methyl furfural (HMF) and diastase activity are the seven honey standards chosen to contrast differences between genuine *A. mellifera* honey and honey from the Meliponinae genera

*Melipona, Scaptotrigona* and *Trigona*. Accordingly the following are suggested for Melipona honey.

1) Water content for Meliponinae honey should increase the maximum limit of 20 g/100 g allowed for *A. mellifera* up to 30 g/100 g.

2) The standard for reducing sugars should decrease the minimum limit of 65 g/100 g for *A. mellifera* down to 50 g/100 g.

3) For sucrose the *A. mellifera* honey standard has a maximum limit of 5 g/100 g. There is a difference between the three Meliponinae genera studied, and so for *Melipona* and *Trigona* a higher maximum limit of 6 g/100 g is suggested, whereas for *Scaptotrigona* a lower maximum limit of 2 g/100 g is proposed.

## Medicinal importance

If, because of the regulations set down for *A. mellifera* honey, stingless bee honey cannot be called 'honey', then the term 'divine elixir' has been suggested for Meliponinae honey. The characteristics of honey from honey bees that prevent its spoilage by fermentation are quite well understood, but this is not so with Meliponine honey, although we know that it is free from fermentation.

Honey and ghee are considered as food of the Gods in most folklores. Honey is a natural antibiotic and has been used for centuries on wounds, burns and scrapes. Stingless bee honey has a great role in Ayurveda. The Ayurvedic medicines in which honey is being widely used will be more effective with stingless bee honey than with *Apis* honey. Honey and ghee act as good natural preservatives and carrier of the herbs oils. It has great healing properties and are effective for asthma and allergy problems. Juice extracted from pumpkin mixed with honey and sugar has medicinal properties and it is beneficial in reducing the heat of the body, inflammation and bleeding in the throat, impurities of the blood, boils and plethora.

In Ayurveda, eight types of honey are described depending on the type of bee which collects it. They are Pouttika, Bhramara, Kshoudra, Makshika, Chatra, Arghya, Oudalaka, Dala.

Pouttika - This honey is collected by very large bees from the nectar of poisonous flowers. It increases vata, causes gout and burning sensation in chest. It is also sedative and reduces fat.

Bhramara - This honey is collected by large bees and sticky in nature.

Kshoudra - (Honey collected by medium sized honey bees) light and cold in nature. Dissolves Kapha.

| | | |
|---|---|---|
| Makshika | - | Honey collected by small honey bees very light and dry natured. Usefull in Vata Kapha diseases and kapha diseases. |
| Chatra | - | Heavy and cold in nature useful in gout, Leucoderma (Shwitra). |
| Arghya | - | Good for eyes but causes arthritis. |
| Oudalaka | - | Useful in skin diseases, and helps in modulation of voice. |
| Dala | - | Dry and reduces vomiting. |

Amongst all the above **"Makshika"** is considered as the best type with immense medicinal properties.

## Antibacterial activity

The reasons for the antibacterial activity of honey are controversial. A laboratory demonstration of its antibacterial activity was first carried out by Dold *et al*(1937), who gave the name 'inhibine' to the substance which inhibited bacteria and he suggested the possibility that hydrogen peroxide was responsible for the antibacterial activity of honey since both the antibacterial activity of honey and hydrogen peroxide were destroyed by light. White *et al.* (1962) reported that hydrogen peroxidase which is produced by the glucose oxidase of honey could be the inhibitory substance against bacteria. However, it is known that honey itself, as well as bacteria produce a cataiase that eliminates hydrogen peroxide. But although catalase is active with high concentrations of hydrogen peroxide, it is of low activity with physiological levels. The amount of cataiase necessary to destroy the antibacterial activity was found to be unexpectedly high. A solution of hydrogen peroxide used as an antiseptic is likely to be far less effective than a "slow release preparation" in the form of honey. Hydrogen peroxide rapidly breakdown into water and oxygen and its production and decomposition are continuous.

## Therapeutic uses

1. Honey contains sugars which are quickly absorbed by our digestive system and converted into energy, this can be used as instant energizer.
2. Honey is hygroscopic it speeds up healing, growth of healing tissue and dries it up.
3. Honey acts as a sedative and is very useful in bed wetting disorders.
4. Honey is very good antioxidant which restores the damaged skin and gives soft, young looks.
5. Honey has antibacterial properties due to its acidic nature and enzymically produced hydrogen peroxide.

6. Constant use of honey strengthens the white blood corpuscles to fight bacteria and viral diseases.

In Ashtanga Hridaya the great classic of Ayurveda, the therapeutic uses of honey are explained as follows (in Sanskrit).

> "Chakshushayam Chedi tritshleshmavishahidmaasrapittanut
> Mehakushtakrimicchardishwaasakaasaatisaarajit
> Vranashodhana sandhaanaropanam vaatalam madhu

a. Honey is very good for eyes and eye sight.
b. It quenches thirst.
c. Dissolves kapha.
d. Reduces effects of poison.
e. Stops hiccups.
f. It is very useful in urinary tract disorders, worm infestations, bronchial asthma, cough, diarrhoea, nausea and vomiting.
g. Cleanse the wounds.
h. It heals wounds.
i. Helps in quick healing of deep wounds.
j. Initiates growth of healthy granulation tissue.
k. Honey which is newly collected from bee hive increases body weight and is a mild laxative.
l. Honey which is stored and is old helps in metabolism of fat and scrapes Kapha.

Ayurveda explains another special quality of honey. Honey is called as "Yogavahi". The substance which has a quality of penetrating the deepest tissue is called as Yogavahi. When honey is used with other herbal preparations it enhances the medicinal qualities of those preparations and also helps them to reach the deeper tissues.

# 19 FEW HOME REMEDIES WITH HONEY

Consuming one spoon of honey daily help us to lead a healthy long life.

a. Mix 2 teaspoons of honey with carrot juice and consume regularly. This helps to improve eyesight and is very helpful for those who sit before computer for long hours.

b. In cold, cough and congested chest mix 2 teaspoons of honey with equal quantity of ginger juice and should be consumed frequently.

c. A mixture of black pepper powder, honey and ginger juice in equal quantities, when consumed thrice daily help to relieve the symptoms of asthma.

d. Regular use of one teaspoon of garlic juice mixed with two teaspoons of honey help to control blood pressure.

e. One glass of warm water taken with two teaspoons of honey and 1 teaspoon of lemon juice in early morning reduces fat and purifies blood.

Honey can be used without any side effects for any kind of diseases. Today's science says that even though honey is sweet, if taken in the right dosage as medicine, it does not harm diabetic patients also.

It is found that mixture of honey and cinnamon cures most of the diseases.

**Arthritis**

Take one part honey to two parts of luke warm water and add a small teaspoon of cinnamon powder, make a paste and massage it on the itching part of the body. It is noticed that the pain recedes within a minute or two. For arthritis, patients take one cup of hot water with two spoons of honey and one small teaspoon of cinnamon powder, daily two times, morning and night. If drunk regularly even chronic arthritis can be cured. In a recent research done at the Coppen Hagen University, when the doctors treated their patients with a mixture of one tablespoon honey and half teaspoon cinnamon powder before breakfast, they found that, within a week, out of the 200 people so treated, practically 73 patients were totally relieved of pain and within a month, mostly all the patients who could not walk or move around because of arthritis, started walking without pain.

**Hair loss**

Those suffering from hair loss or baldness may apply a paste of hot olive oil, one tablespoon of honey, one teaspoon cinnamon powder before bath and keep it for approximately 15 min. and then wash the hair.

**Bladder infections**

Take two tablespoons of cinnamon powder and one teaspoon of honey in a glass of luke warm water and drink it. It destroys the germs of the bladder.

**Toothache**

Make a paste of one teaspoon of cinnamon powder and five teaspoons of honey and apply on the aching tooth. This may be done three times a day till the tooth has stopped aching.

**Cholesterol**

Two tablespoons of honey and three teaspoons of cinnamon powder mixed in 16 ounce of black tea will reduce the level of cholesterol in the body by 10 per cent. If taken 3 times a day any chronic cholesterol can be cured.

**Colds**

Those suffering from common or severe colds should take one tablespoon of luke warm honey with 1/4 teaspoon cinnamon powder daily for 3 days. This process will cure most chronic cough, cold and clear the sinuses.

**Stomach upset**

Honey taken with cinnamon powder cures stomach ache and also clears stomach ulcers. The studies revealed that if honey is taken with cinnamon powder the stomach is relieved of gas trouble. Cinnamon powder sprinkled on two tablespoons of honey, taken before food, relieves acidity and digests the heaviest of meals.

**Heart diseases**

Make a paste of honey and cinnamon powder, apply on bread or chappati instead of jelly and jam and have it regularly for breakfast. It reduces the cholesterol in the arteries and saves the patient from heart attack. Also those who have already had an attack, if they do this process daily, are kept miles away from the next attack. Regular use relieves loss of breath and strengthens the heart beat. In America and Canada, various nursing homes have treated patients successfully and have found that due to the increasing age the arteries and veins, which lose their flexibility and get clogged, are revitalized.

## Immune system

Daily use of honey and cinnamon powder strengthens the immune system and protects the body from bacteria and viral attacks. Scientists have found that honey has various vitamins and iron in large amounts. Constant use of honey strengthens the white blood corpuscles to fight bacteria and viral diseases.

## Longevity

Tea made with honey and cinnamon powder, when taken regularly arrests the ravages of old age. Take 4 spoons of honey, 1 spoon of cinnamon powder and 3 cups of water and boil, to make tea. Drink 1/4 cup 3 to 4 times a day. It keeps the skin fresh and soft and arrests old age. Life span also increases.

## Pimples

Three tablespoons of honey mixed with one teaspoon of cinnamon powder, make it a paste and apply on the pimples before sleeping and wash it next morning with warm water. If done daily for two weeks, it removes pimples from the roots.

## Skin infections

Applying honey and cinnamon powder in equal parts on the affected parts cures eczema, ringworm and all types of skin infections.

## Weight loss

Regular use of mixture of honey and cinnamon powder in one cup of luke warm water will help to reduce body weight. It can be taken daily in the morning, 1/2 hour before breakfast on an empty stomach and at night before sleeping. If taken regularly it reduces the weight of even the most obese person. Regular use does not allow the fat to accumulate in the body even though the person may eat a high calorie diet.

## Cancer

Advanced cancer in stomach and bones has been cured successfully when the patients were given one tablespoon of honey with one teaspoon of cinnamon powder daily for one month, 3 times a day (Recent research in Japan and Australia).

## Fatigue

Recent studies have shown that the sugar content of honey is more helpful than detrimental to the body strength. Senior citizens who take honey and cinnamon powder in equal parts are more alert and flexible.

**Precautions to be taken before using honey**

a. Honey should not be mixed with hot foods.

b. Honey should not be heated directly.

c. Honey should not be consumed when you are working in hot environment where you are exposed to more heat.

d. Honey should never be mixed with rain water, hot and spicy foods and fermented beverages like whisky, rum, brandy etc, ghee and mustard.

# 20 STINGLESS BEES AND CROP POLLINATION

Stingless bees are generally flower visitors and important pollinators of crops in tropical and subtropical parts of the world (Willie, 1965). They are visitors to flowers of crop species in many parts of India but not in Punjab, which is outside their geographic range (Batra, 1967). Though wind pollination does occur in crops like litchi, fruit set is higher with the presence of stingless bees and little or no fruit set is obtained under selfing (Pandey and Yadava, 1970). A saponaceous rainforest under stony tree in Costa Rica, *Lupania guatemalensis* is pollinated by *Trigona* sp. (Bawa, 1977). Roubik (1979) reports that in the low land neotropics 52 species of plants are visited by *Melipona* and 108 of the 128 species visited by other stingless bees. Species of *Trigona* are the most abundant and effective pollinators of the androdioecious *Xerospermum intermeduim* (Appanah, 1982). In Australia, *Trigona* bees are the most efficient pollinators due to the large amount of pollen carried on their bodies and the close contact they make with the stigma (Anderson *et al.*1982). Bichee and Sharma (1988) reported a mean seed yield of 633 g / 30 plants by *T. iridipennis* pollination in sunflower compared to 352 g / 30 self pollinated plants. The concept of ensuring stingless bee pollination in crops and consequently yield increase by transferring colonies in artificial hives, was proposed by Heard (1988). According to Singh (1989) stingless bees are the most common insects visiting mango. Pintandi *et al.* (1990) reported that the percentage of seeds obtained by natural pollination by *T. postica* was higher than the percentage obtained through artificial intraspecific self pollination. Adejas *et al.* (1992) showed that in *Brassica napus* L. var., *T. spinipes* resulted in an yield increase of 799 pods/m$^2$ compared to 308 pods/m$^2$ in non insect pollinated crops. Pollen of mango was found in pollen stores of *Trigona angustilla* in Chiapas (Sosa *et al*,1994).

Of the 13 Australian epiphytic orchids whose pollinators are confirmed, nine are pollinated by stingless bees (Adams and Lawson, 1993). Pollination requirement vary with crop species. More than 50 per cent of existing species of plants propagated by seeds are dependent on insects for pollination (Mishra, 1995). It was reported by Maues and Venturieri (1995) that *Bixa orellana* (Bixaceae) is efficiently pollinated by *Melipona melanoventer* and *Trigona* spp. Although wind may effect some pollination, bees are the most important agents of pollination and are attracted by the fragrance and nectar of the flowers. The most common visitors include *Melipona* sp. and *Scaptotrigona postica*. Pollination by Meliponini is the dominant pollination system in Myrtaceae (Lughadha and Proenca, 1996). The potential of stingless bee as pollinators in green house crop was asserted by Woo *et al.*(1996). Melipona species accounts for 53.2 per cent of the visitors of male flowers in watermelon. Under glasshouse condition in Japan, stingless bees were reported to be potential pollinators owing to their general characters like polylecty, tolerance to high temperature, activity throughout the year and easy transportation (Amano *et al.*, 1999). Roubik (2000) reported orchids pollinated by stingless bees. Singh *et al.* (2001) reported that yield and quality of hybrid seeds was influenced by bee visit on various sterile male rows in sunflower.

# 21 SCOPE FOR MELIPONICULTURE

The stingless bee honey has great medicinal properties. This honey is used for treating several ailments. In Ayurveda, along with *Aloe vera* it is used as a remedy to cure even cancer. Medicinal values of this honey are yet to be investigated fully. Well equipped laboratories to assess the enzymes present in the honey is a felt need for future research. Meliponiculture is still in its infancy when compared with apiculture. There is immense scope to exploit this species for commercial beekeeping. Besides being honey producer, stingless bees possess many characteristics that enhance their importance as crop pollinators both in wild and agricultural situations. Challenges to their widespread use include the lack of adequate number of hives and lack of adequately improved management technology. Dearth of knowledge of the pollination needs in the agro -ecosystem also demands further exploration. There are no crops known to be exclusively pollinated by stingless bees. Rearing stingless bees in every homesteads provide not only honey needed for the families but will assist in yield enhancement of crops and thus food safety. It also offers potential scope for employment generation to unemployed women and youth in rural areas.

# REFERENCES


Abner, T. S.and Mary, H. S. 1966. Catalase in honey. *J. Apic. Res.* 17: 37-43

Adams, P.B. and Lawson, S.D. 1993. Pollination in Australian orchids *Aust. J. Bot.* 41 : 553-575

Adejas, J.E.B., Nogveira and Couto, R.H. 1992. Entomophilous pollination in rape (*Brassica napus* L. var. Oleifera) in Brazil. *Apidologie* 43 : 203-209

AICRP 2003. Annual report for 2002-03, All India Co-ordinated Research Project on Honey bee Research and Training Centre, Vellayani Centre. p.63

AICRP 2004. Final report of ICAR Adhoc Scheme on Bioecology, domestication and managment of stingless beess- Indian Council of Agriucltural Research, New Delhi, pp 76

Amano, K., Nemoto, T. and Heard, A. 1999. What are stingless bees and why and how to use them as crop pollinators. *Rev. Biol. Trop.* 47 : 130-142

Anderson, D. and Gibbs, A. 1982. Viruses and Australian Native bees. *J.Kans.Ent.Soc.*55: 131-134

Anderson DL, Sedgley M, Short JRT,Allwood AJ. 1982. Insect pollination of mango in

Northern Australia. *Aust. J.Agric. Res.* 33:541–48

Appanah,S.1982. Pollination of androdioecious *Xerospermum intermedium* Radlk. (Sapindaceae) in a rain forest. *Biol. J. Linn. Soc.* 18 : 11-34

Baker, D.M. and Baker, E.W. 1988. New mites from the nests of stingless bees (Apidae : Meliponinae) from Asia. *Int. J. Acarol.* 14 : 127-136

Baker, E.W. and Delfinado, M. 1985. An unusual species of *Neocypholaelaps* (Acari : Amerosiidae) from the nests of stingless bee (Apidae : Meliponinae). *Int. J. Acarol.* 11 : 227-232

Bassindale, R. 1955. The stingless bees. *Apidologie* 6 : 295-339

Batra, S.W. 1967. Crop pollination and the flower relationships of the wild bees of Ludhiana, India. *J. Kans. Ent. Soc.* 40 : 164-167

Bawa, K.S. 1977. The reproductive biology of *Cupania guatemalensis* Radlk. (Sapindaceae). *Evolution* 31 : 52-63

Bentham, F.D.J., Van, I.F., Velthius, H.H.W. and Van, F.D.J. 1995. Biology of the stingless bee, *Plebeia remota* (Holmberg) : observations and evolutionary implications. *Insect. Soc.* 42 : 71-87

Bichee, S.L. and Sharma, M. 1988. Effect of different modes of pollination in sunflower *Helianthus annus* L. (Compositae) sown on different dates by *Trigona iridipennis* Smith. *Apiacta* 23 : 65-68

Boon, K.S. 2002. Sweet and sour salty bees. International symposium on Tropical Forestry Research, 2-4 March 2002. *Abstract* : 90

Bruijin, L. 1993. Traits of stingless bees. *Bee Wld* 74:12-14

Bruijin, L. 1996. Traits of stingless bee . *Honey Pegone* 4 : 7-9

Craig, C.L. 1994. Predator foraging behaviour in response to perception and learning by its prey : interactions between orbspinning spider and stingless bees. *Res. Popl. Ecol.* 35 : 45-52

Craig, C.L., Webber, R.S. and Bernard, G.D. 1996. Evolution of predator prey systems : Spider foraging plasticity in response to the visual ecology of prey. *J. Kans. Ent. Soc.* 69:132-134

Crane, E. 1985. Honey bees. *J. Apic. Res.* 36 : 403-415

Crane, E. 1990. Bees and beekeeping : Science practice and world resources. *Bee Wld* 71 : 23-41

Crane, E. 1992. The past and present status of beekeeping with stingless bees. *Bee Wld* 73 : 29-42

Darchen, R. 1971. *Trigona (Axestotrigona) oyani*, a new African species of bee. Description of its nest built within an ants nest. *Trop. Biol.* 7 : 407

Darchen, R. 1972. The nests of stingless bees. *Trop. Biol.* 8 : 139-150

De Bruijn L.L.M. , and M.J. Sommeijer, 1997. The composition and properties of honeys of stingless bees (Melipona). In: PERSPECTIVES FOR HONEY PRODUCTION IN THE TROPICS, M.J. Sommeijer et al. Eds., NECTAR, Utrecht. 146 - 168.

Delfinado, M., Baker, E.W. and Phoon, A.C.G. 1989. Mites (Acari) associated with bees (Apidae) in Asia with description of a new species. *Am. Bee. J.*129: 609-613

Devanesan S., Nisha M.M., Bennet R. and Shailaja K.K. 2002. Foraging behaviour of stingless bee *Trigona iridipennis* Smith. *Insect Environment* 8 (3) p 131 - 133

Devanesan S., Nisha M.M., Bennet R. and Shailaja K.K. 2003. Natural enemies of stingless bee *Trigona iridipennis* Smith in Kerala. *Insect Environment* 9 (1) p 30 - 31

Devanesan S., Shailaja K.K., Nisha M.M., Premila K.S. and Saraswathi P. 2003. Hiving and management of stingless bee *Trigona iridipennis* Smith in Kerala, South India. Abstr. No.489. 38th Apimondia, International Apicultural Congress Ljubljana, Slovenia, August 24-29, 2003, p 944

Devanesan S., Shailaja K.K., Raakhee M. and Premila K.S. 2004. Morphometric characters of the queen and workers of stingless bee *Trigona iridipennis* Smith. *insect Environment* 9 (4) p 154-155

Disney, R.H.L. and Bartareau, T. 1995. A new species of *Dohrniphora* (Diptera : Phoridae) associated with a stingless beee (Hymenoptera : Apidae) in Australia. *Sociobiology* 26 : 229-239

*Dold, H., Du, D.H. and Dziao, S.T. 1937. Antibacterial activity of honey.*J. Kans. Ent. Soc.* 9:155-167

Dollin, A. 1996. Nests of Australian stingless bees.Technical Bulletin No.2.Australian Native Bee Research Centre,North Richmond, Australia.p.14

Dollin, A. 1997. Keeping Australian stingless bees in a log or box. Technical Bulletin No.3.Australian Native Bee Research Centre,North Richmond, Australia.p.14

Dollin, A. 2001. *Australian stingless bees*. Technical Bulletin No.9 Australian Native Bee Research Centre. North Richmond, Australia p.14

Dollin, A., Heard, J. and Tim, A. 1997. *Keeping Australian stingless bees in a log or box.* Technical Bulletin No.5. Australian Native Bee Research Centre, North Richmond, Australia p. 14

Fain, A. and Flechtmann, C.H.W. 1985. Mites of stingless bees *Melipona seminigra. Int. J. Acarol.*11: 89-91

*Flechtmann, C.H.W., Phoon, A.C.G., and Camarcio, C.A.1974. Mite associated with stingless bees from Brazil. Proceedings of the Fourth International Congress of Acarology, 2-4 August, 1974, University of Austria, Sarlfelder. *Abstract*: 315

*George, C.J. 1934. The bionomics, morphology and metamorphosis of *Melipona iridipennis. Ibid.* 2 : 1-6

Gilliam, M. 1979. Microbiology of pollen and bee brood, the genus *Bacillus. Apidologie* 30 : 269-274

Hallim, M.K. and Sommeijer, M.J. 1994. Beekeeping with *Melipona trinitatis* and *Melipona farosa* in Trinidad.A review. *Proceedings of the Fifth International Conference on Apiculture in Tropical Climates, September 7-12, 1994* (eds. Kendal, E. and Solomon, M.) University of Trinidad, Tobago. pp. 229-231

Heard, T.A. 1988. Propagation of hives of *Trigona carbonaria* Smith (Hymenoptera : Apidae). *J. Aust. Ent. Soc.* 27 : 303-304

Heard, T.A.1999. Behaviour and pollination efficiency of stingless bees and Honey bees on macadamia flowers. *J. Apic. Res.* 51 : 191-198

Huidobro, J.F., Santana, M.P., Sancho, M.T., Muniate, F. S.and Simallozano, J. 1995. Diastase, invertase and b glucosidase activities in fresh honey from north-west Spain. *J. Apic. Res.* 46 : 39-44

Jacob,A., Rajan Asari,P.A and Mohandas,N 1992. A new disease of the Indian honeybee *Apis cerana indica* F. in Kerala *Agric.Res. J. Kerala* 30: 63-64

Kalimi, M.Y. and Sohonie, K. 1965. Mahabaleshwar honey vitamin contents (ascorbic acid, thiamine, riboflavin and niacin) and effect of storage on these vitamins. *J. Nutr. Dietet.* 2 : 9-11

Kamal, T. and Pulak, C. 1994. Beekeeping in India – Ancient and modern. *Kisan Wld* 57 : 53-54

Kerr,W.E.1959. Bionomics of Meliponids –VI. Aspects of food gathering and processing in some stingless bees. Food gathering in Hymenoptera. *Symp. Entomol.Soc.Am.* Detroit : 24-31

Kshirsagar and Chauhan. 1977. Preliminary observation on oviposition behaviour in *Trigona* (*Tetragona*) *iridipennis* Smith. *Indian Bee J.* 39 : 3-6

Lindauer, M. 1957. Communication among the Honey bees and stingless bees of India. *Bee Wld* 38 : 34-39

*Lughadha, E.N. and Proenca, C. 1996. A survey of the reproductive biology of Myrtoideae (Myrtaceae). *Honeybee Sci.* 17 : 480-503 .

Marceau, J., Bioly, R and Person, J.M. 1990. The relationship between hive productivity and honeybee flight activity. *J. apic. Res.* 41: 29-34

Maues, M.M.and Venturieri, G.C. 1995. Pollination biology of *Bixa orellana* and its pollinators in Amazon area. *Honeybee Sci.* 16 : 27-30

*Michener, C.D. 1972. Evolution of the nests of bees. *Am. Zoo.* 12 : 221-227

Michener, C.D. 2000. *The Bees of the World* . John Hopkins University press, Baltimore, Maryland U.S.A.

Mishra, R.C. 1995. *Honey bees and their management in India..* Indian Council of Agricultural Research, Krishi Anusandhan Bhavan, Pusa, New Delhi, p. 162

Mohan, R.G., Lazar, M. and Suryanarayana, M.C. 1981. Foraging behaviour of honey bees in sesame (*Sesamum indicum* L.). *Indian Bee J.* 43 : 97-100

Neto, N.P. 1953. Notes on bioeconomics of *Melipona. East Afr. Agric. J.* 18 : 19-23

Neto, N. P. 1974. Notes on bionomics of meliponines *Bee Wld* 7 : 219-452

Nisha, M.M. 2002. Management of stingless bee *Trigona iridipennis* Smith (Meliponinae: Apidae) in the homesteads of Kerala. M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p.93

Nogueia-Neto,P. 1954. Notas bionomicas sobre meliponines. III – Sobre a enxameagem. *Arq.Mus.Nac.*Rio de Janerio 42 : 219 -452

Nordenskjaeld, N. 1934. Stingless bees. *J. Biol. Chem.* 15 : 107

Oddo, P., Baldi, Z. and Accorti, M. 1990. Diastatic activity in some unifloral honeys. *Apidologie* 41 : 17-24

Pande,Y.D and Bandyopadhyay, S. 1985. The foraging behavior of Honey bees on Flowers of Pigeon Pea (*Cajanus cajan*) in Agartala, Tripura. *Indian Bee J.* 47: 13-15

Pandey, R.S. and Yadava, R.P.S. 1970. Pollinations of litchi (*Litchi chinensis*) by insects with special reference to Honey bees in India. *J. Apic. Res.* 9 : 103-105

Patricia, V. and Patrizio, P. 1996. Diastase and invertase activities in Meliponini and Trigonini honeys from Venezuela. *J. Apic. Res.* 47 : 57-62

Percy, A.P. 1989. Division of *Trigona iridipennis* Smith. colony. *Indian Bee J.* 51 : 149

Phadke, R.P. 1967. Studies on Indian honey. Approximate compositions and physicochemical characteristics of Indian multi floral apiary honeys from *Apis indica* bees. *Indian Bee J.* 22 : 14-26

Phadke, R.P. 1968. Studies on Indian honeys. Proximate composition and physicochemical characterization of honeys from wild honey bees *Apis dorsata, Apis florea* and *Trigona. Indian Bee J.* 23 : 3-8

Pintandi, C.A., Stort, M.N.S. and Manis, M.A.1990. Pollination of *Xylobaium squalem* Lindi (Orchidaceae). *Bee Wld* 15 : 67-80

Pooley, A.C. and Michener, C.D. 1969. Observations on nests of stingless bees in Natal (Hymenoptera : Apidae). *J. Ent. Soc. South. Afr.* 32 : 423-430

Prance, G.T. and Anderson, A.B. 1976. Studies on the floral biology of neotropical Nymphaeaceae. *Acta Amazon* 6 : 163-170 .

Premila K.S., Devanesan S., Arthur Jacob J. and Shailaja K.K. 2007. Foraging plants of stingless bee *Trigona iridipennis Smith* and Physico - chemical characteristics of its honey. Abstr. No. 183, 40th Apimondia, International Apicultural Congress, Melbourne, Australia. Sept.9-14, 2007. p.129

Raakhee, M. 2000. Bioecology and management of stingless bees (Apidae : Meliponinae). M.Sc. (Ag.) thesis, Kerala Agricultural University, Thrissur, p. 68

Raakhee, M. and Devanesan S. 2000. Studies on the behaviour of the stingless bee, *Trigona iridipennis* Smith (Apidae : Meliponinae). *Indian Bee J.* 62 (3&4):59-62

Ramanujam, C.G.K., Fatima, K. and Kalpana, T.P. 1993. Nectar and pollen sources for Dammer Bee (*Trigona iridipennis* Smith) in Hyderabad, India. *Indian Bee J.* 55: 25-28

Roubik, D.W. 1979. Africanized Honey bees, stingless bees and the structure of tropical plant-pollinator communities. *International Symposium on Pollination. Fourth April 1979. Agriculture Experiment Station,* Maryland. *Abstract* : 403

Roubik, D.W. 1992. *Stingless bees. A guide of Panamanian and Mesoamerican species and their nests (Hymenoptera : Apidae : Meliponinae).* Oxford University Press, London, p. 692

Roubik, D.W. 1995. *Stingless bee colonies for pollination.* (ed. Roubik, D.W.). FAO (UN), Rome, p. 324

Roubik, D.W. 2000. Potential pollination out crossing distances flown by honey bees in a Congo forest. *J. Kans. Ent. Soc.* 73 : 137-150

Sakagami, S.F. 1975. My Brazil and its Bees. *Res. Popul. Ecol.* 10 : 127-139

Sakagami, S.F. 1982. Stingless Bees. *Social Insects, Vol. III.* (ed. Hermann, H.R.). Academic Press Inc., New York, p. 362-423

Sakagami, S.F. and Inove, T. 1989. Stingless bees of the genus *Trigona* (Subgenus – *Geniotrigona)* (Hymenoptera :Apidae). *Jap. J. Ent.* 57 : 605-620

Salmah,S., Inoue,T and Sakagami,S. F. 1996. Incubation period and post emergence pigmentation in the Sumatran stingless bee *Trigona (Heterotrigona) itama* (Apidae, Meliponinae) *Japanese Journal of Entomology* 64 (2): 401-411

Schutte, H.A. and Remy, K. 1982. Honey characters. *J. Am. Chem. Soc.* 50 : 19-98

Schwarz, H.F. 1948. Stingless bees (Meliponinae) of the Western Hemisphere. *Bull. Am. Mus. Nat. Hist.* 90 : 1-546

Simoes, D., Bego, L.R., Zucchi, R. and Sakagami, S.F. 1980. *Melalonctia sinistra* an endoparasite phorid fly *attacking Nannatrigona (Scaptotrigona) postica* (Hymenoptera : Meliponinae). *Rev. Brazil. Ent.* 24 : 137-142

Simons, D. 1974. Social regulation in *Nannatrigona postica. J. Kans. Ent. Soc.* 47 : 212-230

Singh, G. 1989. Insect pollinators of mango and their role in fruit setting. *Acta Hort.* 231 : 629-632

Singh, G., Kashyap, R.K., Kumar, P. and Khan, M.S. 2001. Yield and quality of hybrid seeds: Influence of honey bee visitations on various sterile male rows in sunflower. *Seed. Sci . Technol.* 29 : 163-170

Smith, F.G. 1954. Beekeeping observations in Tanganyika. *East Afr. Agric. J.* 18 : 1-3

*Sosa-N´ajera MS, Mart´ýnez-Hern´andezE, Lozano-Garc´ýa MS, Cuadriello-Aguilar JI. 1994. Nectaropolliniferous sources used by *Trigona (Tetragonisca) angustula* in Chiapas, Southern Mexico.*Grana* 33:225–30

Stare, C.K. and Sakagami, S.F. 1987. Largest aggregation of *Trigona. Insect Soc.* 34 : 96-107

Swaminathan, S. 2000. Bioecology of stingless bee (*T. iridipennis*) M.Sc. (Ag.) thesis, Tamil Nadu Agricultural University, Coimbatore, p. 98

Tan, S.T., Wilkins, A.L., Reid, M. and Molan, P.C. 1989. A chemical approach to the determination of floral sources. *J. Apic. Res.* 28 : 212-222

Thapa, R. and Wongsiri, S. 1997. *Eupatorium odoratum* a honey plant for beekeepers in Thailand. *Bee Wld* 78 : 175-178

Vit ,O. P. 1992. Characterization of honey from stingless bees produced in Venezuela : *Am. Bee J.* 132 : 120-130

Wakhle, D.M. and Desai, D.B. 1983. Enzymes in Indian honeys. *Proceedings of Second International Conference on Apiculture in Tropical Climate, April 24-25, 1983* (ed. Phadke, R.P). Indian Agriculture Research Institute, New Delhi, pp. 703-710

Wakhle, D.M. and Desai, D.B. 1991. Estimation of antibacterial activity of some Indian Honeys. *Indian Bee J.* 51 : 80-90

Weaver, N. 1981. Beekeeping with stingless bee, *Melipona beecheii* by the Yucatan Maya. *Bee Wld* 62 : 7-9

White, J.W. 1994. The role of HMF and diastase assays in honey quality evaluation. *Bee Wld* 75 : 104-117

White, J.W. and Subers, M.H. and Schepartz, A.I. 1962. The identification of inhibine in honey. *Am. Bee. J.* 35 : 430-437

Willie, A. 1963. Phylogenetic significance of an unusual African stingless bee, *Meliponula bocandei* (Spinola). *Rev. Biol. Trop.* 11 : 25-45

Willie, A. 1965. Stingless bees in the Mesoamerican region. *Rev. Biol. trop.* 13 : 271-291

Willie, A. 1983. Biology of the stingless bees. *Ann. Rev. Ent.* 28 : 41-64

Woo, K.S., Kim, J.H., and Mappatoba, I.S.A. 1996. The foraging activity of stingless bees, *Trigona* sp. (Apidae, Meliponinae) in the green house. *Korean J. Apic.* 11 : 82-89

*Original not seen