MANAGEMENT OF STINGLESS BEE *Trigona iridipennis* Smith (Meliponinae : Apidae) IN THE HOMESTEADS OF KERALA

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Dedicated to My
Achan and Amma

DECLARATION

I hereby declare that this thesis entitled "**Management of stingless bee *Trigona iridipennis* Smith. (Meliponinae : Apidae) in the homesteads of Kerala**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "**Management of stingless bee *Trigona iridipennis* Smith. (Meliponinae : Apidae) in the homesteads of Kerala**" is a record of research work done independently by Ms. Nisha. M.M. (2000-11-17) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Nishanu

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LIST OF ABBREVIATIONS

^0C	Degree Celsius
%	Per cent
EC	Electrical Conductivity
m	Metre
μ	Micro
μg	Microgram
cm	Centimetre(s)
g	Gram
mm	Millimetre
viz.	Namely
ml	Millilitre
kg	Kilogram
cc	Cubic centimetre
spp.	Species
et al.	And others
TRS	Total reducing sugars
HMF	Hydroxyl Methyl Furfuryl
Fig.	Figure
N	Normal
CD	Critical difference
h	Hour
TV	Titre value
A.O.A.C.	Association of Official Agricultural Chemists
F/G	Fructose/glucose ratio

INTRODUCTION

1. INTRODUCTION

The honeybee and the fruits of its toil have been familiar to man since prehistoric times. There is an increasing awareness in the world today of the importance and the role of indigenous bees in the nature. A wide array of people are attracted to the fascinating world of honeybees, especially because they provide honey, honey products and also on account of their interesting way of social life.

Beekeeping is an ideal, absorbing, instructive and economically profitable hobby. Beekeeping is a farmer friendly enterprise with special advantage that it can be practiced where majority of people are small or marginal land holders or even landless. Beekeeping was practised in erstwhile Travancore in a primitive way which got revolutionized with the introduction of moveable frames in 1924.

Trigona iridipennis Smith is a common stingless bee which is small to medium sized with vestigeal sting. They are sometimes called 'dammer' bee as they collect a kind of resin for constructing their nest along with wax produced from their body. *Trigona* refers to their triangular shaped abdomen and *iridipennis* refers to their irridescent wings. In several regions, the technique of stingless beekeeping was developed 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). Trigona can maintain themselves for years without artificial feeding. The art of meliponiculture has been practised very traditionally in Asia especially Indonesia (Crane, 1992). Stingless bees are the most important natural pollinators of the tropics (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. The foraging range is shorter than *Apis* spp., hence they can be very well utilised in planned pollination especially in the homesteads of Kerala. Stingless bees just like the other nesting *Apis* spp. can be domesticated and used for production of honey. The feral colonies found in tree cavities and wall cavities can be transferred to hives and easily domesticated compared to other honeybees. The honey of stingless bees is more acidic than commercial honey but is highly priced for its 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 damper is the quantity of honey produced by it which is very less and much of that is utilised for its own use.

The bees are hardy and easy to handle. In view of the diversity of climatic regions in Kerala it is implied that subsequent amount of stingless bee honey is produced in Kerala. But the art of domestication has not yet been under full proof. The rich floral diversity of the state provides good scope for meliponiculture. The honey produced is mainly obtained from the feral colonies. A large number of colonies are being destroyed due to their unfair practice of collecting honey. If concerted attempts are made on the conservation, domestication and management of stingless bee it would result in the increase in number of colonies for meeting the demand. An efficient management for multiplication should be intensified for sustainable agriculture and the conservation of biological diversity. The potentialities that meliponiculture offers to agriculture, such as rural employment, nutrition and supplementary income generation especially to women who can easily handle it is substantial in the homesteads of Kerala.

Kerala has a modern, highly efficient and relatively large scale beekeeping entrepreneurs. The present studies were hence taken up with an emphasis on improving meliponiculture with the following objectives :

1. Suitability of hive
2. Handling of bees
3. Foraging behaviour
4. To assess the quality of honey
5. Incidence of pests and diseases

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 ORIGIN AND GEOGRAPHICAL RANGE

The honeybees are paleotropical but extend fairly far northward. Stingless bees are seldom found outside the subtropical regions, but are pantropic which is unique among bees (Moure, 1961). Stingless bees occur in all continent but Meliponini is restricted to the neotropic (Michener, 1974). Stingless bees belong to the sub family Meliponinae in the family Apidae. The species coming under Meliponinae are divided into two tribes Trigonini and Meliponini (Wille, 1979). All Asian and African stingless bee species belong to the tribe Trigonini. The various genera in this tribe include *Trigona, Plebeia, Tetragona* and *Nanotrigona*. The genus *Melipona* consists of 40 species which occur in neotropic (Camargo *et al.*, 1988). In general stingless bees are easily distinguished from the bees by the following three characters : reduction and weakness of wing venation, presence of the penicillium and reduction of the sting (Wille, 1983).

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 which 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. The oldest known specimen of any 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 are among a diverse group with about 500 species (Roubik, 1992).

Stingless bees are considered to have their centre of origin in Africa and have dispersed to other tropical and subtropical parts of the world.

based on paleontological and biogeographic data. This hypothesis is also supported by the fact that their primitive species with a well developed sting system live in Africa exlusively (Dollin 1996).

2.2 SPECIES OF INDIAN STINGLESS BEES

The most common species of stingless bees found in India was for a long time read under the name *Melipona iridipennis* Smith. Later this taxonomy was rearranged and placed under the genus *Trigona,* as *Melipona* is restricted only to neotropics (Michener, 1944). *Trigona iridipennis* Smith is a common stingless bee in the tropical and subtropical regions of India and Sri Lanka (Sakagami, 1978).

Crane (1992) listed 14 species of *Melipona* and 21 species of *Trigona* that have been used in traditional beekeeping. The group with the morphology considered to be antique, is *Trigona* the largest and most widely distributed genus in South East Asia (Velthius, 1997).

2.3 NESTING SITES

Stingless bees, in a general way, build more complex nests than *A. mellifera* with great variety of forms, size and place of construction (Schwarz, 1948). *T. denoiti* builds combs generally 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 bee build their nests in empty trunks or in hollow branches or even in soft or hard soil (Pooley and Michener, 1969). *T. oryani* Darchen builds its nest within ant nest of *Crematogaster* spp. using cavities produced by depredation of the diurnal pangolin (Darchen, 1971). Eventhough the great majority of species use closed cavities to build their nests some build completely exposed nests in large cavities, bushes and bird nests and some construct under root cavities. This is the habit of *Schwarziana quadripunctata*, *Paratrigona* spp., *Melipona quinquifasciata* and *Geotrigona* spp. Batumen is laminate when nest is exposed (Sakagami, 1982).

A stingless bee nest has an entrance normally build of wax and mud and sometimes sticky. The form of the entrance varies from one species to another and it is useful in the orientation of the bees and defence of the nest (Sakagami and Inove, 1989). The flight entrance lined with cerumen or propolis and with entrance tube of 6-25 mm long was reported in *T. gribodoi* (Crane, 1992).

2.4 DEFENCE MECHANISM

The sting is vestigial and nonfunctional but the bees have various efficient means of defence for colonies. Some species adopt aggressive ways of defence like biting (*T. cupia* and *T. guscipennis*), emitting a caustic liquid from mouth (all species of *Oxytrigona*) and releasing unpleasant odour (*T. capitata* and *M. marginata*) (Dollin, 1996). However the most common strategy of defence is to make their nests and the entrance invisible to intruders (Bruijin, 1996). *T. iridipennis* is a gentle species and can be manipulated with ease. The insects defend the nest by sealing up all necessary nest openings and sometimes crawl over persons and give tiny nips with their mandibles when their nest is disturbed (Dollin *et al.*, 1997).

2.5 MANAGEMENT OF *T. iridipennis*

2.5.1 Domestication

The most commonly described traditional hive for beekeeping with stingless bees, especially *Melipona beecheii* in Yacatau was a horizontal hollowed log from a selected tree, closed at each end with a disc of wood (Crane, 1985). Wooden boxes of 10 x 12.5 x 10 cm size with a glass top covered by a wooden lid were developed by Centre Bee Research and

Training Institute in Pune for rearing stingless bee *T. iridipennis* (Percy, 1989). A simple box 1.2 x 0.27 x 0.27 m, with a removable lid were 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 was used for housing *M. trinitatis* in Trinidad and in Costa Rica, the small bee *Tetragonisca angustula* were kept in boxes with capacity averaging three litres (Bruijin, 1996). *Trigona carbonaria* were reared in hives consisting of two boxes, an inner box and an outer box. The inner box was designed with three stories 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 (Dollin, 1997). Wooden hives of size 3 x 14 x 15 cm were found superior to bamboo hive and earthen pot for rearing *T. iridipennis* (Raakhee, 2000). Dollin (2001) reported use of bamboo and wooden box as natural hive duplication method, as an alternative for propagating *T. carbonaria.*

2.5.2 Division of *T. iridipennis* Colony

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 practised 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 new hive. Natural hive duplication by connecting new hive (box or bamboo) with a tube to natural hive and propagating was developed by Dollin (2001).

2.5.3 Dynamics of Brood Cell Usage and Construction

Trigona standingeri Gribodoi builds vertical double sided combs like those of *A. mellifera* which is unique among Meliponinae (Smith, 1954). The cell building of stingless bees is entirely different and rather resembles that of solitary bees. Cells are built one by one. New cells are started only after prior cells are provisioned with larval food, oviposited and sealed (Darchen, 1972). The post feeding larvae assumes an erect position, spin cocoons and pupate. As the pupae age, the cell walls are removed so that cocoons are exposed and in large nests, a new comb is started in this space, such that there are two advancing fronts of cells. Thus older combs have light colour, because of loss of cerumen (Michener, 1974).

New building material is produced by depositing wax scales, produced from the dorsal wax glands. Plant resin is brought in by foragers and are dumped on a resin dump, generally very near to the exit of the nest. Small parts of this stored resin are taken to the wax deposit and mixed with the wax. This mixture of building material cerumen is used in addition to the cerumen scraped from existing nest structures, to build new brood cells (Sakagami and Zucchi, 1974).

Brood combs of *T. denoiti* are spirally arranged in single or double spirals (Fletcher and Crewe, 1981). Brood cells are constructed in cluster forms in *Trigona nigra* (Sommeijer *et al.*, 1984). The brood cells house eggs and larvae. The larval brood cells are build of brown cerumen. Prior to pupation the larvae spin a silken cocoon. Much of the brood cell cerumen is then stripped away leaving the cocoons largely exposed. Queens are reared in special cells which are found on the edge of the comb (Adams and Lawson, 1993). In *Trigona* spp. the worker cells and drone cells are similar. The brood cells are used only once in all stingless bees. There is always an excess of gynes (young and virgin queens) in stingless bee colonies, most of which are killed. This helps in quicker replacement of queen and facilitate division of colonies (Bruijin, 1994). According to Bentham *et al.* (1995) cell building and provisioning were the activities of a small group of workers (4-9) in *Plebeia remota.*

Drumond *et al.* (1996) studied that in *Plebeia emerina* eggs were laid in batches, brood cells constructed synchronously and provisioned. The brood cells are arranged in clusters in *T. iridipennis* which envisage them to fit well in irregular shaped cavities. The brood combs are made of cerumen, suspended and separated by connectives and pillars (Swaminathan, 2000). In *T. carbonaria*, the combs are spiral, only the African species *Dactylurina staudingeri* has vertical, double combs each consisting of two layers of horizontal cells opening in opposite directions, as in the case of *Apis* spp. (Dollin, 2001).

2.5.4 Pollen and Honey Storage

Kshirsagar and Chauhan (1977) reported that in *T. iridipennis*, the storage pots were seen close to brood cells. The height and diameter of honey and pollen pots were recorded as 6.638 and 6.78 mm and 6.64 and 6.64 mm respectively. Both honey and pollen pots in *Trigona* are much larger than brood cells. The pots are mainly built of cerumen, a mixture of the wax and plant resin.

The hive bees hydrate the honey to prevent the spoilage of honey by microbes and then seal the pot as *Apis* spp. Honey store is lower than pollen store. The honey storage is limited to the amount that can be consumed by the colony before fermentation occurs (Roubik, 1985). Providing larval food is by stocking each cell with special honey and pollen mixture (Roubik, 1990). New pots are built next to adjacent older pots, hence pots look like bunch of grapes (Dollin, 1996). In most species honey pot and pollen pots have the same form and size, but in some species of *Tetragona* there are two types of storage pots, the pollen pots being more elongate and more cylindrical. Also when storage pots are alike honey and pollen pots are more or less spatially divided (Bruijin, 1996).

The involucrum surrounds the brood combs and regulates the temperature around brood cells. Propolis dumps are stored near the entrance and other crevices (Noll *etal.*,1996). Pollen stores of *T. iridipennis* are larger than honey stores and pollen colour change and become darker on aging. The harvestable honey surplus ranged from 250-1000 g/hive (Swaminathan, 2000). The amount of honey stored in the colony varies enormously among the species with some such as *Melipona compressipes* storing more than eight litres during a year and others like *Plebeia* which store only a few cubic centimeters (Dollin, 2001).

2.5.5 Population Buildup

Schulz (1909) reported population of *T. iridipennis* as 2,550 in a nest. The largest number of cells and cocoons (82,000) was observed in a nest of *T. corvina* (Michener, 1946). The production of males by the laying workers increases, the genetically active population of the colony (Beig *et al.*, 1972). According to Michener (1973) the population of *T. frontalis, T. spinipes, T. mirandula, T. buyssoni, T. buchwaldi* was 1900, 5500, 2281, 136 and 1326 respectively.

2.5.6 Task Allocation

Social life in the stingless bees, as in other social insects involves division of labour. Only the females are divided into castes, which are queen and workers (Neto, 1953). According to Bassindale (1955) the different tasks among the workers are not rigidly established but reflect tendencies towards certain tasks at certain ages. Simons (1974) subjected that the number of guards increased in weak colonies. The relation between age sequence to worker polyergism and some morphofunctional features in *Scaptotrigona postica* was described by Sakagami (1975). The task sequence progressed more rapidly in colony containing virgin queens. The sequence of activities can be divided into 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).

2.5.7 Longevity of Colonies

Little is known about the longevity of the colonies of stingless bees. The known maximum report is 10 years (Wille, 1963).

2.6 FORAGING BEHAVIOUR

Peckolt (1894) was the first to identify that in Brazil the stingless bees *T. jatay*, *T. bipunctata* and *T. mosquito* started foraging activity at 0700 h, 0700h and between 0530 h and 0600 h respectively during good weather. Lindauer (1957) reported that *T. iridipennis* communication ceased at 100 metre and flight ceased at 120 metre. It was also reported that *T. iridipennis* started foraging activity at 0700 h and ended the same at 1700 h. The foraging period was the longest compared to all other bee species and spread more or less evenly over the entire period. Peak foraging for nectar was recorded in the morning and in the evening, while for pollen the peak period was recorded between 0900 h – 1000 h.

The presence of brood stimulated colony foraging in general and pollen gathering in particular and a change in the amount of brood changed the proportion of foragers collecting pollen (Free, 1967). Pollen collection is correlated with honey production (Cale, 1968). During worsened foraging conditions, the larger colonies foraged less than the smaller ones, because in smaller colonies larger proportion of bees assumed the duty of foraging (Preece, 1969). Tsibulskii (1969) showed that the foraging activity of bees was related to the quantity of brood in the colony and the amount of unsealed brood. The amount of pollen collected and stored increased with increasing amount of brood. Doull (1970) reported that the number of foragers per unit of population was same or little less in smaller colonies than in larger ones. Pollen foraging remained more in queenless colonies when brood was present and nectar was absent. But the total pollen and nectar foraging was higher in queen right colonies (Jaycox, 1970).

Kendal and Solomon (1973) observed that insects with small bodies carry little pollen compared with larger, hairy-bodied insects. It was asserted by Barker and Jay (1974) that no significant difference existed in the proportions of incoming foragers or in the weights of pollen collected between standard and small colonies but the amount of food brought to the colony was found to be roughly proportional to the number of bees in the colony. It was asserted by Flechtmann and Rochelle (1979) that *Trigona spinipes* robbed nectar from within holes in the calyx. . The intensity of foraging in a colony was related to temperature, time of day and humidity over the season (Fowler 1979; Abrol, 1998). The availability of nectar in the colony stimulated pollen foraging, while that of pollen stimulated nectar foraging (Hoopingarner and Taber, 1979). Large aggressive *Trigona* spp. did not continue to visit feeders on which there were Africanized honeybees competing for forage (Roubik, 1980).

Brantizes (1981) reported that *T. fulviventries* var *guiama* collected pollen and nectar only from stomata inflorescence of bread fruit and never from pistillate flowers. Goel and Kumar (1981) observed *T. iridipennis* in considerable abundance on sunflower (*Helianthus annus* L.). The bee was reported as a major pollinator of sunflower crop owing to their large numbers during the blooming phase with most preferred time during 1000 h and 1300 h. *Trigona* foraged on extrafloral nectaries of sesame (*Sesamum indicum*) (Mohan *et al*., 1981). It was reported by Schuster (1981) that *T. amathea* bees collected honeydew from membracids. The potential pollinator's choice of plant lies in the ability of a flower to attract bees using colour, size, odour, time of opening and the height and position of a flower. Poricidal anthers make it difficult for *Trigona* workers to obtain pollen since they lack the ability to buzz pollinate but *T. williana* managed to obtain pollen from poricidal anthers of cassia by destroying anthers, because these species have pollen of high protein content (Renner, 1983). Both pollen and nectar foragers do not offer trophallactic food to nest mates. However both pollen and nectar foragers do solicit and receive food trophallactically (Sommeijer *et al.*, 1983). Location of resin glands close to stigma and anthers make *Trigona* bees as effective pollinators (Ambruster, 1985). *T. iridipennis* collected resin or latex for nest building for which group foraging is performed (Howard, 1985).

Cortopass and Ramalho (1988) determined that *A. mellifera* workers do not collect pollen grains larger than 71 mm in diameter, while *T. spinipes* workers, which prefer pollen grains in the range of 20-30 mm (medium size) do not collect pollen upto 100 mm in diameter. Peak population of *T. iridipennis* was reported at 1300 h and visited 1.28 umbel/mt during pollen foraging in onion (*Allium cepa*) (Mohan and Suryanarayana, 1988). To obtain nectar from flowers with tubiform corolla *T. williana* bees perforated the corolla tube damaging the flowers (Roubik, 1982). The main pollen and nectar sources for *Mellipona* spp. appeared to be plants from the families melastomataceae, myrtaceae, solanaceae and leguminosae (Ramalho *et al.*, 1989). Sceley (1989) propounded that pollen and honey foraging are regulated quite differently from one another. Pollen collection and storage is a tightly regulated system in honeybees; whereas, nectar collection seems to occur relatively independent of actual honey stores until colonies are severely stressed. They also reported that foraging activity of bees normally occur within a limited range of microclimate condition. Kalpana and Ramanujan (1990) highlighted the importance of *Prosopis juliflora* as a major nectar and pollen source of *Trigona*. It was propounded by Haris and Beattie (1991) that *T. carbonaria* induces some reduction in pollen viability and this may be the effect of resins harvested for nest constructions. The disruption of pollen function by *T. carbonaria* reported to be much less severe than that produced by ants. Silveira (1991) determined that *Croton* spp. and Graminae were more important by volume of pollen loads collected than families with larger number of pollen grains such as Myrtaceae. Garcia *et al.* (1992) reported that stingless bees collected seeds and epicarp of fruits to build up structures of nests.

It was asserted by Malerbo and Noguiracouto (1992) that *T. spinipes* and *T. angustulla* preferred white and yellow flowers when compared to pink and orange flowers. Sedgley *et al.* (1992) reported that *Trigona* collected polyads in their pollen baskets from *Acacia mangium* and *A. auriculiformis* in Malaysia and Australia. Floral display and dense fragrance attracted *Trigona* spp. to orchids (Adams and Lawson, 1993). It was reported by Ramanujam *et al.* (1993) that *Peltoforum pterocarpum* served as the major pollen for *T. iridipennis* while Eucalyptus and loranthus, served as minor nectar and pollen source. Leuceana, tamarind, delonix, neem, lawsonia, ageratum as nectar sources . Bees which visit palms with large inflorescence are opportunistic pollen thieves, effecting pollination only occasionally and accidentally. Inflorescence of the peach palm, visited by *T. williana, T. branneri* and *T. fulviventris* collected pollen from a dense white carpet of male flowers which had fallen on the ground at the base of the plant. This behaviour which is due to the difficulty to reach tall plants (Marques *et al.*, 1993a). It was reported by Marques *et al.* (1993b) reported that *T. williana* workers monopolize the flowers of a host plant, not allowing other Meliponine bees to approach but such behaviour is not observed on plants with very abundant pollen including Anacardiaceae, flacourtiaceae, myrtaceae, which have flowering peak during dry season. Miranda and Clement (1993) that preference for pollen of different species depends on different parameters, among which the nutrient content in the form of proteins, sugars, vitamins and enzymes are highly dependent. During the rainy season competition is more intense. Both inter and intra specific aggressive interactions are observed.

Vitali *et al.* (1994) reported *T. spinipes* as effective pollinators of *Murraya exotica*. Dispersal of eucalyptus seeds by the resin collecting stingless bee, *T. carbonaria* was reported by Wallace and Trueman (1995)

T. hypogea, an obligate necrophagous stingless bee made honey from juices directly collected from fruits, from extra floral nectaries (Noll *et al.*, 1996). It was reported by Mohan *et al.* (1996) that *T. iridipennis* collected nectar from extrafloral nectaries in cotton. Mohan and Singh (1997) asserted that *T. iridipennis* foraged on white salvia for nectar and on lavender for pollen. Sanchez *et al.* (1997) studied the diversity of pollen sources for stingless bee and reported Moraceae as potent pollen source. It was reported by Corff *et al.* (1998) that the bee *T. fulviventris* accounted for 95 per cent of all visits to *Begonia tonduzii* and visited male flowers 15.4 times as often as female flowers.

Lazari *et al.* (1998) reported that *T. spinipes* and *Nanatrigona testacricornie* were the most frequent flower visitor of *Caesalpinia peltophoroides* with peak activity between 0900 h and 1300 h. Heard (1999) asserted that stingless bees preferred tall flowers and dense inflorescence with corolla tube shorter and flowers with wide corolla tube permitting their entry inside. Raju *et al.* (1999) propounded *Trigona* sp. as flower visitors of *Semicarpes anacardium*. Viraktamath *et al.* (1999) reported in Karnataka the important pollen source of *Trigona* spp. during December was *Euphorbia pulcherima*, *Eupatorium odoratum*, *Antigonon leptopus*, *Petunia* sp., *Bougainvilla* sp. and *Mimosa pudica* and during February pollen sources was quiscalis, *Erythrina indica* and *Bignonia venusta*. During March important pollen source was *Samanea saman* and *Bauhinia purpuria*. The bees collected pollen and nectar from coconut palm. The bees trapped more during windy season (July-August). They collected the sap oozing out from the shaved surface of the spadix during the commencement of tapping process which lasted for 10 days (Muthuraman *et al.*, 2002).

2.7 CROP POLLINATION BY STINGLESS BEES

Stingless bees are important pollinators of crops in tropical and subtropical parts of the world (Wille, 1965). Stingless bees are visitors to flowers of crop species in many parts of India but not in Punjab, which is outside their geographic range (Batra, 1967). Wind pollination does occur but fruit set is higher by stingless and little or no fruit set is obtained under selfing in Litchi (Pandey and Yadava, 1970). A saponaceous rainforest under stony tree in Costa Rica, *Lupania guatemalensis* is pollinated by *Trigona* sp. (Bawa, 1977). It was reported by Prance and Anderson (1976) that *T. spinipes* pollinates *Nymphaea ampla.* Roubik (1979) reported that in the low land neotropics 52 species of plants were visited by *Melipona* and 108 of the 128 species visited by other stingless bees. Species of *Trigona.* were the most abundant and effective pollinators of the androdioecious *Xerospermum intermeduim* (Appanah, 1982). It was observed by Bichee and Sharma (1988) that mean seed yields of 633 g / 30 plants by *T. iridipennis* pollinations were obtained in sunflower compared to 352 g / 30 plants of self pollination. The concept to enhance stingless bee pollination to crops by transferring colonies to artificial hives was reported by Heard (1988). According to Singh (1989) stingless bees are the most common insects visiting mango. It was reported by Pintandi *et al.* (1990) that the percentage of seeds obtained by natural pollination by *T. postica* was higher than the percentage obtained through artificial intraspecific self pollination. It was reported by Adejas *et al.* (1992) that in *Brassica napus* L. var. *oleifera*, *T. spinipes* resulted in significant yield increase of 799 pods/m^2 compared to 308 pods/m^2 of non insect pollination. Increase in average seed weight was also reported. It was reported by Macta *et al.* (1992) that *Nannotrigona testaceicornis* as most effective pollinators for economic fruit production.

Of the 13 Australian epiphytic orchids whose pollinators are confirmed, nine are pollinated by stingless bees (Adam and Lawson.

1993). Pollination requirement vary with crop species. More than 50 per cent of existing species of plants propagated by seeds are dependent upon insects for pollination (Mishra, 1995). It was reported by Maues and Venturieri (1995) that *Bixa orellana* (Bixaceae) is efficiently buzz pollinated by *Melipona melanoventer* and *Trigona* spp. Insects are needed to pollinate the protogynous flowers *Myrciaria dubia* (Myrtaceae). 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 includes *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 greenhouse crop was asserted by Woo *et al.* (1996). Melipona species accounts for 53.2 per cent of the visitors of male flowers in watermelon. For glasshouse pollination 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 influenced bee visit on various sterile male rows in sunflower.

2.8 STINGLESS BEE HONEY

Stingless bee honeys are produced in the tropic and have a good reputation in traditional medicine (Dold *et al.*, 1937). Honeys of *Melipona* are predominantly being made of nectar from flowers. But in *Trigona* it is not so. They have broad dietary habits. They use other materials such as fruit juice, honeydew, fungus and liquids from dead animals (Bruijin, 1993). *Trigona* bees produce meagre quantities of dense, darkish, sour honey upto a maximum of 100 ml / colony (Ramanujam *et al.*, 1993). *Trigona* visits small and poisonous flowers and produce honey which is heat producing and causes acidity and this is said to be the reason for its medicinal property (Kamal and Pulak, 1994). Ancient Indians used Trigona honey for wound, ulcers, kidney disorders and intestinal infection (Bruijin, 1996). It was reported by Boon (2002) that honey of stingless bees has been attributed with medicinal property due to resin chemical leached from storage pots within the hive, therefore the honey is sweet but strongly acidic and hence sour.

2.8.1 Physio-Chemical Composition of Honey

Antibacterial factor in honey was first identified by White *et al.* (1962) Kalimi and Sohonie (1965) reported that different vitamins are present in honey and these are thiamine, riboflavin, nicotinic acid, vitamin K, folic acid, biotin, pyridoxine, pantothenic acid, ascorbic acid and carotene. These vitamins decreased as storage period increased. It was reported by Abner and Mary (1966) that honey possessing significant diastase activity generally contain significant catalase activity. Also where honey has significant peroxide accumulation show low in catalase and vice versa. Phadke (1967) reported that difference in nectar source may account for the different properties of honey which account for high ash, acidity and protein. It was asserted by Phadke (1968) that *Trigona* honey do not granulate even after three years inspite of highly dissolved solids. Neto (1974) discriminated between various types of stingless bee honey on basis of flavour. It was reported by Gilliam (1979) that low pH and high sugar levels are important antibiotic factors. Honey of *T. iridipennis* found to be unifloral in origin, showed 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. It was asserted by Wakhle and Desai (1983) that the level of sucrose is a better indicator of natural honey than the HMF content and analysis of HMF content issued for honey sample which are low in enzyme content. Tan *et al.* (1989) reported that organic substances known as degraded carotenoids occur only in *Calluna vulgaris* honey and revealed that gas chromatography analysis of organic substances in a honey could assist in the identification of its floral origin. Honey production increases with increase in number of forager bees (Marceau *et al.*, 1990). It was reported by Oddo *et al.* (1990) 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 μg/g).

Vit (1992) asserted that stingless bee honey had higher value of moisture content and acidity. *Trigona* honey are highly resistant to unwanted fermentation (Crane, 1992). *Trigona* bees produce meagre quantities of dense, darkish and somewhat sour honey with a maximum of 100 ml/colony (Ramanujam *et al.*, 1993). Propolis from *T. angustula* showed antibacterial activity against *Bacillus subtilis,* staphylococus and micrococcus (Liska, 1994). Variation in honey enzyme activity has been shown to occur due to the amount of sucrose in food sources, rate of nectar flow and even age of bees (White, 1994). It was reported by Huidobro *et al.* (1995) that the diastase and invertase activity indicates freshness of honey. Specific gravity and refractive index are important properties. The most pleasing aroma composition of honeys are those with low boiling point which are most evanescent. Hydroxy methyl furfuryl 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 (μ moles P-nitrophenyl glucopyranoside/kg/ honey/minute) varied from 15.9 – 214.3 (Patricia and Patrizio, 1996).

Bruijin (1996) reported that stingless bees honey are 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). It was reported by Raakhee (2000) 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* was reported to be 24.17 per cent (Swaminathan, 2000).

2.9 PESTS AND DISEASES

George (1934) reported a species of *Megachile* which visited the nest of *T. iridipennis* and snatched wax from the entrance. It was asserted by Flechtmann *et al.* (1974) that a small whitish mite *Neotydeolus therapeutikos* was found on the comb in nests of *T. postica.* Simoes *et al.* (1980) reported that the endoparasite phorid fly, *Melaloncta sinistia* attacked the bee *Nannatrigona (Scaptotrigona) postica.* The larvae of phorid fly were found inside the abdomen of worker bees of *N. postica* and were not found in *A. mellifera* nor in other *Melipona* spp. It was reported by Anderson and Gibbs (1982) that *Trigona* pupae were infected with Kashmir bee virus. 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* from Brazil (Fain and Flechtman, 1985). Aggressive workers of *Ptilotrigona, Partamona* and *Trigona*, however do attack predators and large nest aggregation of two to three or to several dozens of colonies are often seen in *T. fuscobalteata, T. sapiens, Scaptotrigona luteipennis* and other *Partamona* spp. (Stare and Sakagami, 1987). 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). 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 of the natural enemies of stingless bees. Large animals like civets, bears, honey badgers, tamandus, tayras, primates, chimpanzees were also important enemies of stingless bees (Roubik, 1995). It was reported by Craig *et al.* (1996) that a large orb spinning spider *Nephila clavipes* feeds on *T. fluviventris* yellow webs and attracted and intercepted *T. fluviventris m*ore frequently than webs of any other colour. Five *Bacillus* species have been reported as being associated with stingless bee colonies of *T. hypogea* (Iaponte, 1996). Raakhee (2000) observed ants (*Solenopsis geminata*) entering the hives of weak colonies and robbing pollen stock.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present studies on management of stingless bees, *Trigona iridipennis* Smith (Meliponinae: Apidae) was carried out in the Department of Entomology, College of Agriculture, Vellayani.

3.1 EVALUATION OF HIVES

Healthy and disease free stingless bee colonies were procured from beekeepers during the month of July 2001 (Plate1 and 2) and maintained in the apiary. Three types of hives, wooden, earthen pot and bamboo each with four treatments having capacity T_1–25 x 10 x 15 cm (3750cc), T_2–20 x 10 x 15 cm (3000cc), T_3–15 x 10 x 15 cm (2250cc), and T_4–10 x 10 x 15 cm (1500cc) were used and three replications were maintained owing to a total of 36 colonies.

3.1.1 Wooden Box

Wooden boxes made of anjili (*Artocarpus hirsutus*) wood enclosing volume T_1–25 x 10 x 15 cm (3750cc), T_2 – 20 x 10 x 15 cm (3000cc), T_3 – 15 x 10 x 15 cm (2250cc), and T_4 – 10 x 10 x 15 cm (1500cc) were used (Plate 3). A lid was provided at the top and an entrance hole of diameter 8 cm at one end of the box near the bottom plank was provided for entry of bees (Plate 4). The boxes were hung on a suitable support at a preferable height.

3.1.2 Earthen Pot

Earthen pots enclosing volume T_1–25 x 10 x 15 cm (3750cc), T_2 – 20 x 10 x 15 cm (3000cc), T_3 – 15 x 10 x 15 cm (2250cc), and T_4 – 10 x 10 x 15 cm (1500cc) were used (Plate 5). A small hole of diameter 8 cm on one side served as the bee entrance. The pot was closed with a piece of wooden plank.

Plate 1 Healthy parent colony in a bamboo hive

Plate 2 Healthy stingless bee colony in earthen pot.

Plate 3 Wooden hives of different size for rearing *T.iridipennis*

Plate 4 Hive entrance of *T.iridipennis*

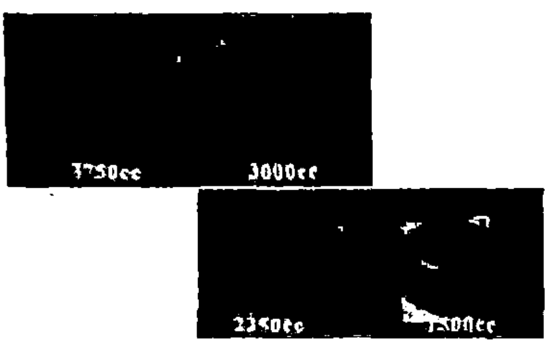


Plate 5 Earthen pots of different size for rearing *T.iridipennis*

Plate 6 Bamboo hives of different size for rearing *T.iridipennis*

3.1.3 Bamboo Hive

Bamboo bits split longitudinally into two equal semicircular halves enclosing volumes T_1–25 x 10 x 15 cm (3750cc), T_2–20 x 10 x 15 cm (3000cc), T_3–15 x 10 x 15 cm (2250cc), and T_4–10 x 10 x 15 cm (1500cc) were used (Plate 6). A small hole of diameter 8 mm on one side served as the bee entrance.

3.1.4 Brood Development

To each new hive approximately same volume of brood, pollen and honey pots were transferred from healthy colonies. The volume of brood, pollen and honey transferred to each hive were recorded. These new hives were maintained at the apiary. These divided colonies were used for the assessment of brood development by measuring the length, breadth and height of the brood at 15 days interval for a period of one year. The data was interpreted using split plot design.

3.1.5 Pollen Storage

The quantity of pollen stored by the bees were recorded by measuring the volume of the pollen storage in the hive. The pollen storage was measured by taking the length, breadth and height of the pollen stores at 15 days interval for a period of one year. The data was interpreted using split plot design

3.1.6 Population Buildup

The new daughter colonies were observed for the population buildup by recording the strength of the colony, presence of queen, presence of drones and presence of queen cell.

3.1.7 Honey Yield

Honey yield from 36 colonies was assessed. The honey was extracted by exposing the honey pots in the sun. The volume of honey stored were measured by taking the length, breadth and height of the honey pots at 15 days interval for a period of one year. The data was interpreted using split plot design.

3.2 FEASIBILITY OF REUSE OF EXTRACTED HONEY POTS IN THE HIVE

Five healthy colonies were selected for assessing the feasibility of reuse of honey pots in the hive. Two methods were followed. In the first method the honey was extracted by transferring the honey storage pots to a tray and exposing the same to sunlight. The emptied honey pots were collected intact and transferred to hives to assess its reuse by the bees. In the second method about 10 honey pots were selected per colony and were uncapped using a needle (5 cm long). The honey was extracted using a syringe without needle. To demarcate the used honey pots a glass bangle (5 cm diameter) was placed around. This uncapped honey extracted honey pots were kept and observed daily for assessing the reuse by the bees.

3.3 FORAGING ACTIVITY

Ten standard colonies were selected for the foraging activity studies. The foraging activity was recorded from 0600 h to 1800 h at biweekly intervals. The number of incoming foragers (nectar and pollen gatherers) were observed over a five minutes period at the entrance of the hive. Bees incoming with yellow colour pollen load hanging on to their legs with in the pollen baskets were considered as pollen collectors and those incoming foraging bees with out pollen load were considered to be nectar gatherers. The observations were carried out for a period of one year.

3.3.1 Flora Visited by the Bees

To identify the major flora visited by bees, the flora encountered by the bees either for pollen or nectar or for both were observed regularly in and around the campus and documented. The pollen collected by bees were recorded by the presence of pollen load on their legs. The foragers without pollen loads were considered to be nectar gatherers.

3.4 CHEMICAL ANALYSIS OF HONEY COLLECTED FROM DIFFERENT TRACTS

Twenty two honey samples (Table1) were collected from different tracts of Kerala and subjected for chemical analysis. Each samples maintained at five replications were analysed for acidity, sugars, ash, specific gravity, refractive index, moisture content, specific heat and PH. Mostly the method of analysis of the Association of the Official Agricultural Chemists of U.S.A (A.O.A.C,1975) were employed except for specific gravity where specific gravity bottle method was followed.

3.4.1 Acidity

Ten grams of honey was dissolved in 50 ml distilled water and mixed thoroughly. Boiled for 10- 15 minutes and volume was made upto 100 ml. From this 100 ml solution, 25 ml was taken in a conical flask, four to six drops of phenolphthalein indicator was added and titrated against standard NaOH (IN). Blank was determined using water instead of honey. Acidity was calculated as follows :

Acidity (as formic acid) in 100 g honey (per cent)

$$= T.V. \times N \times 0.023 \times \frac{100}{25} \times 100$$

where, V = Volume of sodium hydroxide used

N = Normality of sodium hydroxide

W = Weight (gram) of the sample

Table 1 Stingless bee samples collected from different districts of Kerala

Sample Number	Place of collection
H–1	Chengala (Kottayam)
H–2	Edamattam (Kottayam)
H–3	Pathanamthitta
H–4	Ranni (Pathanamthitta)
H–5	Mallapally (Pathanamthitta)
H–6	Pazhumpara (Pathanamthitta)
H–7	Kollengode (Palakkad)
H–8	Mannarkad
H–9	Vadakkekara (Mannarkad)
H–10	Karakulam (Palakkad)
H–11	Karamukku (Thrissur)
H–12	Arimboor (Thrissur)
H–13	Chullimanoor (Thiruvananthapuram)
H–14	Panayamuttam (Thiruvananthapuram)
H–15	Menangal (Thiruvananthapuram)
H–16	Thiruvaniyoor (Ernakulam)
H–17	Mamala (Ernakulam)
H–18	Rallanikkal (Ernakulam)
H–19	Pazhukkamatta (Ernakulam)
H–20	Pammakuda (Ernakulam)
H–21	Thoppumpadi (Ernakulam)
H–22	Choondi (Ernakulam)

3.4.2 Sugars

3.4.2.1 Total Reducing Sugars

Five ml of fehlings solution A and B was taken in a 250 ml volumetric flask. 50 ml of distilled water was added and the contents were boiled. Ten gram of honey was taken in a beaker and dissolved with distilled water. The volume was made upto 200 ml. From this 50 ml was pipetted out into another 100 ml volumetric flask and this was taken in the burette. Using methylene blue indicator titration was carried out. The total volume of honey solution used up for titration was noted by colour change from blue to brick red. This would account for the percentage of total reducing sugars.

$$\text{Total reducing sugar (before inversion)} = \frac{2 \times 40 \times 25}{2 \times \text{Titrated value}}$$

3.4.2.2 Sucrose Percentage

Ten gram of honey was weighed and dissolved in distilled water. The volume was made up to 200ml. 50 ml of this solution was pipetted out into an another 100 ml volumetric flask and 1 ml HCl (6.34 N) was added. The contents was kept on a water bath at 60^0C for 10 minutes. The flask was cooled and neutralized with saturated NaOH solution .The volume was made up to 100 ml and was used for titration by taking it in a burette.

Five ml each of fehlings solution A and B was taken in a 250 ml volumetric flask. 50 ml distilled water was added and the contents were boiled. Using methylene blue indicator this was titrated. The colour change from blue to brick red marked the end point of titration. Total volume of honey solution used for titration was recorded and the percentage of total reducing sugars (after inversion) was calculated.

$$\text{Total reducing sugars (after inversion)} = \frac{2 \times 40 \times 25}{2 \times TV}$$

$$\text{Sucrose percentage} = \left[\text{Total reducing sugars after inversion} - \text{Total reducing sugar before inversion} \right] \times 0.95$$

3.4.2.3 Fructose Glucose Ratio

From the original solution (2 ml – 200 ml) 20 ml of honey solution was pipetted out into 500 ml stoppered flask. 40 ml iodine (0.05 N) solution and 25 ml of 0.1 N NaOH was added and placed over water bath (20^0C) for exactly 10 minutes. The solution was acidified with 5 ml of 2 N H_2SO_4 and titrated against (0.05 N) $Na_2S_2O_3$ using starch as indicator. A blank was also conducted using 20 ml of water instead of honey. The fructose / glucose ratio was calculated using the formula:

$$\text{Glucose (per cent)} = \frac{B - S \times 0.4502}{0.2} = W$$

where, B = Volume of $Na_2S_2O_3$ solution required for blank

S = Volume of $Na_2S_2O_3$ solution required for sample

$$\text{Fructose (per cent)} = \frac{\text{TRS BI (before inversion)} - \text{Glucose}}{0.925} = X$$

$$\text{True glucose} = \text{Glucose} - (0.012 \times \text{fructose}) = Y$$

$$\text{True Fructose} = \frac{\text{TRS BI} - \text{True glucose}}{0.925} = Z$$

$$\text{Fructose/glucose ratio} = \frac{\text{True glucose}}{\text{True fructose}} = \frac{Z}{Y}$$

3.4.3 Ash

Five gram of honey was weighed accurately into an ignited and preweighed silica dish and gently boiled until the sample solidified. The sample was then kept in a muffle furnace at 500°C for 3 hours and ignited till white ash was obtained.

$$\text{Ash (per cent)} = \frac{100\,(W_2 - W)}{W_1 - W}$$

where, W_1 = weight in gram of dish with sample

W_2 = weight in gram of dish with ash

W = weight in gramof empty dish

3.4.4 Specific Gravity (Specific Gravity Bottle Method)

The specific gravity bottle was cleaned thoroughly dried and weighed. Freshly boiled and cooled distilled water was filled up to the mark and again weighed. Subsequently water was removed and again the bottle was dried and filled with honey sample and weighed. Specific gravity was calculated using the formula:

$$\text{Specific gravity at } 27^0\text{C} = \frac{C - A}{B - A}$$

Where, C = weight in gram of the specific gravity bottle.

A = Weight in gram of the empty specific gravity bottle

B = Weight in gram of the specific gravity bottle with water.

3.4.5 Refractive Index

Refractive index of honey samples was measured using an Abbe's refractometer.

3.4.6 Moisture Content

Twenty five gram of honey was taken in a clean and dry petridish. The petridish was then kept in a hot air oven maintained at 100 degree celcius over night and cooled in a dessicator. The heating cooling and weighing was continued until the honey attained a constant weight.

Moisture content was determined as follows

Initial weight of honey =A

Final weight of honey =B

Percent dry weight=B/A x 100 = C

∴ moisture content (D) = 100 – C

3.4.7 Specific Heat

The apparatus employed consists of a heater, made of heavy sheet iron forming an air bath with double walls. The bottom forms a movable door, in which opens two tubes for carrying a thermometer and a gas regulator. An arm is fixed carrying a hook to which is attached a fine wire to support the body to be heated and passing freely into the heating chamber. A movable wire gauge aids in regulating the temperature. A calorimeter formed of two vessels is fixed to a sliding base, which permits it to be brought under the air bath at the proper moment. To bring the heated sample into the calorimeter the wire gauze is removed and with one hand the calorimeter is shoved under the air bath by which motion the movable bottom is opened by the peg; with the other hand the wire holding the sample is cut allowing the sample to fall into the calorimeter. The temperature of the water in the calorimeter and the water value of the whole apparatus is obtained in this manner. The honey samples are conveniently held in light glass stoppered bottles. The heat value of the bottle and attached wire are determined and allowance made therefore in the calculation. The specific heat is calculated using the formula

$$S = (P + P_c + P_t)(\tau - t) - P_g \cdot S(T - \tau)$$

Where, P = weight (gram)of water in calorimeter

P_c = water value of calorimeter

P_t = water value of thermometer

τ = end temperature of calorimeter

t = beginning temperature of calorimeter

P_g = weight (gram)of glass container

S = water value of container

T = Constant temperature of air bath

3.4.8 PH

Ten grams of honey was dissolved in 100 ml double distilled water. The pH of the solution was determined with an ELICO pH meter having a combination electrode at 27°C.

3.4.9 Statistical Analysis

The data obtained on analysis of 22 samples with five replication was subjected to statistical analysis by applying the technique of analysis of variance using CRD and pair wise comparison of treatments was followed wherever significant difference existed.

3.5 PESTS AND DISEASES

When the hives were opened to record the observations, they were frequently observed for the presence of any attack of pest or disease. In addition to it, during frequent visit to the apiary, the hives were examined for any pest and disease incidence.

RESULTS

4. RESULTS

The results obtained from different experiments are presented in this chapter.

Parent colonies procured from different beekeepers were transferred into different hives, viz., wooden box, earthen pot and bamboo and maintained in the apiary of College of Agriculture, Vellayani. Each hives were maintained under four treatments i.e., T_1 : 3750cc, T_2 : 3000cc, T_3 : 2250cc and T_4 : 1500cc with three replications each. The divided colonies took a month to get established well. As the colony developed the bees built a entrance tube lined with wax and cerumen through which the bees oriented into the hives (Plate 7). The bees sealed up all the exposed portion of the hives defending themselves against the intruders. New building material are produced by depositing wax and a kind of resin brought in by the foragers and are dumped very near to the exit of the hive (Plate 8). This stored resins are taken to the wax deposit and mixed. This mixture of building material is used to build new brood cells. In some of the colonies the entire colony was surrounded by involucrum (Plate 9). As queen developed in the newly established colony (Plate 10) the area of the brood gradually increased. New cells are started only after the prior cells are provisioned with the larval food (Plate 11). Cells are built one by one. The brood cells are constructed in cluster form (Plate 12) are made of cerumen, suspended and separated by connectives and pillars. When the young bee hatches out, the broken cells were distinguished from the younger brood by their lighter colour (Plate13).

Plate 7 Hive entrance of a feral colony in a cement wall.

Plate 8 Resin dumps inside the hive.

Plate 9 Involucrum seen in stingless bee colony

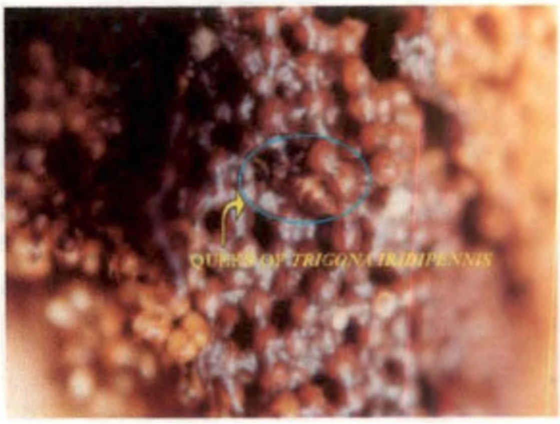


Plate 10 Queen of *Trigona iridipennis*

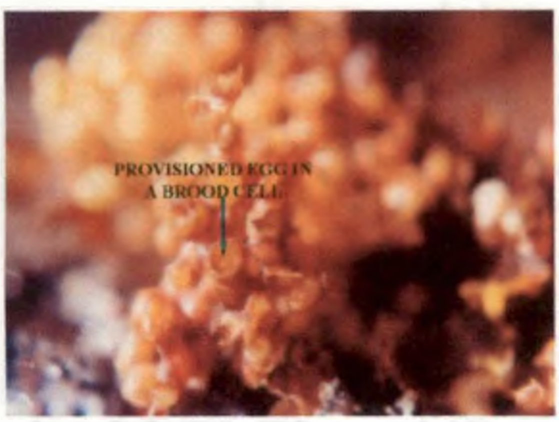


Plate 11 Provisioned egg in a brood cell.

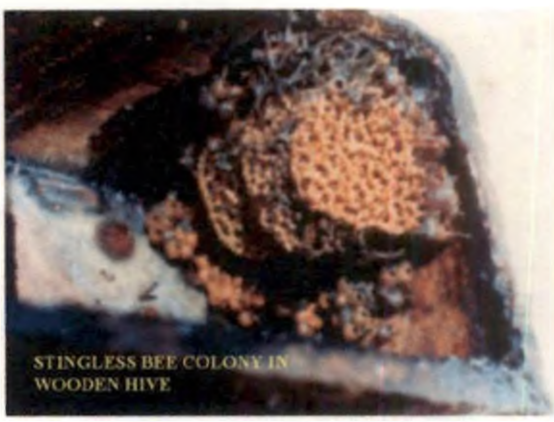


Plate 12 Different layers of brood cluster in a wooden hive.

4.1 EVALUATION OF HIVES *VIZ.*, WOODEN BOX, EARTHEN POTS AND BAMBOO BITS OF DIFFERENT SIZES

4.1.1 Brood Development

The data pertaining to the mean brood development of stingless bee *T. iridipennis* in the divided colonies maintained in wooden hives, bamboo hives and earthen pots each with four different capacities in three replication each are presented in Table 2 and illustrated in Fig. 1. The mean volume of brood transferred to, wooden hive, earthen pots and bamboo hive are 183.3 cm^3, 194.8 cm^3 and 189.5 cm^3, respectively. The brood development in each hive was observed for a period of one year.

4.1.1.1 Wooden Hive

4.1.1.1.1 Monthly Variations in Brood Development

The mean volume of brood transferred to wooden hives was 192 cm^3, 172.66 cm^3, 174.66 cm^3 and 194.00 cm^3 in hives with volume 3750cc, 3000cc, 2250cc and 1500cc respectively during July 2001. Brood volume gradual increased from December 2001 and it was observed that the volume of brood was maximum during the month of February (250.83 cm^3) which was on par with development during March (246.50 cm^3). Mean brood development of 224.75 cm^3 was recorded during the month of April 2001. Brood development during the month of May 2001 (225.33 cm^3) was shown to be on par with brood development during June 2001 (230.00 cm^3). Mean brood development during January 2002 (180.58 cm^3) was shown to be on par with the mean brood development during July (183.33 cm^3) and August (183.50cm^3). Brood development was least during the month of September (156.16 cm^3), October (145.91 cm^3) and November (141.08 cm^3).

Table 2 The mean monthly brood development of *T. iridipennis* in different hives

Sl. No.	Month	Treatment	Wooden, cm^3	Earthen pot, cm^3	Bamboo, cm^3
1.	July	T_1	192.00	193.00	182.00
		T_2	172.66	201.33	188.00
		T_3	174.66	208.00	203.00
		T_4	194.00	177.00	185.33
	Mean		183.33	194.83	189.58
2.	August	T_1	178.66	166.66	176.00
		T_2	191.33	162.66	172.00
		T_3	182.00	182.00	156.00
		T_4	182.00	172.66	182.00
	Mean		183.50	171.00	171.50
3.	September	T_1	149.00	167.00	163.33
		T_2	154.00	158.00	163.33
		T_3	158.00	161.33	161.66
		T_4	163.66	160.00	165.33
	Mean		156.16	161.58	163.41
4.	October	T_1	138.00	147.33	141.33
		T_2	143.33	140.66	138.66
		T_3	151.00	145.33	133.33
		T_4	151.33	153.00	148.00
	Mean		145.91	146.58	140.33
5.	November	T_1	138.00	147.33	150.33
		T_2	143.00	151.66	148.00
		T_3	139.66	154.66	142.66
		T_4	143.66	150.33	151.66
	Mean		141.08	151.00	148.16
6.	December	T_1	157.00	167.66	165.33
		T_2	164.00	162.66	165.00
		T_3	167.66	175.00	176.00
		T_4	165.33	165.33	176.00
	Mean		163.50	167.66	170.75
7.	January	T_1	180.00	177.33	188.33
		T_2	176.00	172.33	176.00
		T_3	184.00	182.33	172.33
		T_4	182.33	188.33	190.66
	Mean		180.58	180.08	181.83
8.	February	T_1	250.00	261.33	266.66
		T_2	238.33	258.33	253.33
		T_3	253.33	250.33	268.00
		T_4	261.66	262.66	274.00
	Mean		250.83	258.08	265.50

Table 2 Continued

Sl. No.	Month	Treatment	Wooden (cm^3)	Earthen pot (cm^3)	Bamboo (cm^3)
9.	March	T_1	246.66	259.33	249.33
		T_2	256.00	251.33	246.66
		T_3	240.00	256.66	246.66
		T_4	243.33	258.33	250.00
	Mean		246.50	256.41	248.16
10.	April	T_1	220.66	233.33	230.00
		T_2	223.33	236.00	230.00
		T_3	221.66	240.00	240.00
		T_4	233.33	238.00	241.33
	Mean		224.75	236.83	235.33
11.	May	T_1	198.66	223.33	230.66
		T_2	196.66	210.66	217.33
		T_3	234.00	206.66	216.66
		T_4	224.66	216.66	236.66
	Mean		225.33	214.33	225.33
12.	June	T_1	230.00	233.33	230.00
		T_2	230.00	220.00	230.00
		T_3	223.33	220.00	223.33
		T_4	236.66	222.33	236.66
	Mean		230.00	225.66	230.00

Significant at .05 level

CD (hives) – 2.760

CD (treatments) – 3.187

CD (Interaction between hives and treatments) – 5.520

CD (Monthly variations) – 7.369

CD (Interaction between hives and monthly variation) – 12.673

CD (Interaction between treatments and monthly variation) – 14.737

CD (Interaction between hive, treatments and monthly variation) – 25.526

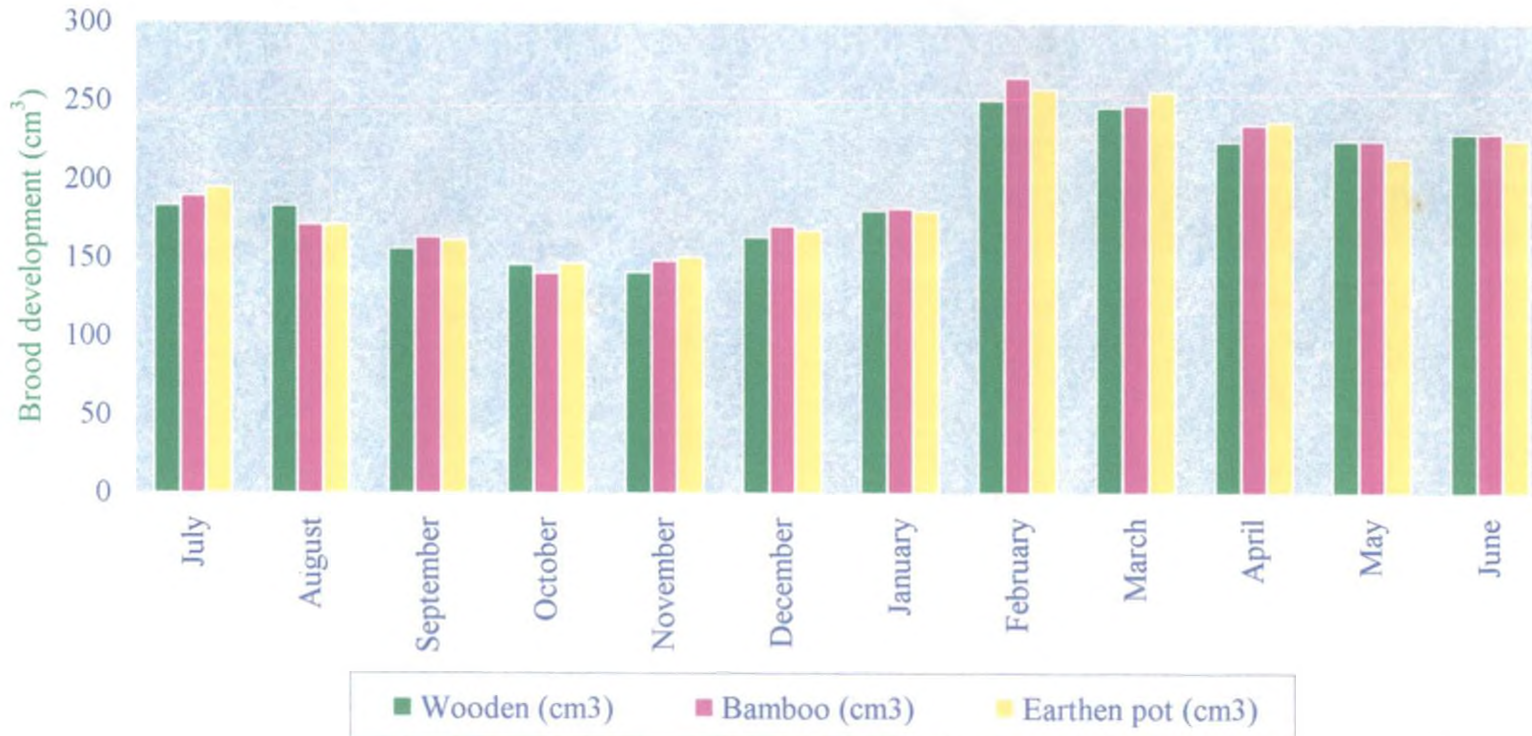


Fig. 1 Mean monthly brood development of *T. iridipennis* in different hives

4.1.1.1.2 Superior Hive Capacity

The brood development in different hive capacities varied in different months. During the month of February when the brood development was maximum, wooden hive having capacity 1500cc showed maximum brood development (261.66 cm^3) which was on par with wooden hive (3750cc) with brood development (246.66 cm^3), wooden hive (3000cc) with brood development (256.00 cm^3) and wooden hive (2250cc) with brood development (240.00 cm^3) during the month of March and wooden hive (2250cc) with mean brood development (223.33 cm^3) during June. Wooden hive (1500cc) during the month of June with mean brood development 236.66 cm^3 was on par with wooden hive (2250cc) with brood development (234.00 cm^3), wooden hive (1500cc) with mean brood development (224.66 cm^3) during may and brood development of 220.66 cm^3, 223.33 cm^3, 221.66 cm^3, 233.33 cm^3 in wooden hive 3750cc, 3000cc, 2250cc and1500cc respectively during April. Brood development was least during September, October and November. Hives with capacity 3750cc and 3000cc showed least development compared to other hives with capacity 2250cc and 1500cc during brood rearing season.

4.1.1.2 Earthen pot

4.1.1.2.1 Monthly Variation in Brood Development

The mean volume of brood transferred to earthen hives was 193 cm^3, 201.33 cm^3, 208 cm^3, 177 cm^3 in hives with volume 3750cc, 3000cc, 2250cc and 1500cc respectively during July 2001. A gradual increase in brood development was noticed from November and maximum brood development was noticed during the month of February (258.08 cm^3) which was on par with the brood development during March (256.41 cm^3) and April (236.83 cm^3). Mean brood development during April (236.83 cm^3) was on par with the mean brood development during June (225.66 cm^3). Brood development was least during the month of October (146.58 cm^3)

which was on par with the brood development during November (151.00cm^3).

4.1.1.2.2 Superior Hive Capacity

The mean brood development in different capacities varied under different months. Maximum brood development of 262.66 cm^3 was noticed during February in earthen pot having capacity 1500 cc which was on par with earthen pot 3750cc, 3000 cc and 2250 cc having brood development of 261.33 cm^3, 258.33 cm^3 and 250.33 cm^3 respectively. This was on par with the mean brood development of 259.33 cm^3, 251.33 cm^3, 256.66 cm^3, 258.33 cm^3 during March in hives having capacity 3750 cc, 3000 cc, 2250 cc and 1500 cc respectively and earthen pot (2250cc) with brood development of 240 cm^3, earthen pot (1500cc) with brood development of 230 cm^3 of April. Brood development was comparatively less in earthen pot with volume 3000cc and 2250cc during brood rearing season.

Interaction between hives with different capacities under different months reveals that among the different types of hives used, bamboo showed better response to brood development. Wooden hives revealed comparatively less response to brood development. Considering the monthly brood development, a gradual increase in brood development was noticed from November with a peak period during February and least during October. Among the different types of hives used with different volumes, statistical analysis revealed that bamboo hive with capacity 1500cc revealed better response to brood development than hives having capacities 3000cc, 2250cc and 3750cc.

4.1.1.3 Bamboo Bit

4.1.1.3.1 Monthly Variation in Brood Development

The mean volume of brood transferred to bamboo hive was 182 .00cm^3, 188.00 cm^3, 185.33 cm^3 and 203 cm^3 in hives with volume

3750cc, 3000cc, 2250cc and 1500cc respectively. Brood development showed a gradual increase from November and maximum development was noticed during the month of February (265.50 cm^3). Brood development was comparatively good during the month of March (248.16 cm^3). Mean brood development during the month of April was 235.33 cm^3 which was on par with the mean brood development during the month of May (225.30 cm^3) and June (230 cm^3). Mean brood development was least during the month of October (140.33 cm^3) which was on par with the development during November (148.16 cm^3).

4.1.1.3.2 Superior Hive Capacity

The mean brood development in different hives with different capacities varied under different months. Brood development was maximum in hives with capacity 1500cc during February (274.00 cm^3) when the brood development was at its peak. Bamboo hive (3750cc) with mean brood development (266.66 cm^3) was shown to be on par with bamboo hive (3000cc) with mean brood development (253.33 cm^3), bamboo hive (2250cc) with mean brood development (268 cm^3) of February. This was on par with bamboo hive (1500cc), bamboo hive (3000cc), bamboo hive (2250cc) and bamboo hive (3250cc) of March having brood development of 250 cm^3, 246.6 cm^3, 246.6 cm^3 and 249.33 cm^3 respectively. Brood development was least during the month of October (140.33 cm^3) and November (148.16 cm^3)

4.1.2 Pollen Storage

The data pertaining to the pollen storage of stingless bee *T. iridipennis* in the experimental colonies having different capacities 3750cc, 3000cc, 2250cc and 1500cc with three replications are presented in Table 3 and the mean monthly variation in pollen storage in different hives are illustrated in Fig. 2. The mean volume of pollen transferred to wooden hive, earthen pot and bamboo hive are 16.5 cm^3, 18 cm^3 and 18 cm^3 respectively. The

Table 3 The mean monthly Pollen storage of *T. iridipennis* in different hives

Sl. No.	Month	Treatment	Wooden (cm^3)	Earthen pot (cm^3)	Bamboo (cm^3)
1.	July	T_1	18.00	18.00	18.00
		T_2	16.00	18.00	18.00
		T_3	14.00	18.00	18.00
		T_4	18.00	18.00	18.00
	Mean		16.5	18.0	18.0
2.	August	T_1	24.00	21.00	21.00
		T_2	24.00	18.00	24.00
		T_3	18.00	24.00	18.00
		T_4	21.00	24.00	24.00
	Mean		21.75	21.75	21.75
3.	September	T_1	25.33	28.33	25.33
		T_2	27.00	26.00	26.00
		T_3	26.00	27.00	26.00
		T_4	25.00	26.00	28.00
	Mean		25.83	26.83	26.33
4.	October	T_1	32.66	30.00	32.66
		T_2	30.00	30.66	32.00
		T_3	30.66	32.00	30.00
		T_4	32.66	31.33	34.00
	Mean		31.33	31.66	32.16
5.	November	T_1	41.33	43.33	43.33
		T_2	43.33	42.66	44.00
		T_3	42.66	44.00	44.00
		T_4	46.00	42.66	44.66
	Mean		43.33	43.16	44.00
6.	December	T_1	50.00	53.33	52.00
		T_2	50.00	51.33	53.33
		T_3	50.66	53.33	52.66
		T_4	54.00	53.33	53.33
	Mean		51.17	52.33	52.83
7.	January	T_1	54.66	60.00	61.33
		T_2	58.00	62.66	62.00
		T_3	60.00	62.66	62.66
		T_4	64.00	60.00	64.00
	Mean		59.16	61.33	62.50
8.	February	T_1	61.33	66.66	66.66
		T_2	64.00	69.33	66.66
		T_3	66.66	69.33	69.33
		T_4	72.00	66.66	72.00
	Mean		66.00	68.00	68.66

Table 3 Continued

Sl. No.	Month	Treatment	Wooden (cm^3)	Earthen pot (cm^3)	Bamboo (cm^3)
9.	March	T_1	54.00	52.00	54.00
		T_2	55.33	55.33	52.66
		T_3	54.00	52.00	52.66
		T_4	52.66	53.33	56.00
	Mean		54.00	53.16	53.83
10.	April	T_1	48.00	42.00	48.66
		T_2	49.33	47.33	48.66
		T_3	47.33	48.66	47.33
		T_4	45.33	45.33	49.33
	Mean		47.50	45.83	48.50
11.	May	T_1	42.00	38.66	39.33
		T_2	39.33	42.66	38.66
		T_3	37.33	40.00	39.33
		T_4	40.00	40.66	40.00
	Mean		39.66	40.50	39.33
12.	June	T_1	43.66	40.00	39.33
		T_2	42.66	43.33	41.33
		T_3	40.00	43.00	42.00
		T_4	42.00	43.33	42.33
	Mean		42.68	42.41	41.25

	CD
Hive	0.978
Treatments	1.130
Interaction between hive and treatments	1.956
Monthly variations	1.401
Interaction between hive and month	2.427
Interaction between treatments and month	2.802
Interaction between hive, treatment and month	4.853

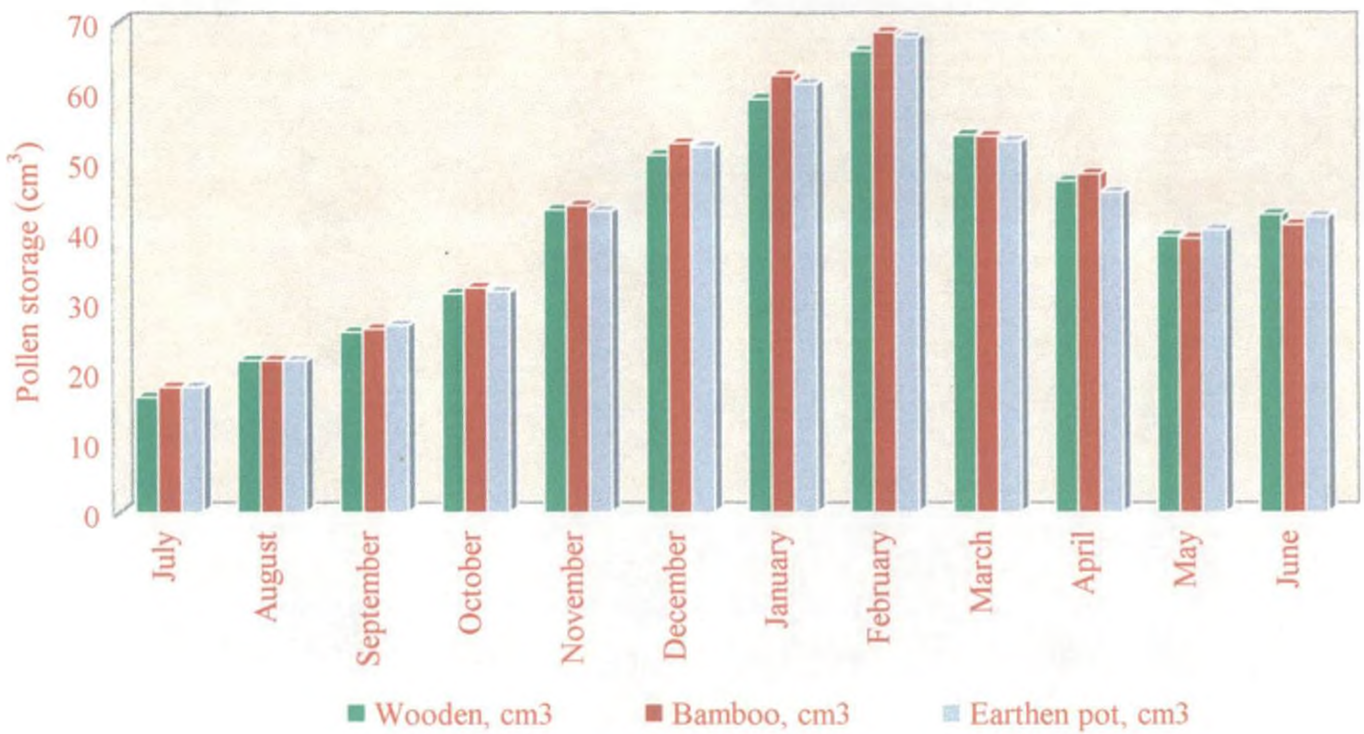


FIg. 2 Monthly pollen storage of *T. iridipennis* in different hives

extent of pollen storage in each hive was observed for a period of one year. Pollen stores (Plate14) were larger than honey stores. The number of pollen pots in unit area and measurement in different hives were observed and it was observed that 15 pollen cells were present in an area 4 cm^2 and average weight of pollen storage per pot was 0.25 g. The average diameter of pollen pot varied from 7.0 – 7.3 mm with mean of 7.1 mm. Similarly mean height was 9.43 mm.

4.1.2.1 Wooden Hive

4.1.2.1.1 Monthly Variations

The mean volume of pollen transferred to each hive having capacity 3750cc, 3000cc, 2250cc and 1500cc was 18 cm^3, 16 cm^3, 14 cm^3 and 18 cm^3 respectively. Pollen storage gradually increased soon after division and during the month of February, maximum storage (66.6 cm^3) was noticed. There was a gradual decrease in the pollen storage (39.66 cm^3) until May and again pollen storage increased from June (42.68 cm^3).

4.1.2.1.2 Superior hive capacity

The mean pollen storage in different hive capacities showed that all treatments were on par with each other except wooden hive with volume 3750cc. When interaction between the treatments and months were taken wooden hive (2250cc) with pollen storage of 66 $cm^3$and wooden hive (1500cc) with pollen storage of 72 cm^3 showed better hive capacity with maximum pollen storage.

4.1.2.2 Earthen Pot

4.1.2.2.1 Monthly variations

Pollen storage gradually increased and maximum storage was noticed during the month of February (68.00 cm^3). There was a gradual decrease thereafter till May (40.50 cm^3) and again increased during June (42.41cm^3).

4.1.2.2.2 Superior hive capacity

The mean pollen storage in different capacities were shown to be on par with each other. When interaction between the hives and months were taken earthen pot with volume 3000cc and 2250cc showed maximum pollen storage.

Statistical analysis revealed that of the different hive capacities used bamboo hive with volume 2250cc and 1800cc showed maximum pollen storage. Pollen storage was found to be maximum during the month of February.

4.1.2.3 Bamboo Hive

4.1.2.3.1 Monthly variation

Pollen storage gradually increased and maximum storage was noticed during the month of February (68.66 cm^3). There was a gradual decrease in the pollen storage thereafter till May (39.33 cm^3) and again increased during June (41.25 cm^3).

4.1.2.3.2 Superior hive capacity

When interaction between the hives and months were taken bamboo hive (2250cc), bamboo hive (1500cc) showed maximum pollen storage of 72 cm^3 during February. During all the months bamboo hive with capacity 1500 cc was shown to have maximum pollen storage than with capacity 3750cc, 3000cc and 2250cc.

4.1.3 Population Buildup

The experimental colonies were analysed for the population buildup. The colonies took a month to get established well. The bee strength remained less for the first two months thereafter the colony got established well. Presence of queen cells were noticed from November to March. The average number of queen cells per colony was at the range of 5-22 (Table 4). Drones were also seen during this time. After this period the colony showed remarkable buildup of population. There was a slight decline in the population buildup during June. Queen cells were larger in size than worker brood cells (Plate 15). They were found intermixed with worker brood cells. The average height and diameter of queen cells was 4.5 mm, 4mm respectively.

The *Trigona* usually construct an entrance tube for making easy entry of the bee inside the hive. A group of 5 - 9 guard bees were present at the entrance to defend the nest against intruders. It was observed that nests with wider entrance had more number of guard bees. Task allocation (Fig. 3) is very significant in that 8.00 per cent guard bees were seen involved in guarding. 44.00 per cent of the total population were involved in foraging, 22.00 per cent worked on brood comb, 10.00 per cent were involved in ripening of honey, 8.00 per cent on removal of wastes and 8.00 per cent working with cerumen.

4.1.4 Honey Storage

The data pertaining to the honey storage of stingless bee *T. iridipennis* in the divided colonies maintained in different hives with capacity 3750cc, 3000cc, 2250cc and 1500cc with three replication are presented in Table 5 and the mean monthly variation in honey storage in different hives are illustrated in Fig. 4. The mean volume of honey transferred to wooden hive, earthen pot and bamboo hive were 24.5 cm^3, 24.08 cm^3 and 23.66 cm^3 and respectively. The extent of honey storage in

Table 4 Average number of queen cells / colony

Treatment	Replication	November			December			January			February			March		
		W	E	B	W	W	E	B	E	B	W	E	B	W	E	B
T_1	R_1	Nil	Nil	Nil	4	Nil	Nil	Nil	6	Nil	Nil	Nil	Nil	Nil	Nil	8
	R_2	Nil	6	3	Nil	Nil	Nil	9	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	R_3	Nil	Nil	Nil	Nil	8	Nil	Nil	Nil	5	Nil	Nil	Nil	2	Nil	Nil
T_2	R_1	Nil	Nil	Nil	Nil	5	Nil	Nil	Nil	Nil	9	Nil	Nil	Nil	Nil	11
	R_2	Nil	10	Nil	Nil	Nil	16	6	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	R_3	Nil	Nil	14	8	Nil	Nil	Nil	15	Nil	Nil	Nil	Nil	Nil	Nil	Nil
T_3	R_1	22	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	12	10
	R_2	Nil	Nil	12	Nil	Nil	Nil	Nil	Nil	Nil	20	22	Nil	Nil	Nil	Nil
	R_3	Nil	11	Nil	Nil	Nil	Nil	19	Nil	18	Nil	Nil	Nil	Nil	Nil	Nil
T_4	R_1	Nil	14	22	14	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
	R_2	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	18	18	20	Nil	Nil	Nil	Nil
	R_3	Nil	Nil	Nil	16	Nil	18	Nil	Nil	Nil	Nil	20	Nil	Nil	Nil	Nil

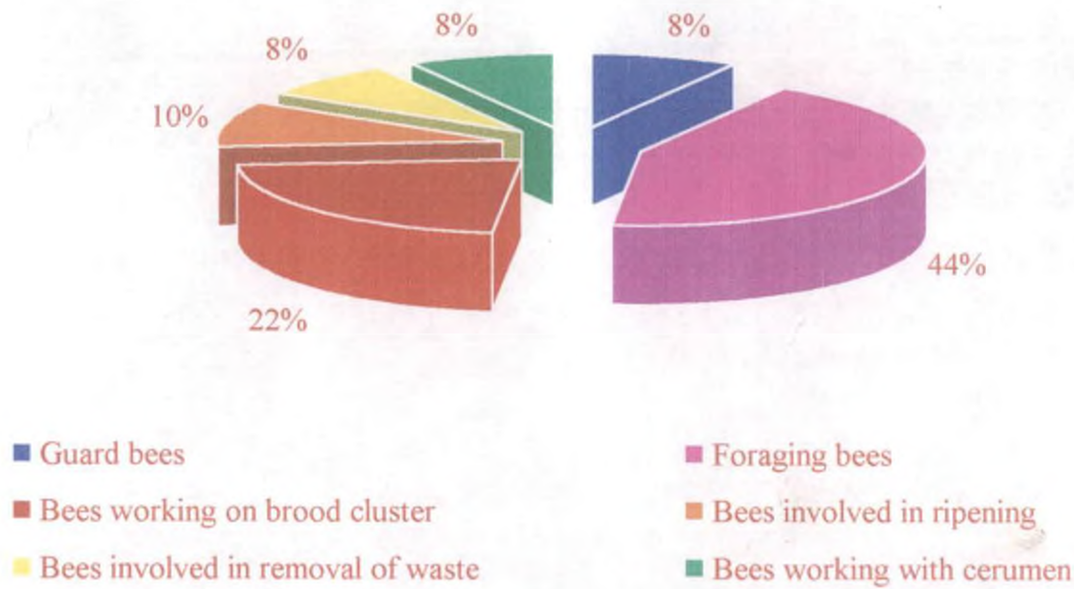


Fig. 3 Percentage task allocation of bees

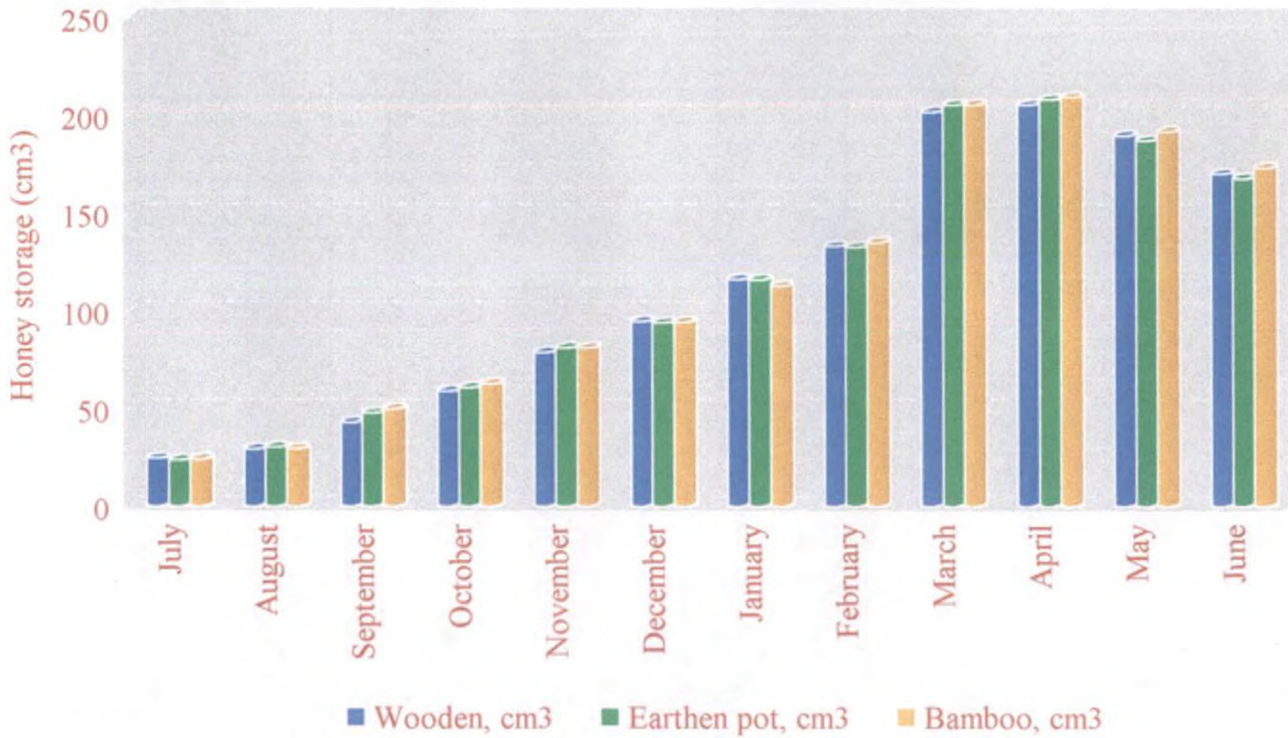


Fig. 4 Mean monthly honey storage of *T. iridipennis* in different hives

each hive was observed for a period of one year. The number of honey pots in unit area and measurements (height, diameter, quantity) in different types of hives were recorded and average honey yield obtained is presented in Table 6. The honey pots filled with honey (Plate 16) were formed in clusters (Plate 17). The honey was harvested by exposing the honey pots in sun light (Plate 18). The average diameter of honey pot was recorded as 0.95 cm in bamboo, 0.91 cm in earthen pot and 0.93 cm in wooden hive. The height of the honey pots ranged from 0.70-0.90 cm with mean value of 0.90 cm in bamboo hive, 0.70 cm in earthen pot and 0.80 cm in wood hive. An average of 15 cells were present in an area of 4 cm^2. Average quantity of honey per pot ranged from 0.40 to 0.50 ml, while honey yield per hive ranged from 120 – 350 ml. Maximum honey yield of 350 ml per hive was recorded in bamboo hive having capacity 1500 cc.

4.1.4.1 Wooden Hive

4.1.4.1.1 Monthly Variations

A gradual increase in honey storage was noticed as the colony got established. The established colonies were divided during the month of July 2001 and approximately equal volume of honey 24.50 cm^3, 25 cm^3, 25 cm^3, 24 cm^3 was transferred to each hive having capacity 3750cc, 3000cc, 2250cc and 1500cc respectively. By April 2002 the mean volume of honey was found to be increased to 201.33 cm^3, 201.33 cm^3, 204.66 cm^3 and 208 cm^3 in hives having capacity 3750cc, 3000cc, 2250cc and 1500cc respectively.

4.1.4.1.2 Superior hive capacity

The quantity of honey storage in each hive varied in different months. During the month of March and April maximum honey storage of

Plate 13 Stages of brood
a) Mature brood
b) Intermediate stage
c) Young brood

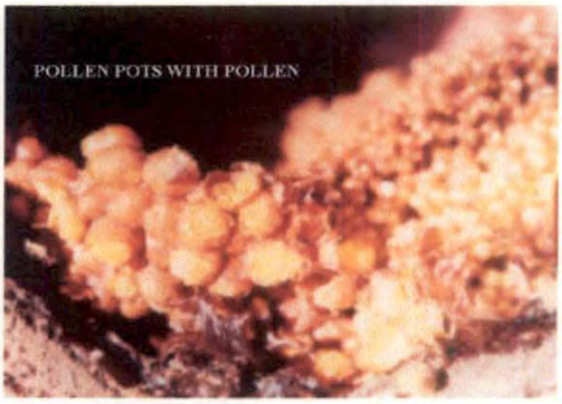


Plate 14 Pollen pots with pollen

Plate 15 Royal cells in a brood

Plate 16 Single honey pot with honey

Plate 17 Cluster of honeypots filled with honey.

Plate 18 Harvested honey in a plate

Table 5 The mean monthly honey storage of *T. iridipennis* in different hives

Sl. No.	Month	Treatment	Wooden (cm^3)	Earthen pot (cm^3)	Bamboo (cm^3)
1.	July	T_1	24.00	25.00	25.00
		T_2	25.00	25.00	21.33
		T_3	25.00	26.00	25.00
		T_4	24.00	18.66	25.00
	Mean		24.50	23.66	24.08
2.	August	T_1	29.33	31.33	30.33
		T_2	29.33	29.00	28.33
		T_3	30.66	31.33	28.66
		T_4	27.66	29.33	30.66
	Mean		29.25	30.250	29.50
3.	September	T_1	41.33	49.33	48.66
		T_2	36.66	49.33	48.66
		T_3	45.33	46.66	49.33
		T_4	48.66	45.33	52.66
	Mean		42.917	47.66	49.83
4.	October	T_1	56.66	61.33	59.33
		T_2	62.00	60.00	62.00
		T_3	58.66	58.00	62.66
		T_4	58.66	63.33	66.66
	Mean		59.00	60.66	62.66
5.	November	T_1	78.00	81.33	81.33
		T_2	78.66	80.66	74.66
		T_3	76.66	84.00	81.33
		T_4	82.00	78.66	86.66
	Mean		78.83	81.16	81.00
6.	December	T_1	94.33	93.33	89.33
		T_2	91.33	88.00	90.00
		T_3	95.33	96.33	97.33
		T_4	98.00	98.00	99.11
	Mean		94.75	93.91	94.50
7.	January	T_1	116.00	115.33	114.66
		T_2	128.66	117.33	110.00
		T_3	109.33	118.66	108.66
		T_4	110.66	112.66	118.00
	Mean		116.16	116.00	112.83
8.	February	T_1	135.33	130.00	133.33
		T_2	136.66	132.33	140.00
		T_3	132.66	136.66	127.33
		T_4	128.33	131.66	140.00
	Mean		133.25	132.66	135.16

Table 5 Continued

Sl. No.	Month	Treatment	Wooden (cm^3)	Earthen pot (cm^3)	Bamboo (cm^3)
9.	March	T_1	203.33	205.33	201.33
		T_2	197.33	206.00	208.66
		T_3	201.33	203.33	202.66
		T_4	205.33	206.66	209.33
	Mean		201.83	205.33	205.50
10.	April	T_1	201.33	206.00	206.66
		T_2	201.33	208.66	210.00
		T_3	204.66	209.33	208.66
		T_4	208.00	208.00	212.00
	Mean		205.33	208.00	209.33
11	May	T_1	194.66	197.33	193.33
		T_2	190.00	188.00	186.33
		T_3	184.00	185.00	188.00
		T_4	190.00	178.33	200.00
	Mean		189.66	187.16	191.91
12	June	T_1	172.33	168.00	177.33
		T_2	169.33	175.00	172.66
		T_3	170.00	172.00	165.33
		T_4	169.33	156.33	178.33
	Mean		170.25	167.83	173.41

Significant at 0.05 level

	CD
Hive	1.5
Treatments	1.733
Interaction between hive and treatments	3.001
Monthly variations	3.185
Interaction between hive and month	5.516
Interaction between treatments and month	6.369
Interaction between hive, treatment and month	11.032

208 cm^3 was noticed in wooden hive with capacity 1500 cc followed by 204.66 cm^3 in wooden hive having capacity 2250 cc.

4.1.4.2 Earthen Pot

4.1.4.2.1 Monthly variation

Division was carried out during the month of July 2001 and the mean volume of honey transferred to each hive was 25 cm^3, 24 cm^3, 26 cm^3, 18 cm^3 in hives having capacity 3750cc, 3000cc, 2250cc and 1500cc respectively. By April 2002 the volume of honey was increased to 206 cm^3, 208.66 cm^3, 209.33 cm^3, 208 cm^3 in hives having capacity 3750cc, 3000cc, 2250cc and 1500cc respectively.

4.1.4.2.2 Superior hive capacity

The performance of each hive varied under different months. Hive with capacity 2250cc was found to have maximum honey storage (209.33 cm^3) which was obtained during the month of April.

4.1.4.3 Bamboo Hive

4.1.4.3.1 Monthly Variation

A gradual increase in honey storage was noticed as the colony got established. Division was carried out during the month of July 2001 and the mean volume of honey transferred to each hive was 25 cm^3, 21.33 cm^3, 25 cm^3, 25 cm^3 in different hives having capacities 3750cc, 3000cc, 2250cc and 1500cc respectively. By April 2002 the volume of honey increased to 206.66 cm^3, 210.00 cm^3, 208.66 cm^3, 212.00 cm^3 in hives having capacities 3750cc, 3000cc, 2250cc and 1500cc respectively.

4.1.4.3.2 Superior hive capacity

The quantity of honey storage was found to be maximum in bamboo hive having capacity 1500 cc during all the months. Maximum storage of 210.00 cm^3 was noticed in bamboo hive (1500 cc) during April.

Statistical analysis revealed that among the different hives used bamboo hive exhibited better performance, along with earthen pot. The data during one year observation revealed that there was a gradual increase in honey storage as the colony got established. Honey storage reached its peak during April. Maximum honey yield of 350 ml per hive was recorded in bamboo hive with capacity 1500cc. Decline in honey storage was noticed from June in all the hives.

Table 6 Average densities of honey pots in different hives

Sl. No.	Parameter	Mean value		
		Bamboo	Earthen	Wooden
1.	Diameter	0.95 cm	0.91 cm	0.93 cm
2.	Height	0.9 cm	0.7 cm	0.8 cm
3.	Quantity of honey / pot	0.5 ml	0.40 ml	0.45 ml
4.	Yield (ml)/hive			
	3750cc	150	120	200
	3000cc	143	160	210
	2250cc	200	300	170
	1500cc	350	260	190

4.1.5 Handling of Bees

Handling of bees in scientific means is important in view of the varied floral availability, climatic factors and behaviour of bees. The present study was hence taken up to evolve suitable of handling stingless bee species.

Climatic condition play an important role in manipulation of bees. Rainy and cloudy seasons were found unsuitable for opening the hive. Since many of the bees were found inside the hive during rainy or cloudy weather condition and it would result in the destruction of large number of bees when bees are handled during this season. The most preferable time for opening or division of colonies was found to be between 0800 h and 1200 h. It was noticed that when the brood was less it was unfair to undergo division as the divided colonies did not perform well. It was noticed that, the disturbed honey pots while undergoing division was liable to fermentation and more vulnerable to infection. So care taken not to disturbing honey pots. It was observed that brood loss during division should be minimized, otherwise the colony failed to establish well. Presence of excess pollen and honey in the colony was shown to be more prone to pests and disease attack so it and hence, it is preferable to remove excess pollen and honey once in a year to maintain healthy colonies. The division was more successful when mature queen cells were present as it was found to reduce the establishment time.

It was observed that, of the different experimental hives used, handling of bees was more easier in wooden box. While opening hive with a hive tool it was noticed that in bamboo hive which is made of two semi circular half, the direction of hive opening is to be marked. If not, the colonies are liable to be hanged in a different direction and the bees find it difficult to find their entry. The brood cluster are likely to be misplaced affecting the normal developmental of the colony. Same is the case with wooden box and earthen pot.

4.2 NUMBER OF HONEY POTS REUSED BY THE BEES

Two methods were followed. In the first method five healthy colonies were selected to study the reuse of honey pots by the bees. Ten honey pots within a diameter of 5 cm were marked in each colony. The honey filled within the honey pots were extracted out using a syringe with out needle. The emptied honey pots were kept inside the hive as such, these emptied honey pots were observed for the reuse by the bees. The second method the honey extracted by transferring the honey storage pots to a tray and exposing the same to sunlight were examined for the reuse by the bees when the emptied pots were kept intact in the hives. It was observed that in both the methods the bees did not use the emptied honey pots for refilling the honey, instead, they used it to worn off parts of the emptied honey pots for other purpose, mainly for the reconstruction of the other honey pots beneath and near by. The mean number of days taken by bees for reuse of emptied honey pots are presented in Table 7. The data indicated that the bees took used up emptied honey pots at the rate of three pots per day.

Table 7 Mean number of days taken for reuse of emptied honey pots by *T. iridipennis*

Number of days	Honey pots reused				
	Colony I	Colony II	Colony III	Colony IV	Colony V
3/3/02	30 %	40 %	30 %	40 %	40 %
4/3/02	30 %	30 %	40 %	30 %	20 %
5/3/02	40 %	30 %	30 %	30 %	40 %

4.3 FORAGING ACTIVITY

4.3.1 Diurnal Variation

Foraging activity of stingless bees *Trigona iridipennis* was observed from 0060 h in the morning till 1800 h in the evening for a period of one year. The data pertaining to diurnal variations of foraging activity are presented in Table 8 and illustrated in Fig. 5. The data pertaining to foraging activity revealed that the bees started foraging activity by 0070 h

Table 8 Diurnal variations in the foraging activity (nectar and pollen) of *T. iridipennis*

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

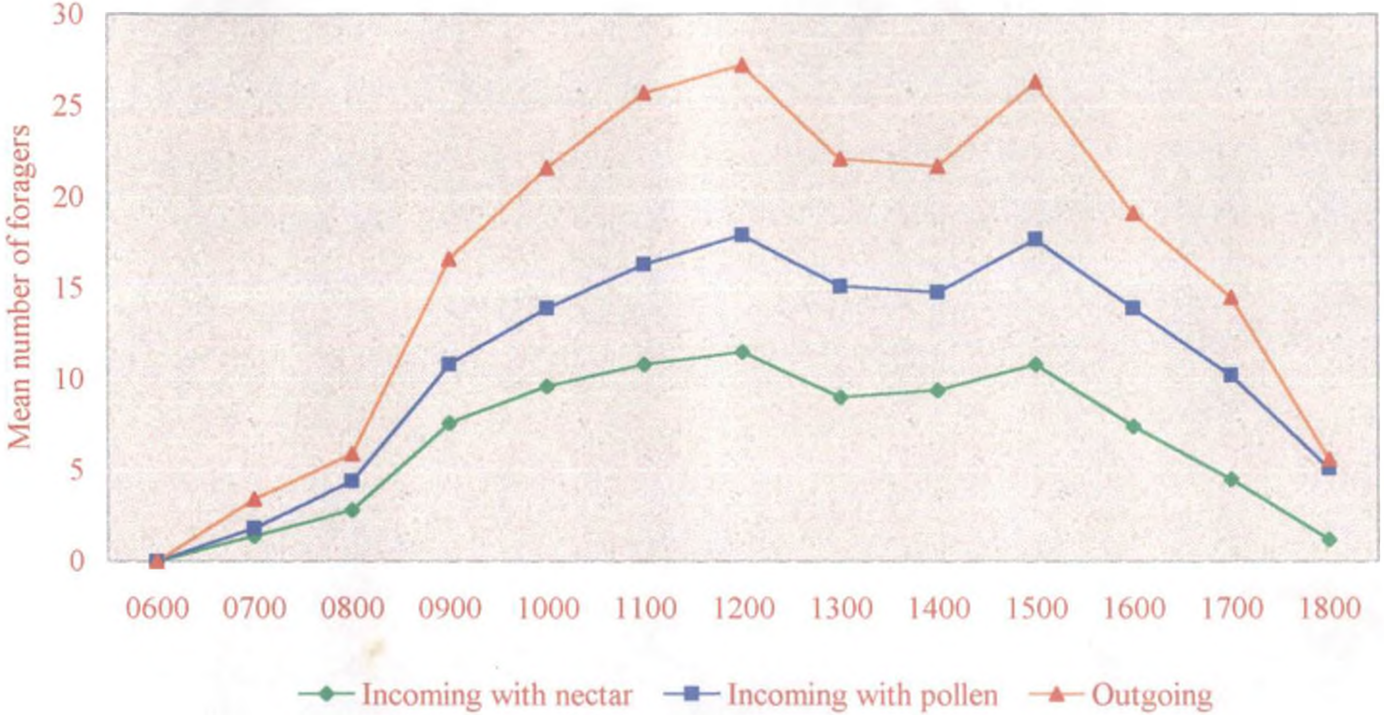


Fig. 5 Diurnal variations in the foraging activity of *T. iridipennis*

in the morning and gradually increased the activity reaching the first peak activity at 1200 h and second peak at 1500 h then again declined. The activity was almost nil after 1800 h.

Bees incoming with pollen was easily recognized by yellow colour pollen grains hanging on to their legs with in pollen baskets . The bees started collecting pollen from 0070 h but the activity was comparatively low till 0080 h. The activity increased gradually reaching the first peak at 1200 h. A decline in pollen collection by bees was observed from 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 to be incomers with nectar. The bees started collecting nectar from flowers around 0070 h. A gradual increase in the activity occurred from 0090 h. First peak activity was seen around 1200 h and next peak at 1500 h.

4.3.2 Monthly Variation in Foraging Activity

The data pertaining to monthly variation in the foraging activity is presented in Table 9 and illustrated in Fig. 6. Observations taken for one year relating to the foraging activity revealed maximum activity from April to August and during October. Peak period of activity was observed during July with maximum foraging bees. Lowest foraging activity was observed during the month of December and January.

It was observed that the number of incoming foragers with pollen was more during July to October and less during January and December.

The incoming foragers without pollen load is considered to be the nectar gathers. It was observed that the foraging bees incoming with nectar were more during July, August and October. Nectar collection by bees was least during the months of January and December.

Table 9 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

4.3.3 Flora Visited by Bees

The flora visited by *T. iridipennis* are presented in Table 10. It was observed that 76 plants were visited by the stingless bees for nectar or pollen or both. Of this twenty plants (chilli, brinjal, coral creeper, cannon ball tree, birds cherry, rose, guava, sunflower, cashew, drumstick, tamarind, tapioca, ixora, castor, pea cock plant, wild tapioca, eucalyptus, sandal, sesbania and radish) provided both nectar and pollen. Thirty five plants (rubber, balsam, banana, duranta, euphorbia, hamelia, marigold, phyllanthus, indigofera, brassica, burmese, red gram, chinese cabbage,

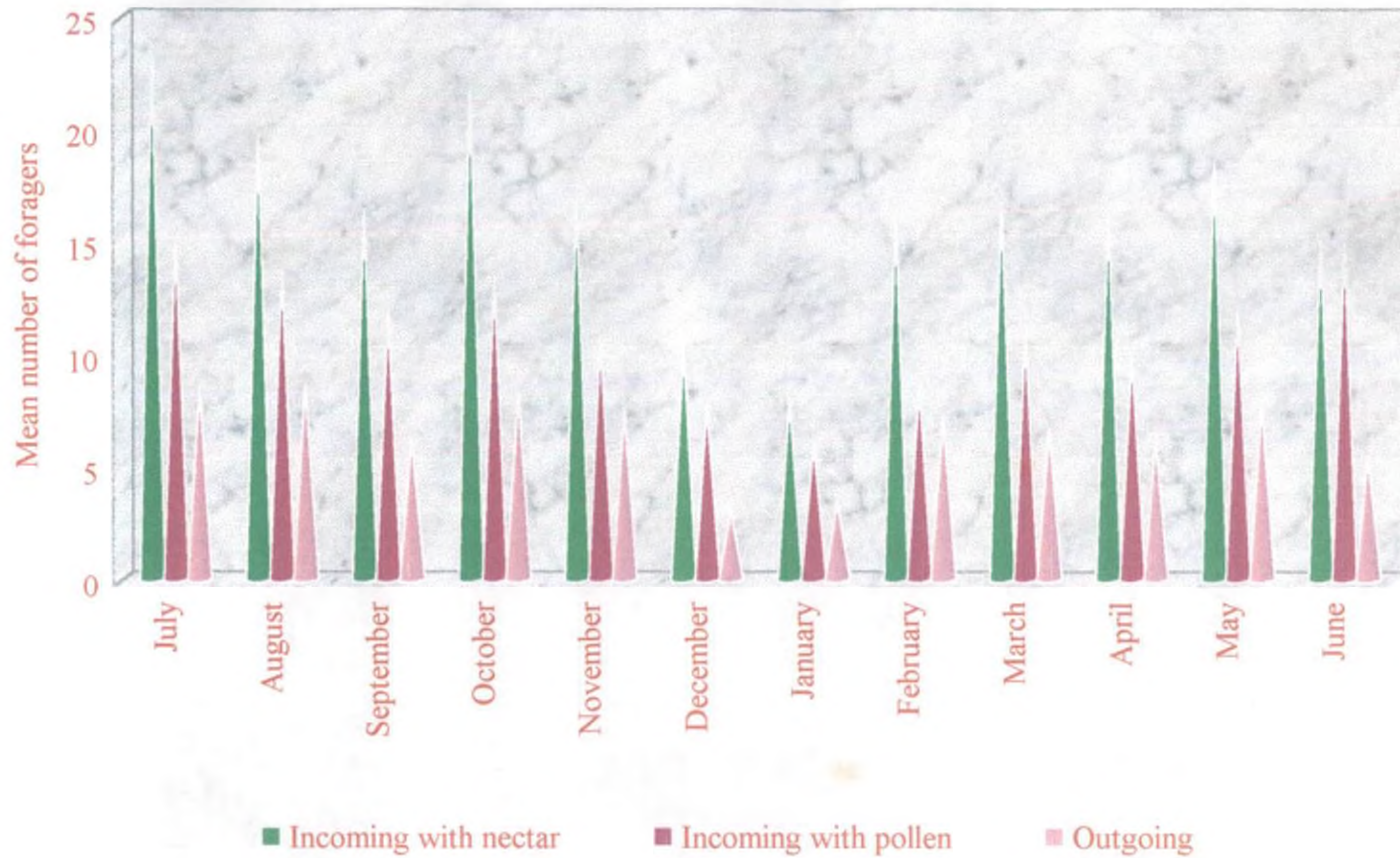


Fig. 6 Monthly variations in the foraging activity of *Trigona iridipennis*

Table 10 The stingless bee flora of Kerala

Sl. No	Common Name	Scientific Name	Family	Source
A.	**Medicinal Plants**			
1	Indigofera	*Indigofera tinctoria*	Papilionaceae	N
2	Touch-me-not	*Mimosa pudica*	Mimosaceae	P
3	Ixora	*Ixora coccinea*	Rubiaceae	N+P
4	Phyllanthus	*Phyllanthus niruri*	Euphorbaceae	N
5	Castor	*Ricinus communis*	Euphorbaceae	N+P
6	Javanese wool plant	*Aerva lanta*	Amarantaceae	N
7	Nagadandi	*Baliospermum monatanum*	Euphorbaceae	N
8	Periwinkle	*Vinca rosea*	Apocynaceae	N
9	Boerhavia	*Boerhavia diffusa*	Nyctaginaceae	N
10	Puliyarala	*Oxalis carniculata*	Oxalidaceae	N
11	Lowsonia	*lawsonia alba*	Lythraceae	P
12	Holybasil(Thulsi)	*Ocimum sanctum*	Laminaceae	N
B.	**Plantation crops**			
13	Rubber	*Hevea brasiliensis*	Euphorbiceae	N
14	Coconut	*Cocos nucifera*	Palmaceae	P
15	Cashew	*Anacardium occidentale*	Anacardiaceae	N+P
16	Coffee	*Coffea arabica*	Rubiaceae	N
17	Coffee	*Coffea robusta*	Rubiaceae	N
C.	**Condiments and spices**			
18	Chilly	*Capsicum annum*	Solanaceae	N+P
19	Tamarind	*Tamarindus indica*	Caesalpinaceae	N+P
20	Cinnamon	*Cinnamomum zeylanicum*	Lauraceae	P
21	Mustard	*Brassica juncea*	Umbelliferae	N
D.	**Vegetable crops**			
22	Sponge gourd	*Luffa cylindrica*	Cucurbitaceae	P
23	Drumstick	*Moringa olerifera*	Moringaceae	N+P
24	Chinese cabbage	*Brassica pekinensis*	Umbelliferae	N
25	Dolichos	*Dolichos lablab*	Papilionaceae	N
26	Waterleaf	*Talinum triangulare*	Portulacaceae	P
27	Radish	*Raphanus sativus*	Cruciferae	N+P
28	Bilimbi	*Averrhoa bilimbi*	Oxalidaceae	P
29	Onion	*Allium cepa*	Liliaceae	P
30	Brinjal	*Solanum melongena*	Solanaceae	N+P
31	Sweet gourd	*Momordica cochinchinensis*	Cucurbitaceae	P
E.	**Field crops**			
32	Bajra	*Pennisetum typhoides*	Poaceae	P
33	Sunflower	*Helianthus annus*	Compositae	N+P
34	Burmese	*Burmese corianter*	Umbelliferae	N
35	Redgram	*Cajanus cajan*	Papilionaceae	N
36	Gingely	*Sesamum indicum*	Pedaliaceae	N
37	Blackgram	*Vigna mungo*	Fabaceae	N
F.	**Fibre crops**			
38	Cotton	*Gossypium hirsutum*	Malvaceae	P
39	Jute	*Corchorus olitorlus*	Tiliaceae	P
40	Cotton tree	*Bombax malabarium*	Malvaceae	P

G.	**Fruit crops**			
41	Mango	*Mangifera indica*	Anacardiaceae	P
42	Banana	*Musa sp.*	Musaceae	N
43	Guava	*Psydium guajava*	Myrtaceae	N+P
44	Papaya	*Carica papaya*	Caricaceae	P
H.	**Ornamental plants**			
45	Balsam	*Impatiens balsaminae*	Balsaminaceae	N
46	Rose	*Rosa sp*	Rosaceae	N+P
47	Coral creeper	*Antegonon leptopus*	Polygonaceae	N+P
48	Duranta	*Duranta goldiana*	Verbinaceae	N
49	Hamelia	*Hamelia patens*	Rubiaceae	N
50	Anthurium	*Anthurium andreanum*	Areaceae	P
51	Marigold	*Tagetes erecta*	Compositae	N
52	Peacock plant	*Cesalpinia pucherima*	Cesalpiniaceae	N+P
53	Golden dew drop	*Duranta plumieri*	Verbinaceae	N
54	Canna	*Canna indica*	Cannaceae	N
55	Poinsettia	*Euphorbia pulcherima*	Euphorbiaceae	N
56	Golden rod	*Solidago canadensis*	Compositae	P
57	Ball lilly	*Haemanthus cinnabarinus*	Amaryllidaceae	P
58	Bird of paradise	*Heliconia rostrata*	Zingiberaceae	N
59	Nymphea	*Nymphea stellata*	Nympheaceae	P
60	Sage	*Salvia splendens*	Labiatae	P
61	Gladiolus	*Gladiolus grandiflorus*	Iridaceae	N
I.	**Herbs, shrubs & bushes**			
62	Euphorbia	*Euphorbia hiruta*	Euphorbiacea	N
63	Crotolaria	*Crotalaria variteoss*	Papilionaceae	N
64	Crotalaria	*Crotalaria macronata*	Papilionaceae	N
65	Wild tapioca	*Manihot glaziovi*	Euphorbiaceae	N+P
66	Sesbania	*Sesbania rostrata*	Papilionaceae	N
67	Jatropa	*Jatropa sp.*	Euphorbaceae	N
68	Cassia	*Cassia alata*	Cesalpiniaceae	N
69	Justica	*Justica simplex*	Acanthaceae	N
70	Zizipus	*Zizipus nummularia*	Rhamnaceae	N
J.	**Tuber crops**			
71	Tapioca	*Manihot esculenta*	Euphorbaceae	N+P
K.	**Green manure crop**			
72	Glyricidia	*Glyricidia maculata*	Papilionaceae	N
L.	**Forest Trees**			
73	Cannonballtree	*Cauropita guinensis*	Apocynaceae	N+P
74	Birdscherry	*Mundingia calbura*	Verbinaceae	N+P
75	Eucalyptus	*Eucalyptus globulus*	Mrytaceae	N+P
76	Sandal	*Santalum album*	Sandalaceae	N+P

crotalaria, dolichos, two coffee sp., Javanese-wool plant, golden dew drop, nagadandi, canna, gingilly, blackgram, heliconia, poinsettia, glyricidia sp., periwinkle, jetropa, boerhavia, bird of paradise, cassia, justica, puliyarala, zizipus, ocimum) provided nectar only and 20 plants (mango, bajra, cinnamon, anthurium, sponge gourd, touch-me-not, cotton, water leaf, jute, bilimbi, golden rod, ball lilly, onion, nymphea, cotton tree, lawsonia, sweet gourd, papaya, gladiolus, sage and coconut) provided pollen only (Plate 19).

4.4 HONEY ANALYSIS

Twenty two samples of stingless bees *T. iridipennis* were collected from different tracts in and around Kerala and subjected to chemical analysis. Samples were analysed to find out if any significant difference existed between the samples collected from different tracts. The data on chemical analysis were subjected to statistical analysis using CRD and the mean value of different samples are presented in the Table 11. The colour of honey collected from different tracts varied from light yellow to dark amber colour (Plate 20). In all samples the amount of fructose was more than glucose.

4.4.1 Acidity

The acidity of 22 samples were analysed. Significant difference was found between the samples. Mean value of acidity were highest in sample 19 (Pazhukkamalla, Ernakulam) (0.298) and least in Sample 2 (Edamattam, Kottayam) (0.178).

4.4.2 Total Reducing Sugars

The total reducing sugars of 22 samples were analysed. Significant difference was found between the samples. Mean total reducing sugars was found to be more in sample 17 (Mamala, Ernakulam) (77.1) which

a. Chilly - *Capsicum annum*

b. Coral creeper - Antegonon leptopus

c. Peacock plant - *Caesalpinia pulcherima*

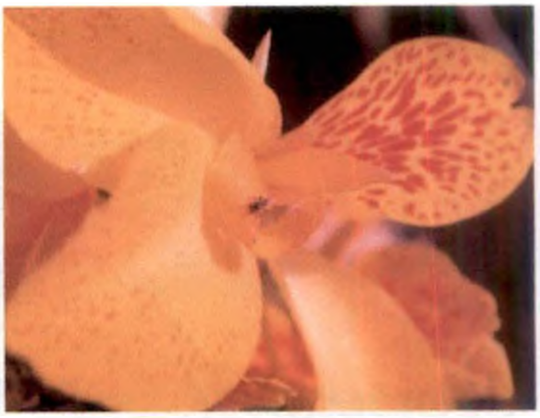
d. Tapioca - *Manihot esculenta*

e. Periwinkle - *VInca rosea*

f. Mustard - Brassica juncea

Plate 19 Bee flora

g. Banana - ***Musa*** **spp.**



h. Canna - ***Canna indica***

i. Papaya - ***Carica papaya***

j. Salvia - ***Salvia splendens***

k. Sweet gourd - ***Momordica cochinchinensis***

l. Gladiolus - ***Gladiolus grandiflorus***

m. Touch me not - *Mimosa pudica*

n. Onion - *Allium cepa*

o. Coconut - *Cocos nucifera*

p. Bird of paradise - *Heliconia rostrata*

q. Brinjal - *Solanum melongena*

r. Black gram - *Vigna mungo*

s. Japanese wool plant - *Aerva lanata*

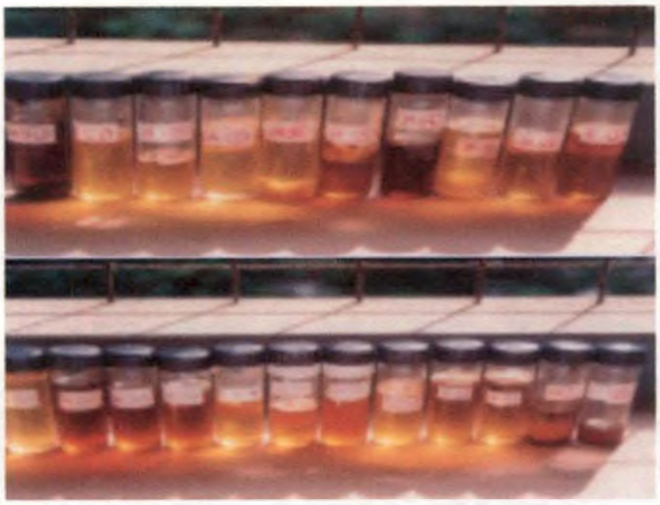


Plate 20 Stingless bee honey samples from different locations

was on par with sample 9 (Vadakkekara, Mannarkad) (76.772), sample 4 (Ranni, Pathanamthitta) (75.91), sample 21 (Thoppumpadi, Ernakulam) (75.74), sample 10 (Karakulam, Palakkad) (75.696), sample 8 (Mannarkad) (75.634), sample 2 (Edamattar, Kottayam) (75.442) and sample 14 (Panayamuttam, Thiruvananthapuram) (74.95) and least in sample 12 (Arimboor, Thrissur) (69.85).

4.4.2.1 Glucose

The glucose content of 22 samples were analysed. Significant difference was found between the samples. Mean glucose content was maximum in sample 17 (Mamala, Ernakulam) (37.36) and least in sample 13 (Chullimanoor, Thiruvananthapuram) (32.29).

Sample 17 (Mamala, Ernakulam) (37.36) was on par with sample 9 (Mannarkad, Vadakkekara) (37.2), sample (Ranni, Pathanamthitta) (36.52), sample 10 (Karakulam, Palakkad) (36.08). Sample 14 (Panayamuttam, Thiruvananthapuram) (35.92), sample 8 (Mannarkad) (35.8), sample 2 (Edamattam, Kottayam) (35.6), sample 15 (Menangal, Thiruvananthapuram) (35.36), sample 7 (Palakkad, Kollengode) (35.48) and sample 16 (Thiruvaniyoor, Ernakulam) (35.07).

4.4.2.2 Fructose

Fructose content of 22 samples were analysed. Significant difference was found between the samples. Percentage of fructose was found to be maximum in sample 8 (Mannarkad) (39.85) and sample 9 (Mannarkad, Vadakkekara) (39.84) which was on par with all other treatments except sample 3 (Adoor, Pathanamthitta) (37.96), sample 16 (Thiruvaniyoor, Ernakulam) (37.84), sample 7 (Palakkad) (37.8) and sample 5 (Mallapally, Pathanamthitta) (37.57).

4.4.2.3 Glucose Fructose Ratio

The glucose fructose ratio of 22 samples studied revealed that they were no significant differences between the samples. Mean value of sample 13 (Chullimanoor, Thiruvananthapuram) showed higher percentage of glucose fructose ratio (1.17), which was on par with sample 1 (Chengala, Kottayam) (1.17). Glucose fructose ratio was least (1.05) in sample 17 (Mamala, Ernakulam).

4.4.2.4 Sucrose

The information on the percentage of sucrose content of bee samples exhibited significant difference between them. Mean sucrose per cent was found to be more (1.18) in sample 13 (Chullimanoor, Thiruvananthapuram) and sample 20 (Pammakuda, Ernakulam) (1.81) which was on par with sample 15 (Menangal, Thiruvananthapuram) (1.79), sample 22 (Choondi, Ernakulam) (1.78), sample 6 (Pazhakumpara, Pathanamthitta) (1.74) and sample 7 (Kollengode, Palakkad) (1.77). Sucrose content was least in sample 8 (Mannarkad) (1.23) and sample 10 (Palakkad, Karakulam) (1.23).

4.4.3 Ash

The percentage of ash content in 22 samples were analysed. No significant difference was found between the samples. Mean percentage of ash content was maximum in sample 12 (Arimboor, Thrissur) (0.1967) and least in sample 2 (Edamattam, Kottayam) (0.178).

4.4.4 Specific Gravity

The specific gravity of 22 samples were analysed. Significant difference was found between the samples relating to specific gravity. Sample 3 (Adoor, Pathanamthitta) (1.3775) and sample 8 (Mannarkad)

(1.3775) showed maximum specific gravity and specific gravity showed least in sample 4 (Ranni, Pathanamthitta) (1.3507).

4.4.5 Refractive Index

Refractive index of 22 samples were analysed. Significant difference was found between the samples. Mean refractive index was found to be maximum in sample 19 (Pazhukkamatta, Ernakulam) (1.4891) and minimum in sample 14 (Panayamuttam, Thiruvananthapuram) (1.4855).

4.4.6 Moisture (per cent)

The percentage of moisture in 22 samples were analysed. Significant difference was found between the samples. Mean moisture content was maximum in sample 14 (Panayamuttam, Thiruvananthapuram) (20.48) which was on par with sample 11 (Karamukku, Thrissur) (20.44), sample 12 (Arimboor, Thrissur) (20.44) and sample 10 (Karakulam, Palakkad) (20.33).

Moisture percentage was found to be less in sample 19 (Pazhakkamatta, Ernakulam) (18.96).

4.4.7 Specific Heat

The information on the specific heat of 22 samples exhibited no significant differences between them. Maximum specific heat of 60.9 calories was recorded in sample 19 (Pazhukkamatta, Ernakulam), sample 15 (Menangal, Thiruvananthapuram), sample 12 (Arimboor, Thrissur), sample 8 (Mannarkad), sample 3 (Pathanamthitta) and minimum specific heat of 60.5 calories was recorded in sample 5 (Mallapally, Pathanamthitta), sample 6 (Pazhumpara, Pathanamthitta), sample 13 (Chullimanoor, Thiruvananthapuram) and sample 21 (Ernakulam).

Table 11 Chemical composition of stingless bee honey collected from different districts of Kerala

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	0.18	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	1.81	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
CD (0.05)	0.1122	0.00221	0.0084	2.4809	2.4809	0.00010	0.5613	2.1163	1.7016	0.0081	0.1006	0.46

4.4.8 pH

The pH of 22 samples were analysed. There were significant differences between the samples. Mean pH was found to be highest in sample 18 (Kallanikkal, Ernakulam) (4.4) which was on par with sample 13 (Chullimanoor, Thiruvananthapuram) (4.38).

Sample 6 (Pazhumpara, Pathanamthitta) (4.34), sample 21 (Thoppumpadi, Ernakulam) (4.34) and sample 9 (Vadakkekara, Mannarkad) (4.3).

pH was found to be less in sample 5 (Mallapaly, Pathanamthitta) (3.76) and sample 3 (Adoor, Pthanamthitta) (3.76).

4.5 NUMBER AND KIND OF NATURAL ENEMIES ASSOCIATED WITH THE COLONIES AT PERIODICAL INTERVALS

The Dipteran fly *Hermetia illucens* L. which thrive on decaying organic matter was newly identified as a pest of stingless bee *T. iridipennis*. The larvae of *hermetia illucens* massively fed 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 its excreta inside the hive resulting in a foul smell(Plate 21). Adult flies are robust, smoky black winged 15-20 mm long. Wings are held over the back when at rest. The black coloured fly is easily recognized by their two translucent spots on the first abdominal segment. The adult fly paved its pathway into the hive through holes and laid yellow to cream coloured eggs in masses of 300 – 500 inside the bee hive. The larvae is plump, flattened, firm, leathery and with tiny, yellowish black head. Larval period extended upto four weeks undergoing six instars. Pupa enclosed in a puparium emerged within two weeks.

A species of *Megachile disjuncta* was found to snatch the wax at the hive entrance (Plate 22).

During the month of May 2002 one of the bamboo hive was seen to be infested by *Amblyscius* sp. The mites were found feeding on the pollen but the honey remained uninfected (Plate 23). The mite species multiplied and the whole colony was destroyed. The bees escaped 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.

Ants (*Solenopsis geminata*) were 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. Species of unidentified spiders were found to predate on bees. They were found attacking the bees at the hive entrance. No disease incidence was noticed during the period of study.

Plate 21 ***Hermetia illucens*** **- a pest of** ***Trigona iridipennis***

Plate 22 ***Megachile disjuncta*** **- a wax snatching wasp of** ***T. iridipennis***

Plate 23 Mite pest (unidentified) of ***T. iridipennis***

DISCUSSION

5. DISCUSSION

The stingless bees, *Trigona iridipennis* are found in tropical parts of India and Kerala has a rich wealth of stingless bee colonies. Mishra (1995) observed that feral colonies are found in the hollow of tree trunks, crevices of masonry walls, rocks and similar situations. *Trigona* are major pollinators of tropical flora. The honey produced is highly valued for its medicinal properties. Beekeeping with stingless bees has not yet been popularized. This may be due to lack of information on the domestication and management.

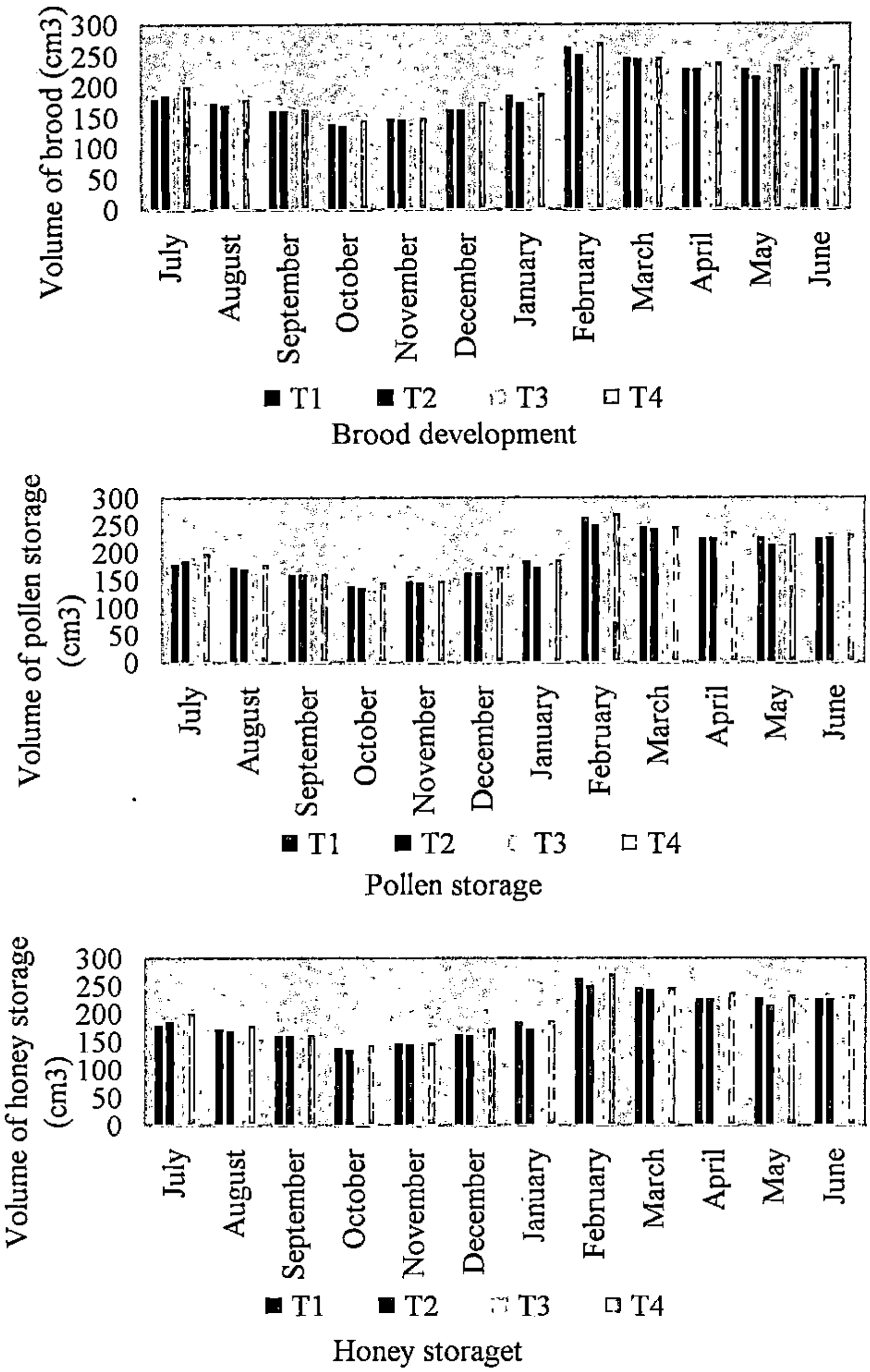
In Kerala information on the domestication of stingless bees and its scientific management are very limited. The present studies were hence taken up to gather formation on their domestication, management and possibility of rearing them in the homestead of Kerala. The findings are discussed below.

The present study was aimed to evaluate the most suitable hive for beekeeping with *T. iridipennis.* The colonies were reared in wooden box, bamboo hive and earthen pot having volume 3750cc, 3000cc, 2500cc and 1500cc respectively. The brood development, pollen and honey storage were observed for an year.. The data indicated maximum brood development in bamboo hive followed by wooden and earthen pot. This contradicts with the innovation of Raakhee (2000) that maximum brood development is in wooden hive. But Dollin (2001) reported the bamboo and wooden box as natural hive duplication method, as an alternative for propagating *T. carbonaria.* The local stingless beekeepers are seen using bamboo hives rather than wooden and earthen hives. The superiority of bamboo hive may be because the species trend to thrive in narrow / hollow natural bamboo structures. The preference to bamboo hive may be due to the brooding pattern in natural habitat of feral colonies having narrow space.

The new colonies are formed by dividing the mother colonies following the method of Michener (1972). Half of the brood cells with queen cells, honey and pollen were shifted to the new hive. The mother colony with queen was shifted from original site in the apiary to a new place away from the old site. The daughter colony was retained in the original place where mother colony was kept. Thus the daughter colony was intact with old queen and young bees, enabling its proper development. By keeping the daughter colony in the original site, the foragers could return to the new hive and hence the colony established easily. The new colony otherwise would have lesser number of workers and hence may take more time to establish. This result that the stingless bee colony could be successfully divided is in confirmation with the result obtained by Percy (1989) and Raakhee (2000). This division of colony without providing a queen to a new colony will be highly benefitted for keeping stingless bees particularly for commercial beekeeping.

In the present study it was seen that the bees established in all three different types of hives namely wooden box, bamboo and earthen pot. It was reported by Raakhee (2000) that *T. iridipennis* showed maximum brood development in wooden box compared to bamboo and earthen pot. Dollin (2001) reported bamboo as a suitable hive for domestication of *T. carbonaria*. Present study showed maximum brood development in bamboo hive with a volume of 1500cc (Fig. 7). It was also observed that the colonies occupied only half a portion of the large hives with capacity 3750cc. It seems that the space was larger than needed. So it was observed that smaller sized hives are more suitable than larger ones.

No earlier records are available on the monthly variation in brood development. In the present investigation, maximum brood development was observed during February and March and minimum brood



T1 - 3750 cc T2 - 3000 cc T3 - 2250 cc T4 - 1500 cc

Fig. 7 Suitability of bamboo hive (1500 cc) development during June and July. This new information obtained will be of much use for beekeeping with stingless bees to plan for various management operations. In the case of *A. cerana indica* and *A. mellifera*, this is the honey flow season where in reduced brood rearing is noticed. But in the case of *T. iridipennis*, maximum brood development is noticed during February and March. The stingless bees collect nectar and pollen even from plants having very small flowers. During February and March these plants will come to full bloom facilitating maximum nectar and pollen availability. Since the bees get natural food from the flora, during this period it enhances brood rearing during this time.

This is a new finding which will be of much use to the stingless beekeepers. The storage of pollen observed from different hives for an year indicated that maximum storage was in bamboo hive having capacity 1500cc followed by earthen pot and wooden hive. This is an indication that *T. iridipennis* prefer bamboo hive for its natural habitat.

The height, diameter and weight of pollen pots were recorded as 6.6 mm, 6.6 mm, 2 g respectively (Kshirsagar and Chauhan, 1977). It was reported by Raakhee (2000) that the height, diameter and weight as 9.7 mm, 7 mm and 0.23 g respectively. Similar observations were recorded in the present study where the height, diameter and weight of pollen pot was 9.6 mm, 7.3 mm and 0.25 g respectively. This indicates that the pollen pots constructed by *T. iridipennis* are much larger than that reported by Kshirsagar and Chauhan (1977). This also confirms the preference of bamboo hive by *T. iridipennis*.

The height, diameter and weight of pollen storage in earthen pot (9.4 mm, 7.0 mm, .23 g), wooden hive (9.3 mm, 7.0 mm, .23 g) and bamboo hive (9.3 mm, 7.0 mm, 0.23 g) was recorded in the present study. Kshirsagar and Chauhan (1977) reported the height, diameter and weight of pollen pots as 6.6 mm, 6.6 mm and 0.2 g respectively. The observation reveals that the maximum sized pollen pot is stored in bamboo hives followed by earthen and wooden hive. This indicates the preference of bamboo hive by the stingless bee. No earlier records are available explaining the monthly variation in the pollen storage. The present finding indicated maximum pollen storage by bees during February which coincides with the blooming season in the state while lowest pollen storage was noted during the month of May/June.

The data on the population build up indicated that the strength of the bees increased with the development of queen cells and drones. Maximum number of bees were noticed during November. Beig *et al.* (1972) reported that the production of males by the laying workers increase the active population of the colony which is in confirmation with the present finding. The observation on the natural build up of queen cells in the different hives indicated that maximum queen cell production was in bamboo hive (18-22) followed by wooden and earthen pots (3-14). This also confirms the preference of bamboo hive for domestication of stingless bees.

The involvement of stingless bees in a colony to undertake various activities were studied in which 8.00 per cent serves as guard bees, 44.00per cent as foraging bees, 22.00 per cent working on brood comb, 10.00 per cent involved in ripening, 8.00 per cent involved in removal of waste and 8.00 per cent working with cerumen. Maximum bees performed as foragers (44.00 per cent). Foragers are highly essential for collection of nectar and pollen which help for the buildup of the colony. 8.00 per cent of bees serve as guard bees which helps to protect the hives from enemies. 22.00 per cent of bees are engaged in brood rearing which is an indication of fast build up of the colonies.

The stingless bees store the nectar in specialized cells called honey pots (Bruijin, 1996). Honey pots are made up of cerumen, a mixture of wax and plant resin. In the present study, the quantity of honey stored in different hives at monthly intervals and measurements on individual honey pots in different hives are covered.

The average quantity of honey stored in bamboo hive was recorded to be maximum (350 ml/hive) in hive having volume 1500cc. The average honey yield ranged from 170-200 ml/hive and 120-300 ml/hive in earthen pot and wooden hive respectively. The honey storage was recorded maximum during the month of March / April. During the end of the honey flow season of Asian bees maximum honey is being stored by the stingless bees. This will be an added advantage to the beekeepers.

The average height, diameter and quantity of honey stored per honey pots were recorded as 0.91 cm, 0.7 cm and 0.4 ml in earthen pot and 0.93 cm, 0.8 cm and 0.45 ml in wooden hive. An average of 15 cells were present in an area of 4 cm^2. The height, diameter and quantity of honey per honey pot were maximum in the bamboo hive. The yield of honey was also move in bamboo hive compared to wooden and earthen hives. The information obtained revealed that the bamboo hive is more suited for storage of honey by the stingless bees.

All these observations confirm the superiority of bamboo hive.

Rainy and cloudy seasons are unsuitable for handling the bees. The present study indicated that 0800 h and 1200h are best suited twice to open the colonies. In the case of wooden hive, the handling is comparatively easier. Large number of queen cells emerged during November. It was found that during this season when the queen cells were present, division of colonies was best suited. But in the case of *A. cerana* division was carried out during August / September.

No information was available about the reuse of emptied honey pots by the bees. The present observation indicated that the stingless bees reuses the wax in which honey is stored. But the brood pots are not reused. Bruijn (1994) reported that brood cells are used only once in all stingless bees. The reuse of cerumen of honey pots will be advantages that the bees can easily reconstruct the honey pots without waiting for getting new cerumen.

The foraging activity of the bees indicated that bee activity was maximum during February which coincides with the flowering season of state.

Fowler (1979) found a significant correlation between flight activity and solar energy. The data on the diurnal activity of bees indicated two peak period of activity i.e., at 1200 h and 1500 h. The activity starts at 0700 h and gradually increase to reach a maximum during 1200 h followed by a decline and again an increase reaching another peak during 1500 h. The activity stops by 1800 h. The foraging activity is related with anthesis. The result obtained is in confirmation with reports of Raakhee (2000). More number of foragers are involved in collecting pollen rather than nectar at both the peak hours of activity that is 1200 h and 1500 h. Sceley (1989) propounded that pollen and honey foraging are regulated quite differently from one_another. Pollen collection and storage is a tightly regulated system in honeybees, whereas, nectar collection seems to occur relatively independent of actual honey stores until colonies are severely stressed.

Seventy eight plants were recorded as flora in the present study. Of this coconut (Ramanujan *et al.*, 1993; Muthuraman, 2002), sunflower (Goel and Kumar, 1981), sesamum, onion (Mohan *et al.*, 1981), acacia (Sedgley *et al.*, 1992), coral creeper (Ramanujan *et al.*, 1993), mango (Singh, 1989), cardamom (Puttanshetti and Prasad, 1973), orchid (Roubik, 2000), delonix, neem, ageratum, bamboo, antigonon, eucalyptus (Ramanujan *et al.*, 1993), coriander (Shelar and Suryanarayana, 1981), caesalpinia, euphorbia (Lazari *et al.*, 1998), cotton (Mohan, 1996), salvia and lavender (Mohan and Singh, 1997), begonia (Corff *et al.*, 1998), curry leaf (Vitali *et al.*, 1994). Raakhee (2000) reported rubber, cashew, chilly, cannan ball tree, drumstick, guava, roseberry, bird's cerry, tamarind, anthurium, bajra, sponge gourd, cinnamon, ixora, touchmenot, balsam, banana, duranta, hamelia, marigold and phyllanthus. Of the 78 plants 34 plants was recorded in the present study which includes indigofera, castor, Javanese woolplant, nagadandi, periwinkle, boerhavia, oxalis, holybasil, mustard, brinjal, sweet gourd, cabbage, dolichos, tapioca, glyricidia, sandal, water leaf, radish, bilimbi, redgram, gingily, papaya, golden rod, ball lilly, bird, of paradise, nymphea, gladiolus, heliconia, crotalaria, sesbania, jatropa, zizipus and justica.

The Trigona apiary honeys vary widely in their colour from light yellow to dark amber colour with all intermediate shades. The percentage of moisture varies from 18.96 to 20.48 in different districts of the state and pH ranged from 3.76–4.40. In all the honey samples the acidity ranged form 0.18–0.29 while the ash content varied from 0.17–0.19 per cent. The specific gravity also ranged from 1.3507–1.3775. The observations of reducing sugar indicated that it ranged from 77.10 per cent to 69.85 per cent. The refractive index value also indicated variation from 1.4855 to 1.4891. The values on glucose and fructose per cent varied from 35.92–33.53 and 38.16–39.74 respectively. The glucose fructose ratio observed indicated variation from 1.17–1.05. The sucrose per cent was also seen varying from 1.23–1.81 and the values on specific heat varied slightly from 60.5 – 60.9. The honey from *A. dorsata, A. florea* and *T. iridipennis* showed high water percentage and pH values with presence of both enzymes and inhibine (Wakhle and Desai, 1991).

Stingless bees honey were mostly multifloral. Hence variations in nectar quality occurred which influenced honey characters like colour and acidity. The moisture percentage of Indian bee honey is 21.46 per cent (Phadke, 1967). Since the moisture per cent is less in *T. iridipennis* honey there is every possibility of reduction of crystallization of honey which is an advantage for the beekeepers.

The pH value of *A. cerana indica* honey ranged from 3.25–4.28 while that of *T. iridipennis* is 4.15 (Wakhle and Desai, 1991). The pH observed in the present study ranged from 3.76–4.4. This variation may be due to the specific preference of the bees to particular plant species or the distribution and density of a particular honey plant in any given locality.

The percentage of ash content in *A. cerana* honey is 0.187 (Phadke, 1967) while that of *Trigona* honey is 1.1 (Raakhee, 2000). The present finding indicated that ash per cent ranged from 0.178–0.196. The difference may be due to the difference in proportion of pollen and extraneous matter which added to the ash content as observed by Phadke (1968).

The specific gravity of *A. cerana indica* honey ranged from 1.392 – 1.40 (Phadke, 1967). The present investigation showed that the specific gravity of the stingless bee honey ranged from 1.350–1.377 which is in conformity with the earlier finding (Phadke, 1967). The refractive index of *Apis cerana indica* honeys is 1.4246 (Phadke, 1968), while that of *Trigona* honey ranged from 1.4855–1.4891. Fructose and glucose in *A. cerana* honey was found to be 36.48 per cent and 33.39 per cent respectively (Phadke 1968), while Ramanujan *et al.* (1993) recorded 43.4 and 32.18 per cent fructose and glucose respectively. The fructose and glucose percentage in *Trigona* honey were found to be 41.6 and 37.1 respectively by Raakhee (2000). In the present finding, the percentage of fructose and glucose ranged from 35.92–33.53 and 38.16-39.74 respectively. All the honey samples contained lesser amount of glucose and fructose which was the main reason for high F/G ratio. Phadke (1968) also observed such a high F/G in *Trigona*. The specific heat of *A. cerana* honey was 60.82 calories while that of *Trigona* ranged from 60.5–60.9 calories.

All the parameters studied in the honey collected from different districts indicated different values. With regard to the significant difference in characteristics between the honey samples collected from different districts, it is not possible at this stage to ascribe them to any specific features of the district. This may be due to variability of flora available in different districts.

During the course of the investigation, a dipteran fly *Hermetia illucens* was identified as a new pest of *T. iridipennis* which was not reported by any other workers. In the present study spiders and ants (*Solenopsis geminata*) were found to predate which was earlier reported by Raakhee (2000). Incidence of a mite attack was found feeding on the pollen stored by *T. iridipennis* which were not reported earlier by any other workers. Delfinado and Baker *et al.* (1989) described *Neocypholaelaps Malayensis* found in the nests of *T. iridipennis* and *T. itama*. Flechtmann *et al.* (1974) reported a small whitish mite *Neotydeolus therapeutikos* found on the combs in nests of *T. postica*. Baker and Delfinado (1985) reported *Neocypholaelaps phooni* a new species of mite found in nests of *T. nritami*.

The present investigation also showed incidence of *Megachile disjuncta* which visited the nest to snatch away wax from the entrance. No earlier reports by other workers have been published on this species of *Megachile disjuncta* as pest attacking *T. iridipennis* colony.

There is no report of serious diseases like Thai Sacbrood Virus, American foul brood and European foul brood diseases prevalent in *Apis* sp. to *T. iridipennis*. This is an indication that this species could be managed very well by the beekeepers.

SUMMARY

6. SUMMARY

The present studies on management of stingless bee, *Trigona iridipennis* Smith in the homesteads of Kerala were conducted in the apiary of College of Agriculture, Vellayani with the following objective.

1. Suitability of hive
2. Handling of bees
3. Foraging behaviour
4. To assess the quality of honey
5. Incidence of pests and disease

The salient features of the study are presented below :

Division was carried out successfully by transferring half the amount of brood cells, pollen and honey pots along with queen cell to the experimental hives viz., wooden box, bamboo and earthen pot. Each hive was maintained under four different hive capacities namely 25 x 10 x 15 cm (3750cc), 20 x 10 x 15 cm (3000cc), 15 x 10 x 15 (2250cc) and 10 x 10 x 15 cm (1500cc). Each capacities were maintained with three replications. The development of brood and quantity of pollen, honey storage was maximum in bamboo hive compared to wooden hive and earthen pots. Brood development and pollen was found to be maximum during the month of February and March. Maximum brood development and pollen storage were seen in bamboo hive with capacity 1500cc. The bee strength increased as the colony got established well. Presence of queen cells and drones were noticed form November to March during which a remarkable population buildup were observed. The population buildup of the colony was found to be more in bamboo hive which had maximum brood, pollen and honey storage.

Honey yield (350 ml/hive) was found to be higher in bamboo hive compared to wooden hive and earthen pot. Maximum honey storage was observed during the month of April.

Bamboo hives with capacity 1500cc were thus found superior to wooden hive and earthen pot with regard to brood development. pollen storage and honey yield.

Handling of bees were found to be more easier with wooden hive compared to bamboo hive and earthen pot. Harvesting of honey was found to be easier in bamboo hive. Bamboo hives with smaller hive capacities (1500cc) were easier to handle than hives with larger capacities.

Investigation on the reuse of emptied honey pots by the bees indicated that the bees reused it not for filling the honey but for reconstruction of worn of honey pots beneath and nearby.

Colony condition which tend to make bees difficult to handle were found to be queenlessness, sudden cessation of nectar flow, very large population and unsuitable weather. The most preferable time for opening or division of colonies were found to be between 0800 h and 1200 h as most of the bees were then out for foraging. It was observed that division was more successful when mature queen cells are present as it was found to reduce the establishment time.

Investigation on the foraging activity of *T. iridipennis* showed two peak period of activity one at 1200 h and the other at 1500h. Peak period of activity were observed during July with maximum foraging bees collecting nectar and pollen.

It was observed in the present study that 76 plants were visited by the stingless bees for nectar or pollen or both. Of this twenty plants (chilli, brinjal, coral creeper, cannon ball tree, birds cherry, rose, guava, sunflower, cashew, drumstick, tamarind, tapioca, ixora, castor, pea cock plant, wild tapioca, eucalyptus, sandal, sesbania and radish) provided both nectar and pollen. Thirty five plants (rubber, balsam, banana, duranta, euphorbia, hamelia, marigold, phyllanthus, indigofera, brassica, burmese, red gram, chinese cabbage, crotalaria, dolichos, two coffee sp., Javanese-wool plant, golden dew drop, nagadandi, canna, gingeley, blackgram, heliconia, poinsettia, glyricidia sp., periwinkle, jetropa, boerhavia, bird of paradise, cassia, justica, puliyarala, zizipus, ocimum) provided nectar only and 20 plants (mango, bajra, cinnamon, anthurium, sponge gourd, touch-me-not, cotton, water leaf, jute, bilimbi, golden rod, ball lilly, onion, nymphea, cotton tree, lawsonia, sweet goard, papaya, gladiolus, sage and coconut) provided pollen only.

The *Trigona* honeys collected from different tracts around Kerala varied widely in colour from light yellow to dark amber colour with all intermediate shades. The percentage of moisture varied from 18.96 to 20.48 in different districts of the state and pH ranged from 3.76 – 4.4. In all the honey samples the acidity ranged form 0.17–0.29 while the ash content varied from 0.17–0.19 per cent. The specific gravity also ranged from 1.3507–1.3775. The observations of reducing sugar indicated that it ranged from 77.12–69.85 per cent. The refractive index value also indicated variation from 1.4855 to 1.4891. The values on glucose and fructose per cent varied from 35.92–33.53 and 38.16–39.74 respectively. The glucose fructose ratio observed indicated variation from 1.17–1.05. The sucrose per cent also seen varied from 1.23–1.81 and the values on specific heat varied slightly from 60.50–60.9.

The dipteran fly *Hermetia illucens* L. was newly identified as a pest of *T. iridipennis*. The larvae massively fed on the pollen, honey, brood and cerumen deposits of *Trigona* leading to complete destruction of the colony giving a foul smell. During the period of study, *Amblyscius* sp. were found to infest *Trigona* colony. The mites were feeding on the pollen but the honey remained unaffected. A species of *Megachile. disjuncta* were found to snatch the wax at the hive entrance. Ants *Solenopsis geminata* were also found to attack the weak colonies. No disease incidence was noticed.

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*Original not seen

MANAGEMENT OF STINGLESS BEE *Trigona iridipennis* Smith (Meliponinae : Apidae) IN THE HOMESTEADS OF KERALA

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8. ABSTRACT

With the objective of studying the management of stingless bees, *Trigona iridipennis* Smith in the homesteads of Kerala, studies were conducted at the College of Agriculture, Vellayani during 2000–2001.

Different management practices were tried. Division of the bee colony could be successfully carried out by transferring equal amount of brood cells, pollen and honey pots along with queen to the different hives viz., wooden, bamboo and earthen pot with different capacities. Bamboo hive with capacity 1500cc was found to be more suitable for hiving *T. iridipennis* since the brood development, pollen storage, population buildup and honey storage were superior in this type of hive. Observations on handling of bees indicated that wooden hives were easy to handle compared to bamboo and earthen pot. Brood development and pollen storage were shown maximum during the month of February, while maximum honey storage was noticed during the month of April. Bee strength increased as the colony got established well. Presence of queen cells and drones were noticed from November to March during which population build up existed. The bee strength was also found to be maximum in bamboo hive which had maximum brood, pollen and honey storage.

Investigation on the reuse of emptied honey pots by the bees indicated that the bees reused it for reconstruction of worn off honey pot parts beneath and nearby. Investigations on the foraging activity of *T. iridipennis* showed two peak periods of activity one at 1200h and the other at 1500h and with maximum activity during July.

It was observed in the present study that 76 plants were visited by the stingless bees for nectar or pollen or both. Of this twenty plants provided both nectar and pollen. Thirty five plants provided nectar only and 20 plants provided pollen only.

The *Trigona* honeys collected from different tracts around Kerala varied widely in colour from light yellow to dark amber colour with all intermediate shades. The percentage of moisture varied from 18.96 to 20.48 in different districts of the state and pH ranged from 3.76–4.4. In all the honey samples the acidity ranged from 0.17–0.29 while the ash content varied from 0.17–0.19 per cent. The specific gravity also ranged from 1.3507–1.3775. The observations of reducing sugar indicated that it ranged from 77.12–69.85 per cent. The refractive index value also indicated variation from 1.4855 to 1.4891. The values on glucose and fructose per cent varied from 35.92–33.53 and 38.16–39.74 respectively. The glucose fructose ratio observed indicated variation from 1.17–1.05. The sucrose per cent also seen varied from 1.23–1.81 and the values on specific heat varied slightly from 60.50–60.9.

A dipteran fly *Hermetia illucens* L., a mite, *Amblyscius* sp. and *Megachile disjuncta* was newly identified as pest of *T. iridipennis*. *Solenopsis geminata* was also observed to attack weak colonies. No disease incidence was noticed.