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SURVEY ON MELIPONICULTURE PRACTICES AT DIFFERENT DISTRICTS OF KARNATAKA, INDIA

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Abstract: The stingless bees, *Melipona*, *Trigona* or *Tetragonal* species (Hymenoptera: Apidae: Meliponini) are highly evolved social insects, live in cryptic colonies. They play a pivotal role in pollination and propagation of innumerable flowering plant species both at forest, cropland and human inhabited landscapes, besides providing medicinally important honey and other useful hive products to mankind since pre-historic times. Stingless bees are used to conduct Meliponiculture activity at different parts of the world. However, their inhabitation, economical and biological applications are not explored much compared to *Apis* species. Present investigation was conducted systematically by selecting different regions randomly which represented maidan (e.g. Bangalore and Ballary Districts), malnad (e.g. Chikkamagalore, Shimoga districts), hilly areas (e.g. Chikkamagalore and Kodagu Districts), coastal region (Dakshina Kannada and Uttar Kannada Districts), arid zone (e.g. Chamarajanagara District) and mountain ranges of Western Ghats (e.g. Kodagu and Chikkamagalore Districts) in Karnataka state. Beekeepers were randomly selected and met them personally using pre-tested questionnaire that included 15 parameters on various aspects about the Meliponiculture activity. Results revealed quite interesting facts. Bangalore and Kalasa (Chikkamagalore district) had more (16% each) Meliponiculturists and it was followed by Kodagu and Sagar (Shimoga district) (8% each). Highest (48%) beekeepers are conducting Meliponiculture on part-time basis, 44% beekeepers doing Meliponiculture on full-time basis and few (8%) beekeepers are practicing Meliponiculture just for hobby. Interestingly, Doctors, Government Employees and Non-government Employees are practicing Meliponiculture on small (68%), medium and large scale (12% each) basis. Beekeepers are using *Apis cerana* (64%), *A. cerana* and *A. mellifera* together (20%) and stingless bees (only 8%) to produce honey. Stingless bees are reared mainly in wooden boxes (47.8%), Areca nut and Bamboo logs (10.9%). However, PVC pipes, Glass boxes, Plywood sheet made boxes, PVC-thermo coal coating pipes, coconut shells, mud pots, clay pots, *Acacia* wood logs, wood polymer composite and Terra-cotta-clay pots were also used to rear stingless bees. Surprisingly, stingless bee honey production potential was very less compared to *Apis* species honey production. Moreover, income generated from Meliponiculture activity, time taken to produce honey, purpose of honey production and biological constraints such as pests and predators interferences during the stingless bees rearing indicated more attention is required to safeguard Meliponiculture activity. Despite the constraints and challenges, there is a wide scope prevailed to do Meliponiculture at different districts to showcase its cultural importance to the younger generation. Legacy of stingless bees in terms of pollination and honey production in the name of Meliponiculture shouldn't be ignored. In this regard, more assistance and encouragements are required to popularize Meliponiculture activity amidst croplands and human inhabited domestic conditions at different parts of Karnataka, India.

Key words: Beekeepers, Meliponiculture activity, Karnataka.

I. INTRODUCTION

The stingless bee species belong to the genera *Melipona*, *Trigona* and *Tetragonal* etc, (Hymenoptera: Apidae: Meliponini) are used as agents of Meliponiculture across the world including India. Since, stingless bees are cryptic in their inhabitation, economical and biological applications are not much explored (Heena and Basavarajappa, 2023). Various researchers have studied the stingless bees at different parts of the world. The biology of stingless bee, *Trigona* species published by Bassindale (1955). Roubik (1983) has recorded the nest and colony characteristics of stingless bees in Panama. Later, Wille (1983) has provided the information on biology of stingless bees. Heard (1994) has recorded the behavior and pollinator efficiency of stingless bees and honeybees on macadamia flowers. Heard (1999) has recorded the role of stingless bees in crop pollination. Michener (2000) has published the bees of the World with special reference to the Tribe Meliponini. Faustino *et al*. (2000) have recorded the emergency queen rearing in stingless bees. Slaa *et al*. (2000) have provided a scientific note on the use of stingless bees for commercial pollination in enclosures. Eltz *et al*. (2002 and 2003) have recorded the stingless bees nest density and nest trees in lowland Dipterocarp forests of Sabah,

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Malaysia. Nogueira-Neto (2002) has recorded the inbreeding and building up small populations of stingless bees. Batista *et al*. (2003) have recorded the nesting sites and abundance of stingless bee, *Meliponini* species amidst heterogeneous habitats of the Atlantic Rain Forest, Bahia, Brazil. Stingless bees were reported at Bwindi impenetrable forests of Uganda and indigenous knowledge of Abayanda by Byarugaba (2004). Later, Eardley (2005) has made taxonomic revision of the African stingless bees. Slaa *et al*. (2006) have reported the stingless bees in applied pollination practices and perspectives. Michener (2013) has published reports on the legacy of stingless bees. However, only few published reports are available on Meliponiculture at different parts of the world. Kent (1984) has studied the stingless beekeeping in Mesoamerican region. Sommeijer (1996) has provided the information on regional program for training and research on tropical beekeeping and tropical bees in Costa Rica. Heard and Dollin (2000) have reported the stingless beekeeping in Australia. Van-Veen *et al*. (2004) have provided an information on production of queens and drones of *Melipona beecheii* (Meliponini) in relation to colony development and resource availability. Villanueva *et al*. (2005) have reported the extinction of *M. beecheii* and traditional beekeeping in the Yucatán Peninsula. Cortopassi-Laurino *et al*. (2006) have analyzed the challenges and opportunities in Meliponiculture at global level. Mexican stingless bee's diversity, distribution and indigenous knowledge has been recorded by Ayala *et al.* (2013). Table 1 shows the stingless bees and Meliponiculture related published few reports found at different countries in the world.

In India, Mohan and Devanesan (1999) have recorded the stingless bee or dammer bee, *Trigona iridipennis* in Kerala. Swaminathan (2000) has studied the stingless bees. Devanesan *et al.* (2003) have recorded the natural enemies of *T. irridipennis* in Kerala. Nair (2003) has studied apiculture resources and management in southern Kerala. Danaraddi and Shashidhar (2009) have recorded the morphological parameters of *T. iridipennis.* Sheetal and Basavarajappa (2009) have studied the spatial distribution of *T. iridipennis* at managed landscapes of Manasagangotri, Mysore. Raju (2009) has recorded the nesting behavior and foraging ecology of *T. iridipennis.* Velmurugan (2011) has studied the nesting behavior and floral resources of *T. laeviceps* at Pantnagara, India. Managanvi *et al.* (2012) have observed the foraging activity of *T. laeviceps.* Muthuraman *et al.* (2012) have made observations on bio-ecology and management of stingless bees for crop pollination. Vijayakumar *et al.* (2013) have recorded the infestation of *Carpoglyphus lactis* (Acari: Carpoglyphidae) mite on *T. iridipennis* in India. Pavithra *et al.* (2013) have recorded the nesting pattern preferences of *T. iridipennis* in Jnanabharathi campus, Karnataka, India. Rasmussen (2013) has recorded the diversity, taxonomy and current status of stingless bees of the Indian subcontinent. Swetha (2013) has studied the floral diversity of stingless bees in Peninsular India. Vijayakumar and Jeyaraaj (2014) have provided a taxonomic notes on *Trigona (Tetragonula) iridipennis* from India. Rahman *et al.* (2015) have recorded the distribution and diversity of stingless bees. Roopa *et al.* (2015) have studied the nesting characteristics and biology of *T. iridipennis*. Layek and Karmakar (2018) have studied the nesting characteristics, floral resources and foraging activity of *T. iridipennis* in Bankura district of West Bengal, India. Layek *et al.* (2022) have assessed the impact of native pollinators and crop yield. Viraktamath and Roy (2022) have provided the description of five new species of *Tetragonula* from India. Gopinatha and Basavarajappa (2023) have recorded the spatio-temporal distribution of stingless bee colonies midst diversified agro-ecosystems of south-eastern Karnataka, India. Heena and Basavarajappa (2023) have demonstrated the eduction of stingless bees from their natural colonies at human modified habitats. However, Meliponiculture is new to Indian region, very few published reports are available. Patnaik and Prasad (2006) have recorded the nesting behavior and suitability of hive structures for their domestication of *T. iridipennis.* Danaraddi (2007) has made the Melissopalynoligical study and recorded the foraging behavior of *T. iridipennis* at Dharwad, Karnataka. Sheetal (2009) has studied nesting ecology and flora of *T. iridipennis* at managed landscapes of Manasagangotri, Mysore. Kumar *et al*. (2012) have recorded the traditional beekeeping of *Trigona* species by Kani tribes of Western Ghats region of Tamil Nadu, India. Singh (2013) has studied the domestication of *T. iridipennis* in a newly designed hive. Virkar *et al.* (2014) have observed the nest duplication of *T. iridipennins.* Pooja and Khan (2015) have assessed foraging activity in queen and queen less colony of *T. iridipennis.* Prem and Jose (2016) have published the novel and innovative technique in Meliponiculture in Kerala. Singh (2016) has recorded the traditional Meliponiculture by Naga tribes in Nagaland. Karthick *et al.* (2018) have recorded the prospects and challenges of Meliponiculture in India. Mythri *et al.* (2018) have demonstrated the colony division techniques for *T. iridipennis*. Layek *et al*. (2021) have recorded the flight range and resource loading-unloading behavior of *T. iridipennis.* Charanakumara *et al.* (2022) have recorded the current status of Meliponiculture and its cultural importance in the Western Ghats region of India. Table 2 shows the stingless bees and Meliponiculture related few published reports found at different parts of India. However, above mentioned published reports from different parts of the world including India are clearly suggested that the information on Meliponiculture in Karnataka is poor. Adequate and updated information on Meliponiculture is sparse and hence, the present investigation was carried out at different districts of Karnataka State, India.

II. MATERIALS AND METHODS

Study area: In Karnataka State, total nine districts were randomly chosen which represented maidan (e.g. Bangalore and Ballari Districts), malnad (e.g. Chikkamagalore, Shimoga districts), hilly areas (e.g. Chikkamagalure and Kodagu

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Districts), coastal region (Dakshina Kannada and Uttar Kannada Districts), arid zone (e.g. Chamarajanagara District) and mountain ranges of Western Ghats (e.g. Kodagu and Chikkamagalore Districts) (Kamath, 2001) for the present investigation (Figure 1). In each district, three Meliponiculturists were randomly selected to collect the detailed information about the Meliponiculture activity. Table 3 shows the physiographic details such as latitude, longitude and altitude, environmental factors such as temperature, relative humidity, rainfall and major crops grown at different districts, which were selected for the present investigation.

Methodology: To document the stingless beekeeping activities and their management, pre-tested questionnaire was prepared. Total 25 Meliponiculturists were randomly selected and met them personally using questionnaire that included 15 parameters on various aspects of stingless beekeeping activity, type of materials used while beekeeping, level of beekeeping, amount of honey produced, financial inputs and vegetation around the apiary using Snowball-Sampling method as per Bailey (1987). Meliponiculturists were met personally using 'walk-in-the-woods' method as per Phillips and Gentry (1993), where Meliponiculturists were interviewed amidst their apiary. Further, information on stingless beekeeping, number of bee boxes kept, duration required to produce honey, honey production, income generated by selling honey, predators and pests interfered with beekeeping activities etc., were collected as per Dewalt and Dewalt (2002) and by following standard methods.

Statistical Analysis: Collected data was systematically complied and critically analyzed by following standard methods as per Saha (2009).

III. RESULTS

Meliponiculturists: Total 25 Meliponiculturists were recorded at nine districts of Karnataka. Meliponiculturists were recorded at Ballary, Bangalore, Chamarajanagar, Chikkamagalore, Dakshina Kannada, Kodagu, Mysore, Shivamoga and Uttar Kannada districts of Karnataka during the present investigation. However, Bangalore and Kalasa (Chikkamagalore district) had more (16% each) Meliponiculturists (Figure 2) and it was followed by Kodagu and Sagar (Shimoga district) (8% each). Remaining districts had almost similar percentage of Meliponiculturists (Figure 2).

Beekeepers practicing Meliponiculture: On an average 8.33 ± 5.5 beekeepers were practicing Meliponiculture on different levels (Table 4). Highest (48%) beekeepers have conducted Meliponiculture on part-time basis and 44% beekeepers were doing Meliponiculture on full-time basis. However, only 8% beekeepers are practicing Meliponiculture just for a hobby (Figure 3).

People practicing Meliponiculture: On an average 6.3 ± 4.4 Meliponiculture activity is being practised by Doctors, Government employees and non-government employees and others at different districts of Karnataka (Table 4). Highest (4.2%) Meliponiculture activity is practised by non-government employees and 40% Meliponiculture was practised by others (Figure 4). Moreover, about 10% Government employees were practicing Meliponiculture at different districts of Karnataka. Quite interestingly, 8% Doctors were shown their interest towards the stingless bee keeping as a hobby at few districts of Karnataka (Figure 4).

Level of stingless bees rearing: On an average 6.3 ± 7.2 were practicing stingless beekeeping on small, medium and large scale basis and few people are doing stingless beekeeping for house hold purpose at different districts in Karnataka (Table 4). Of all, 68% of beekeepers doing stingless bees rearing on small scale basis (Figure 5) and it was followed by large and medium scales (12% each) and only 8% beekeepers were practicing stingless bees rearing for house hold purpose only (Figure 5).

Honeybee species used by beekeepers: Total five types of honeybees (5.0 ± 2.8) were used to produce honey by beekeepers at different districts of Karnataka (Table 5). Of all, *Apis cerana* used predominantly (64%) and it was followed by *A. cerana* and *A. mellifera* together (20%), and only 8% of stingless bees are commonly used to produce honey at different districts of Karnataka (Figure 6). However, 4% of honey is obtained from the natural colonies of *A. dorsata* and remaining 4% of the honey is being exclusively produced by *A. mellifera* colonies (Figure 6).

Materials used to rear stingless bees: Altogether 16 different types of materials were used to rear stingless bees at different districts of Karnataka (Table 5). Of all, minimum 2.9 ± 5.2 types of materials related to bee boxes were used by stingless beekeepers (Table 5). Of all, wooden boxes were predominantly used (47.8%) and it was followed by Areca nut and Bamboo logs (10.9%) were used to rear stingless bees at different districts of Karnataka (Figure 7). Moreover, both Bamboo logs and wooden boxes, only Bamboo logs, PVC pipes, Glass boxes and Plywood sheet made boxes were also used (4.3% each) for stingless bee keeping at different districts of Karnataka (Figure 7).

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Further, wood logs, PVC-thermo coal coating pipes, coconut shells, mud pots, clay pots, Acacia wood longs, Araca nut logs, wood polymer composite and Terra-cotta-clay pots were also used (2.2% each) during stingless bees rearing at different districts of Karnataka (Figure 7).

Stingless bee honey production: Stingless bee honey production potential was very less compared to *Apis* species honey production. Highest (52%) beekeepers produce 100 to 300gram stingless bee honey along with other *Apis* species honey (Table 5 and Figure 8). Remaining beekeepers producing stingless bee honey 100 to 500 gram, 200 to 400 gram and 500 to one kilogram of stingless bee honey by each 16% beekeepers (Table 5 and Figure 8).

Duration of stingless bee honey production: Majority (44%) of the beekeepers require one to two months to produce stingless bee honey and it was followed by three to six months (32%) and four to eight months (16%). Only, 8% beekeepers did took one year and above to produce stingless bee honey at different districts in Karnataka (Figure 9).

Purpose of stingless bee honey production: Majority (80%) of the beekeepers produce stingless bee honey for generating self-income and it was followed by research purpose (16%) and only 4% of the beekeepers produce stingless bee honey for house hold purpose (Figure 10). Thus, on an average 8.33 ± 10.21 beekeepers produce stingless bee honey for various purposes (Table 5 and Figure 10).

Income produced (in Kg) of honey: The income generated due to the sale of stingless bee honey varies considerably at different districts of Karnataka (Table 5). On an average 2.87 ± 1.54 beekeepers were happy with their income generated to sale the stingless bee honey at different districts of Karnataka (Table 5). The income ranged in between Rs. 1,000/- to 3,900/- (Table 5). However, 26% of beekeepers had Rs. 2,000/- to 2,500/- income per kilogram of stingless bee honey and it was followed by 17.4% beekeepers sold their honey for Rs. 1,000/- to 1,500/- kilogram of stingless bee honey (Figure 11). However, only 8.7% beekeepers obtain Rs. 3,800/- to 3.900/- income per kilogram of stingless bee honey. Furthermore details are presented in Figure 11 and Table 5. Thus, income generation from a kilogram of stingless bee honey varied considerably at different districts of Karnataka. Perhaps, it was due to season, availability of honey and number of beekeepers practicing stingless bee keeping. Hence, there is a lot of demand for Meliponiculture activity in Karnataka.

Pest infestation: There were three types of pests infestation was observed at Meliponiculturists. They are small hive beetle, moth and resin beetle species. These pests incidence at different Meliponiculturists was considerably varied and it was 5.8 ±8.2 (Table 6) and their per cent incidence was also varied considerably at different districts of Karnataka (Figure 12). Of all, wax moth infestation was high (78.2%), whereas, small hive beetle infestation was only 8.7% (Figure). However, resin beetle infestation was noticed along with moth and hive beetles for 4.3% and both small hive beetles and moth infestation was 8.6% recorded during the present investigation at different districts of Karnataka (Table 6 and Figure 12).

Predator's incidence: Total seven types of predators were known to attack stingless bees during their culture at different districts of Karnataka (Table 6). They are ants, wasps, spiders, lizards, monkey, hornets and wood borers. On an average 1.8 ± 0.9 predator's incidence was commonly observed at stingless bee keepers at different districts of Karnataka (Table 6). Amongst all the predators, ants, spiders, wasps and lizards interference was high (13.7% each) and quite interestingly, these predators interference was rarely alone but commonly together during stingless bees rearing (Table 6 and Figure 13). Sometimes, ants and wasps together interfered more (9.2%) and remaining predator's interference was just 4.5% with stingless beekeeping activity (Figure 13). Thus, predators also interfere with stingless bee keeping activity at different districts of Karnataka.

IV. DISCUSSION

Twenty five Meliponiculturists from nine districts such as Bellary, Bangalore, Chamarajanagara, Chikkamagalore, Dakshina Kannada, Kodagu, Mysore, Shivamoga and Uttar Kannada showed interesting facts about Meliponiculture activity. Amongst the visited districts, Bangalore and Kalasa of Chikkamagalore district had more Meliponiculturists (16% each) followed by Kodagu and Sagar of Shimoga district, where only few beekeepers (8% each) are rearing stingless bees. Around 48% beekeepers are conducting Meliponiculture on part-time basis and 44% beekeepers are doing Meliponiculture on full-time basis. Interestingly, Meliponiculture activity is being practised by Doctors, Government Employees and Non-government Employees in this part of the state. This clearly indicated that Meliponiculture activity is not conducted as main occupation, but it is being practised as subsidiary activity along with beekeeping activity using *Apis* species and at many places Meliponiculture is an infant stage. The legacy of stingless bees in terms of pollination and honey production in the name of Meliponiculture is set on (Michener, 2013) long back across the world. Beekeepers

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are getting wide scope and opportunities in Meliponiculture at global level, despite there are some challenges prevailed with this activity (Cortopassi-Laurino *et al*., 2006). However, at different districts of Karnataka, stingless beekeeping is being practised on small, medium and large scale basis respectively 68, 12 and 8% and few beekeepers are doing this for house hold purpose. Moreover, beekeepers are using five types of honeybee species (e.g. *Apis cerana*, *A. mellifera*, *A. dorsata*, *A. florea*, *Trigona* or *Tetragonula* species) to produce honey. Of all, *Apis cerana* used predominantly (64%) and it was followed by *A. cerana* and *A. mellifera* together (20%), and only 8% beekeepers are using stingless bees such as *Trigona* or *Tetragonula iridipennis* to produce honey. Hence, stingless beekeeping is not so popular in this part of the state and it requires more publicity, training and scientific awareness among the beekeepers. Published reports are available on various aspects stingless bees. The stingless bee's biology, nests, nest characteristics (Bassindale, 1955; Roubik, 1983 and Wille, 1983), queens and drones rearing (Van-Veen *et al*., 2004; Pooja and Khan, 2015), novel and innovative techniques for stingless bees rearing (Faustino *et al.*, 2000; Virkar *et al*., 2014; Prem and Jose, 2016; Singh, 2016; Mythri *et al.*, 2018; Heena and Basavarajappa, 2023), foraging ecology, foraging behavior and floral source (Slaa *et al*., 2000 and 2006; Danaraddi, 2007; Raju, 2009; Sheetal, 2009; Managanvi *et al.*, 2012; Swetha, 2013; Layek and Karmakar, 2018; Layek *et al*., 2021), natural enemies of stingless bees (Devanesan *et al*., 2003; Vijayakumar *et al*., 2013). All these published reports could be used to know about the resources availability and locally available technology to conduct Meliponiculture (Nair, 2003) to a greater extent. Now, it is possible to rear the stingless bees under domesticated conditions (Singh, 2013) at different parts of Karnataka.

Further, during the present investigation, to rear stingless bees, 16 different types of materials were used at different districts of Karnataka. Of all, wooden boxes were predominantly used (47.8%) and it was followed by Areca nut and Bamboo logs (10.9%) were used to rear stingless bees. Moreover, Bamboo logs, wooden boxes, PVC pipes, Glass boxes and Plywood sheet made boxes were also used for stingless beekeeping activity. Further, wood logs, PVC-thermo coal coating pipes, coconut shells, mud pots, clay pots, Acacia wood longs, Areca nut logs, wood polymer composite and Terra-cotta-clay pots were also used during stingless bees rearing at different districts of Karnataka. Hence, more scope is prevailed to make use of locally available materials, left over plastic or thermo coal sheets and clay pots for making hive boxes to rear stingless bees, thereby, it is possible to reduce the investment on Meliponiculture activity. Surprisingly, very little quantity of stingless bee honey produced compared to *Apis* species in this part of the state. Highest (52%) beekeepers produce 100 to 300gram stingless bee honey along with the honey produced by rearing *Apis* species. Some beekeepers produced 100 to 500 gram, 200 to 400 gram and 500 to one kilogram of stingless bee honey. To produce stingless bee honey, majority (44%) of the beekeepers required one to two months, some beekeepers took three to six months (32%) and four to eight months (16%) in this region. Bassindale (1955), Roubik (1983) and Wille (1983) have studied the stingless bee's biology, nests of stingless bees and nest characteristics that helped to a greater extent to initiate Meliponiculture activities at Mesoamerica, Costa Rica, Australia and Angola (Kent, 1983; Sommeijer, 1996; Heard and Dollin, 2000 and Armor, 2005) and at lowland Dipterocarp forests of Sabah, Malaysia (Eltz *et al.*, 2002; Nogueira-Neto, 2002 and Eltz *et al.*, 2003). Moreover, many beekeepers are producing queens and drones of stingless bees (e.g. *Melipona beecheii*) (Van-Veen *et al*., 2004) and developed the technique to rear queens during the emergency time of need (Faustino *et al.*, 2000). Further, Pooja and Khan (2015) have assessed the foraging activity in queen and queen less colonies and the flight range and resource loading-unloading behavior of *T. iridipennis* (Layek *et al*., 2021). Further, the novel and innovative techniques in Meliponiculture has been published by Prem and Jose (2016) that could help divide the stingless bee nests (e.g. *T. iridipennis*) during their rearing (Virkar *et al.*, 2014 and Mythri *et al.*, 2018). Moreover, published information is available on the traditional Meliponiculture (Singh, 2016) and the eduction of stingless bees from their natural colonies at human modified habitats (Heena and Basavarajappa, 2023). All these reports help undertake suitable measures to improve the honey production potential from stingless bee colonies. In this regard, further in depth investigations are required to update the Meliponiculturists with modern beekeeping techniques in this part of the state. On this line, concerned Apiculture Department from local Government should initiate the programs to update the beekeepers in general and Meliponiculturists in particular. Interestingly, majority (80%) of the beekeepers produce stingless bee honey for getting seasonal income periodically. However, some beekeepers produce stingless bee honey for house hold purpose and they earn on an average rupees 1,000/- to 3,900/- by the sale of stingless bee honey. And, it varied considerably among the beekeepers at different districts of Karnataka. Perhaps, it was due to season, availability of honey and number of beekeepers practicing stingless beekeeping. Despite little honey production by stingless bees, it was observed that there is a lot of demand for stingless bee honey in Karnataka.

Besides, stingless bees (e.g. *T. irridipennis*) have many natural enemies in the nature. Devanesan *et al*. (2003), Vijayakumar *et al*. (2013) have recorded the infestation of *Carpoglyphus lactis* (Acari: Carpoglyphidae) mite on *T. iridipennis*. During the present investigation, 8 pests and 8 predators were reported at the apiary, where Meliponiculture activities were conducted. The small hive beetle, moth and resin beetle species were commonly interfered with the stingless bees and their incidence at different Meliponiculturists. Of all, wax moth infestation was high (78.2%), whereas, small hive beetle infestation was only 8.7%.

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Further, seven types of predators namely: ants, wasps, spiders, lizards, monkey, hornets and wood borers were interfered with normal practising of stingless bees rearing at different districts of Karnataka. Amongst all the predators, ants, spiders, wasps and lizards interference was high (13.7% each) and quite interestingly, these predators interference was rarely alone but occurred together during stingless bees rearing. However, remaining predator's interference was less (4.5%). Thus, predators also interfere with stingless beekeeping activity at different districts of Karnataka. Our observations are on par with the observations of Devanesan *et al*. (2003) and Vijayakumar *et al*. (2013). Despite, all the above mentioned constraints and challenges, there is a wide scope prevailed to do Meliponiculture at different places in India (Karthick *et al.*, 2018; Charanakumara *et al.*, 2022) to showcase its cultural importance to the future generation. In India and other parts of the world, published clearly indicated that the resources availability to conduct Meliponiculture (Nair, 2003). Stingless bees are native pollinators, their presence is very important for the management of crop pollination (Muthuraman *et al.*, 2012) and crop yield (Layek *et al*., 2022). Therefore, assessment of native pollinators like stingless bees help know the potential opportunities for Meliponiculture activities and to manage the local biodiversity to a greater extent. In this regard, our observations are corroborate the observations of Mohan and Devanesan (1999), Slaa *et al*. (2000), Swaminathan (2000), Devanesan *et al.* (2003), Byarugaba (2004), Patnaik and Prasad (2006), Slaa *et al.* (2006), Danaraddi (2007), Raju (2009), Velmurugan (2011), Muthuraman *et al*. (2012), Managanvi *et al.* (2012), Kumar *et al.* (2012), Ayala *et al.* (2013), Eteraf-Oskouei and Najafi (2013), Pavithra *et al.* (2013), Swetha (2013), Vijayakumar *et al*. (2013), Rahman *et al.* (2015), Roopa *et al.* (2015), Singh (2016), Layek and Karmakar (2018) and Charanakumara *et al.* (2022).

V. CONCLUSION

With the help of stingless bees, it is possible to understand the indigenous knowledge of different tribes (e.g. Abayanda, Jeenu, Kurabha, Soliga, Kani, Naga and Korava tribes) who are living at forests and other parts of the world. So, published reports on various aspects of stingless bee species could help undertake Meliponiculture activities at a greater level at different parts of Karnataka**.**

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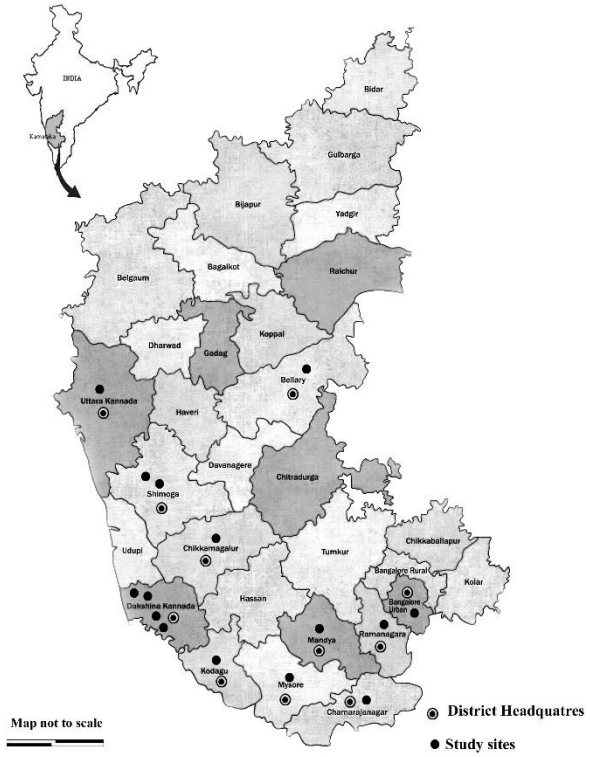

Figure 1. Map showing the study sites in different districts of Karnataka

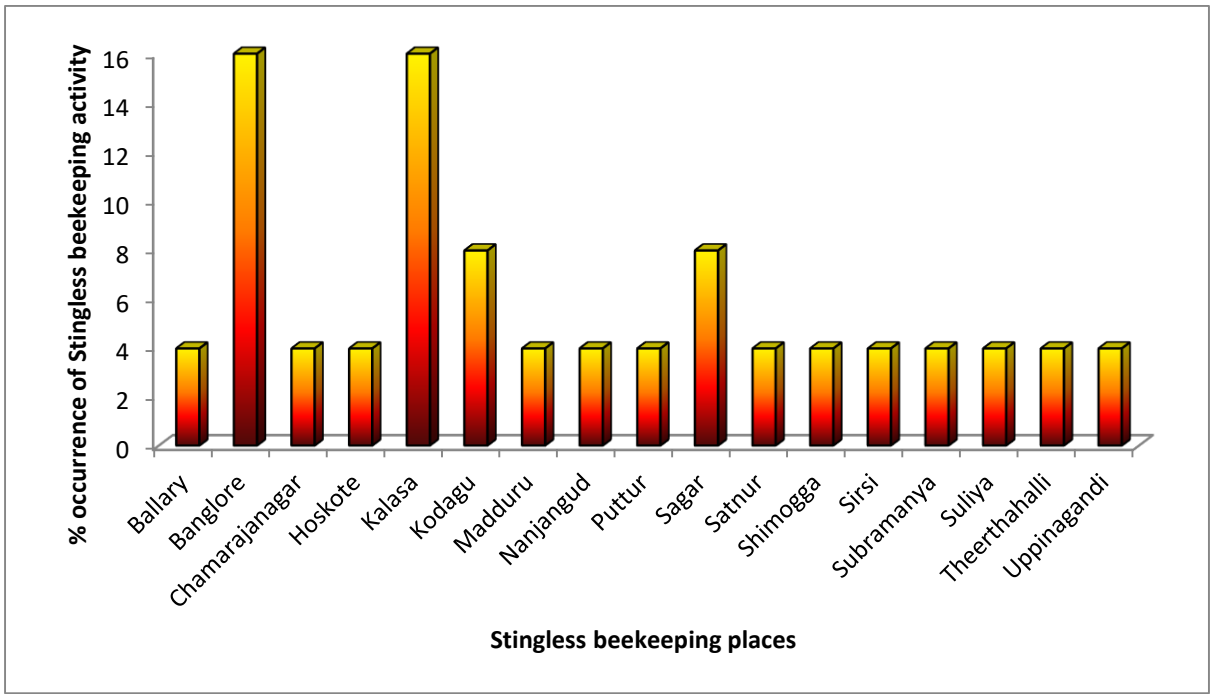

Figure 2. Meliponiculturists found at different places in Karnataka

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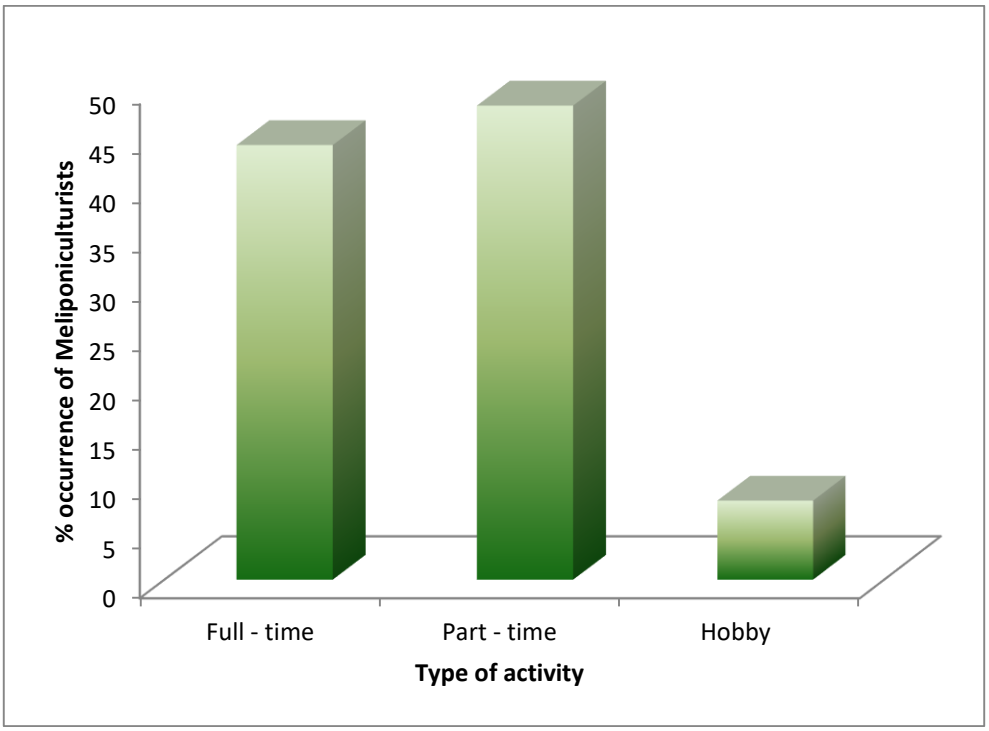

Figure 3. Stingless beekeeping activity undertaken by Meliponiculturists

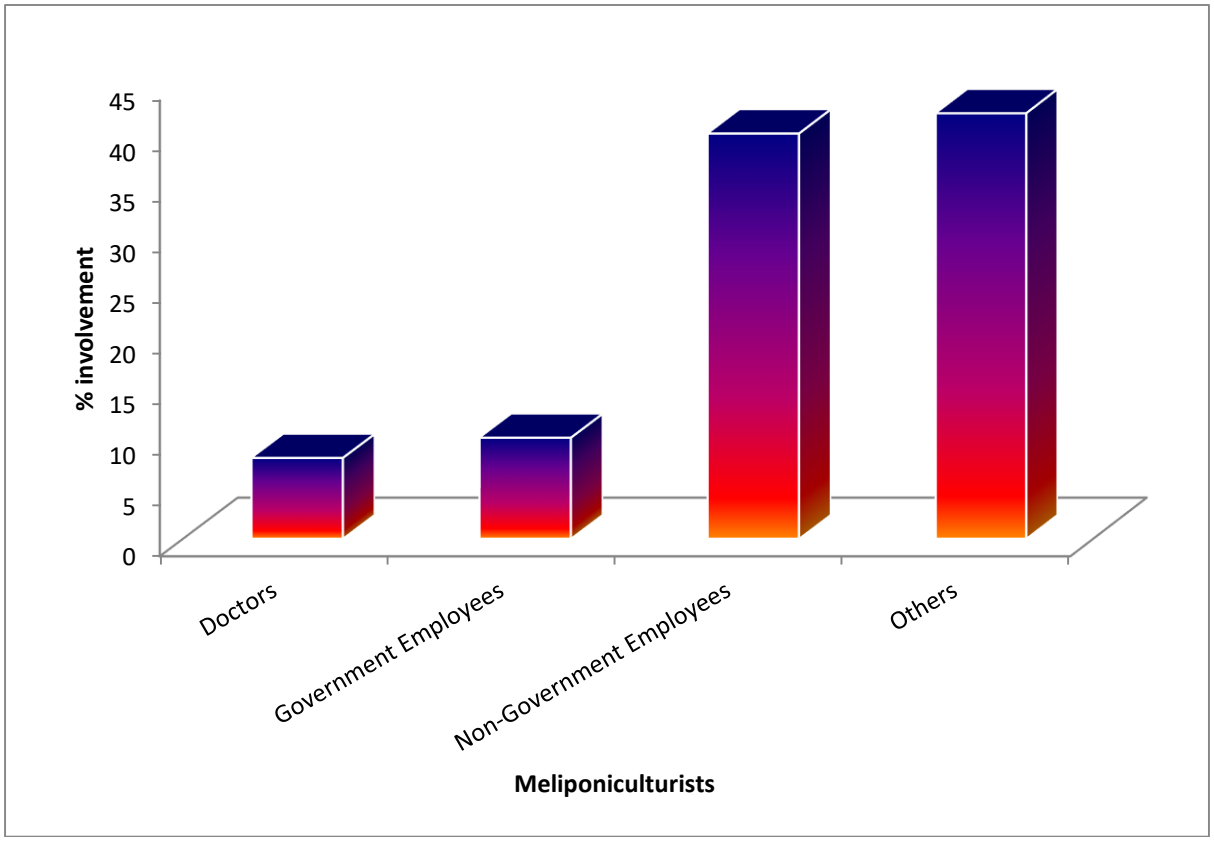

Figure 4. Different people practicing Meliponiculture activity

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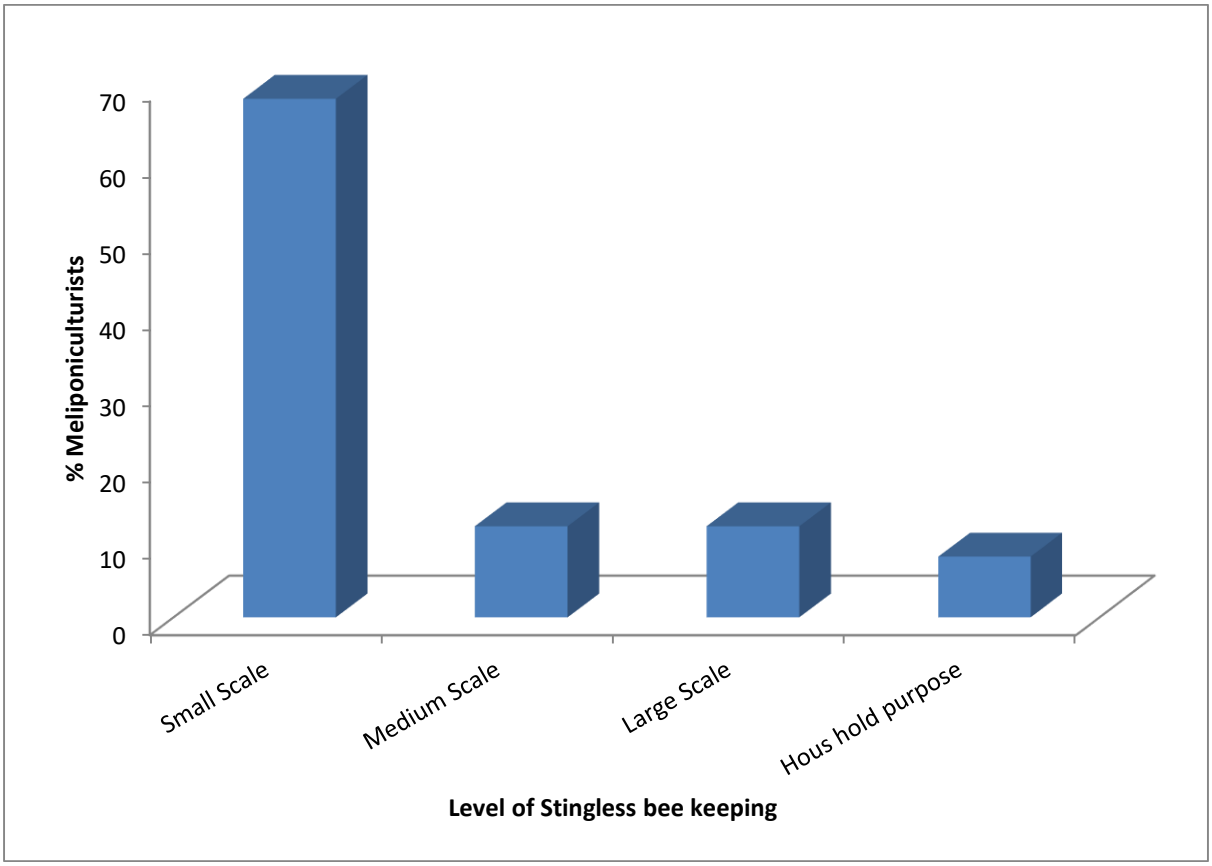

Figure 5. Status of stingless beekeeping activity

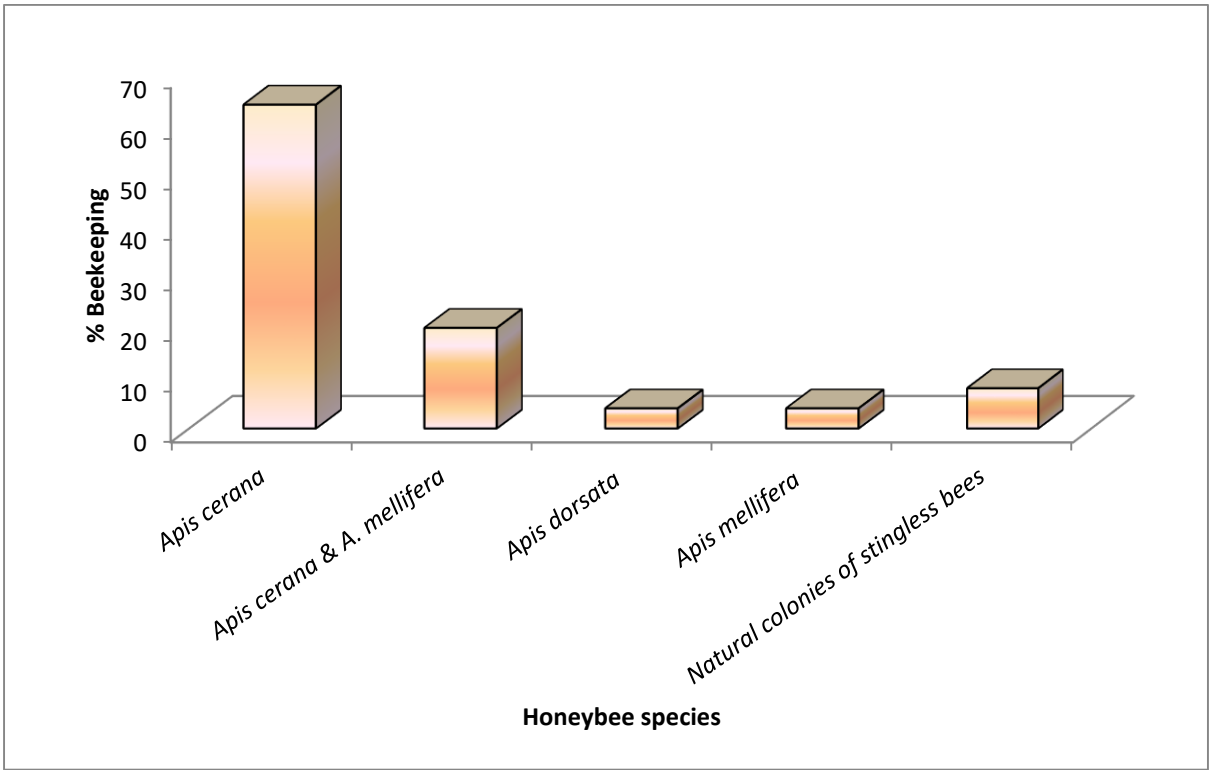

Figure 6. Honeybee species used for beekeeping activity

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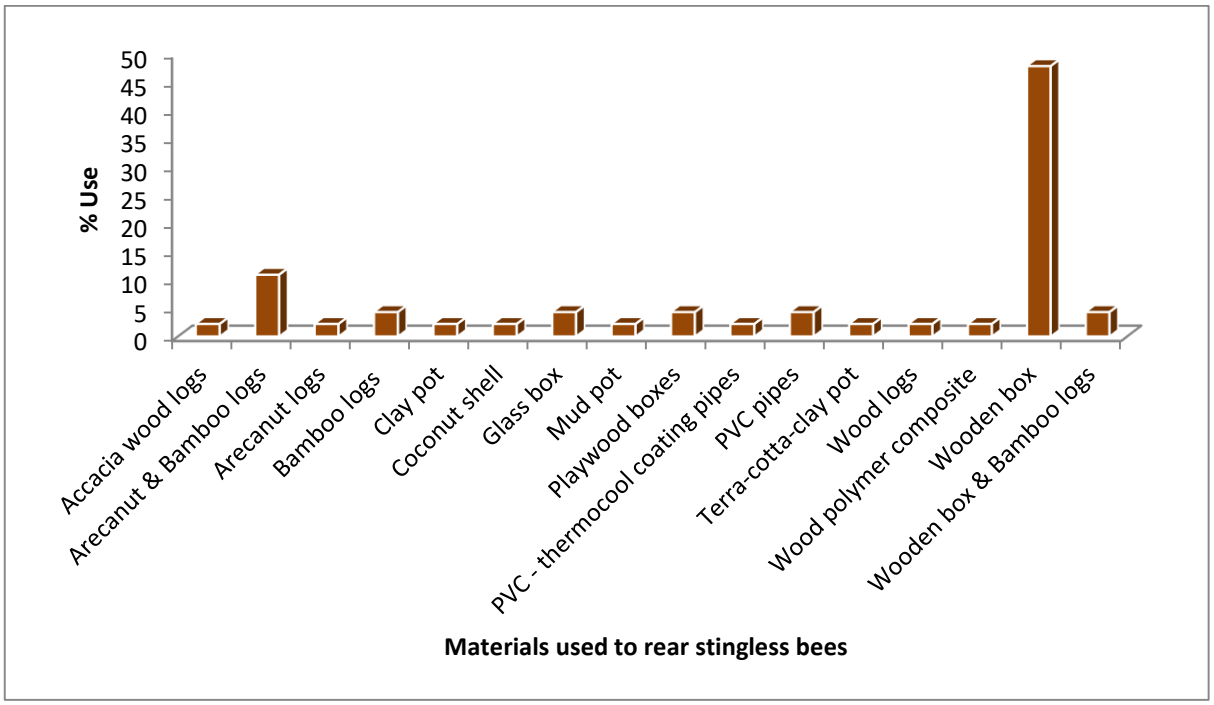

Figure 7. Various materials used to prepare hive boxes for rearing stingless bees

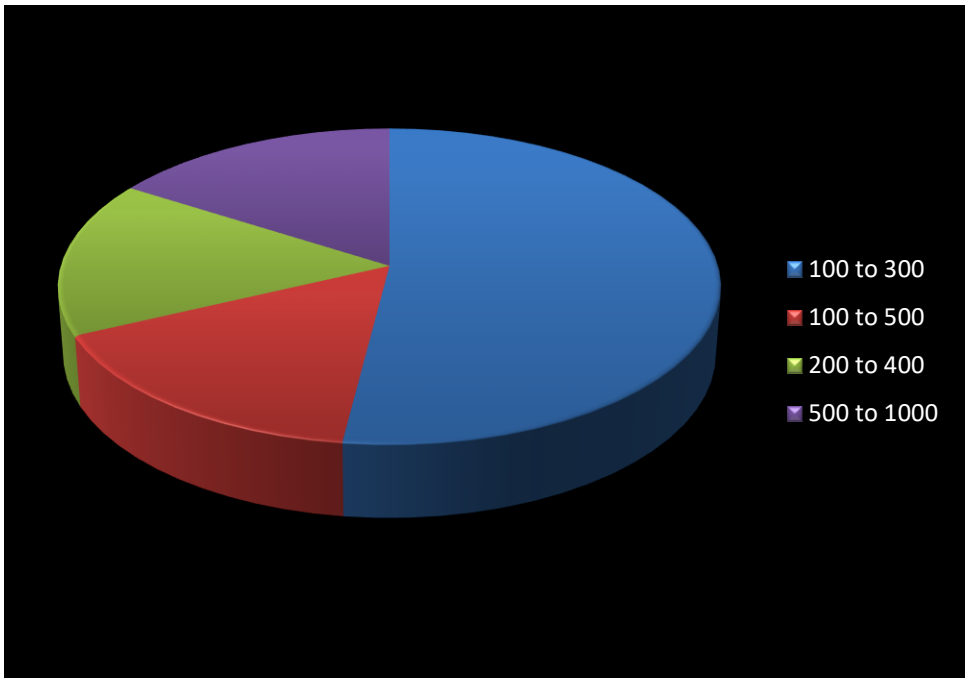

Figure 8. Stingless bee honey produced by Meliponiculturists

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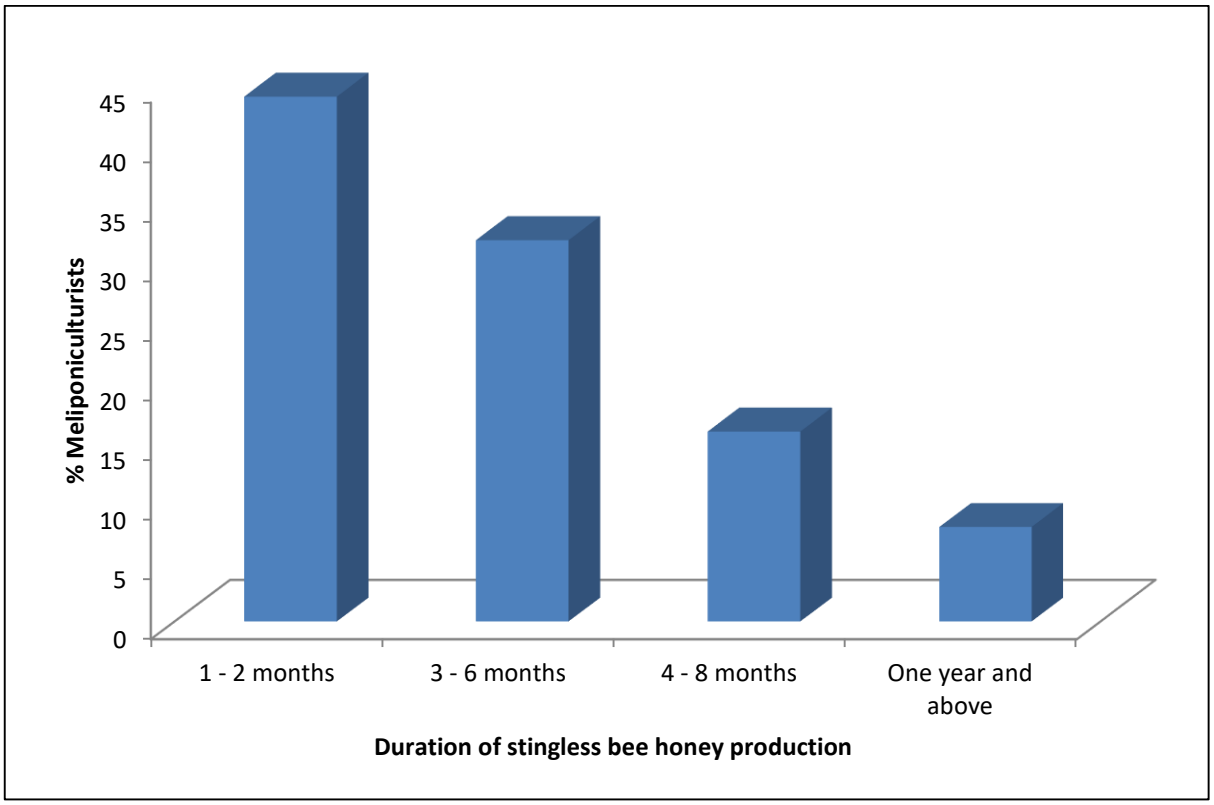

Figure 9. Duration taken to produce stingless bee honey by Meliponiculturists

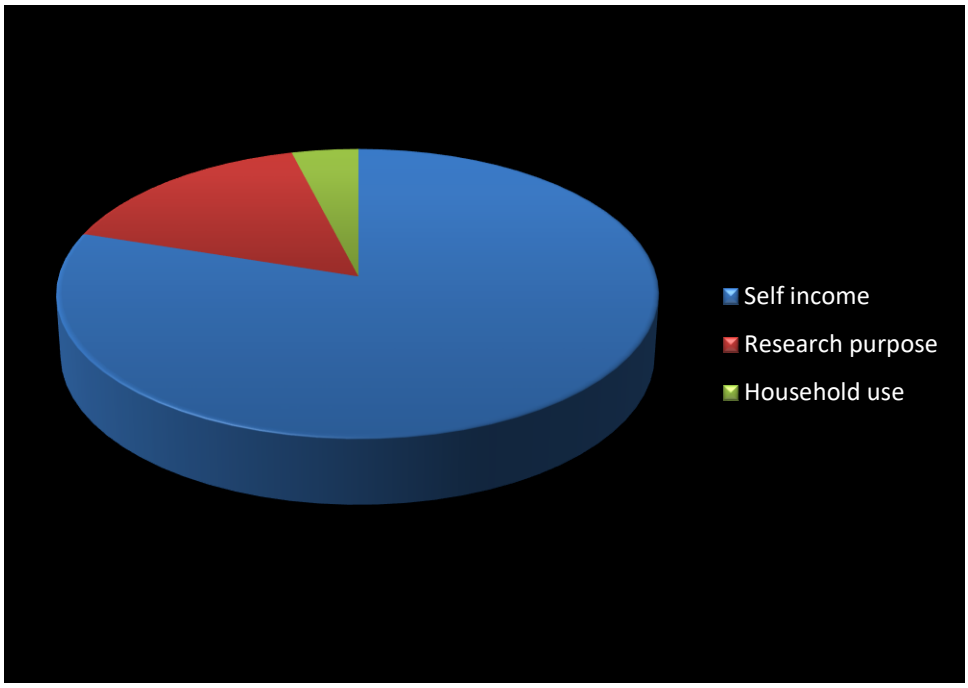

Figure 10. Purpose of stingless bee honey produced by **Meliponiculturists**

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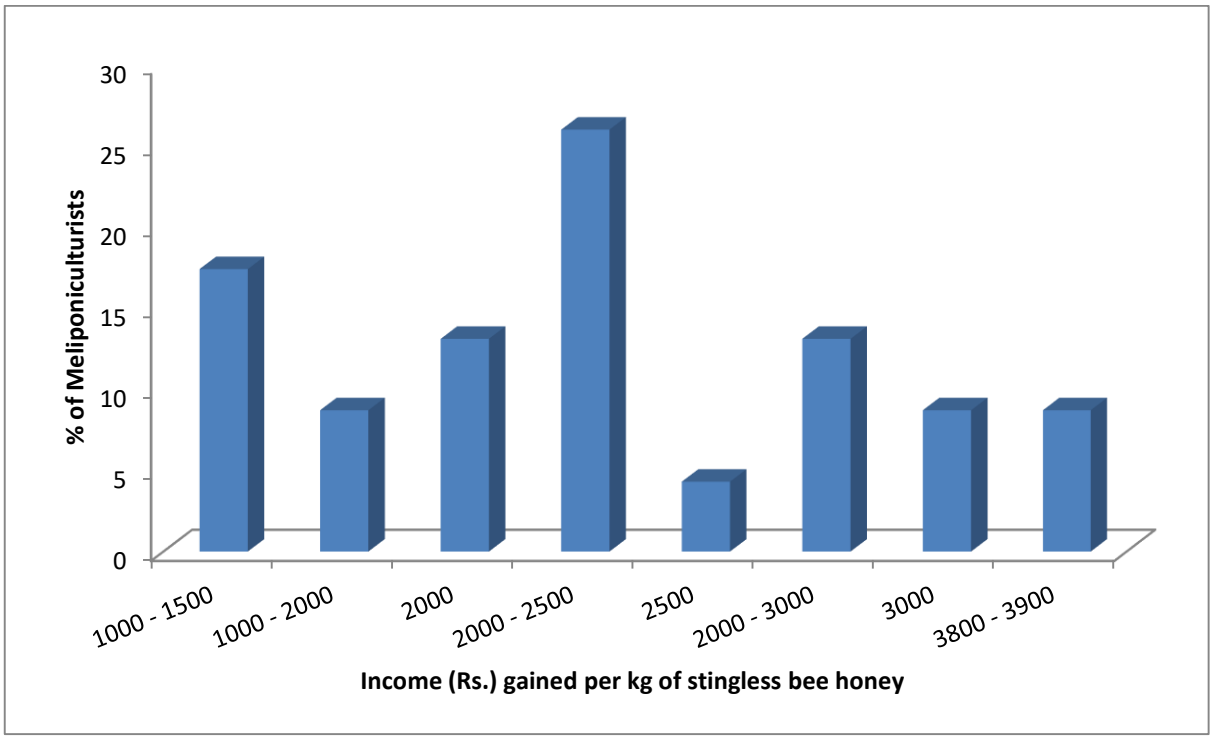

Figure 11. Income produced per kilogram of stingless bee honey by Meliponiculturists

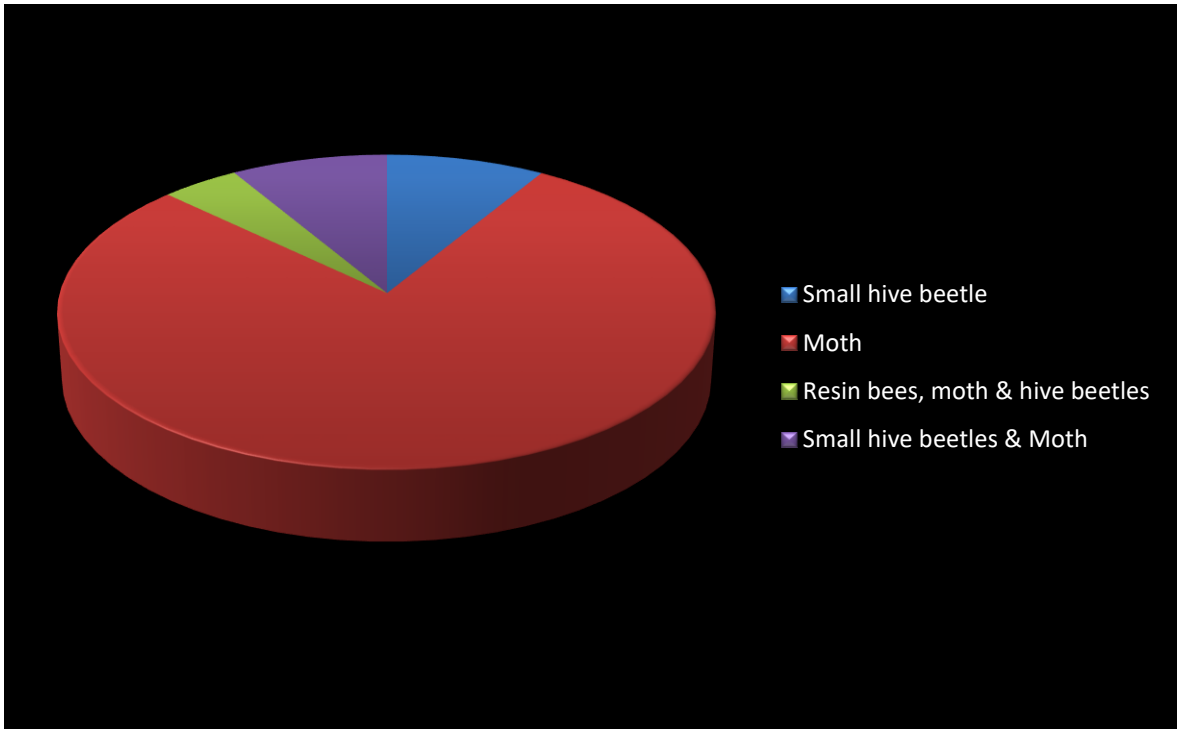

Figure 12. Per cent occurrence of pest infestation to stingless bee colonies

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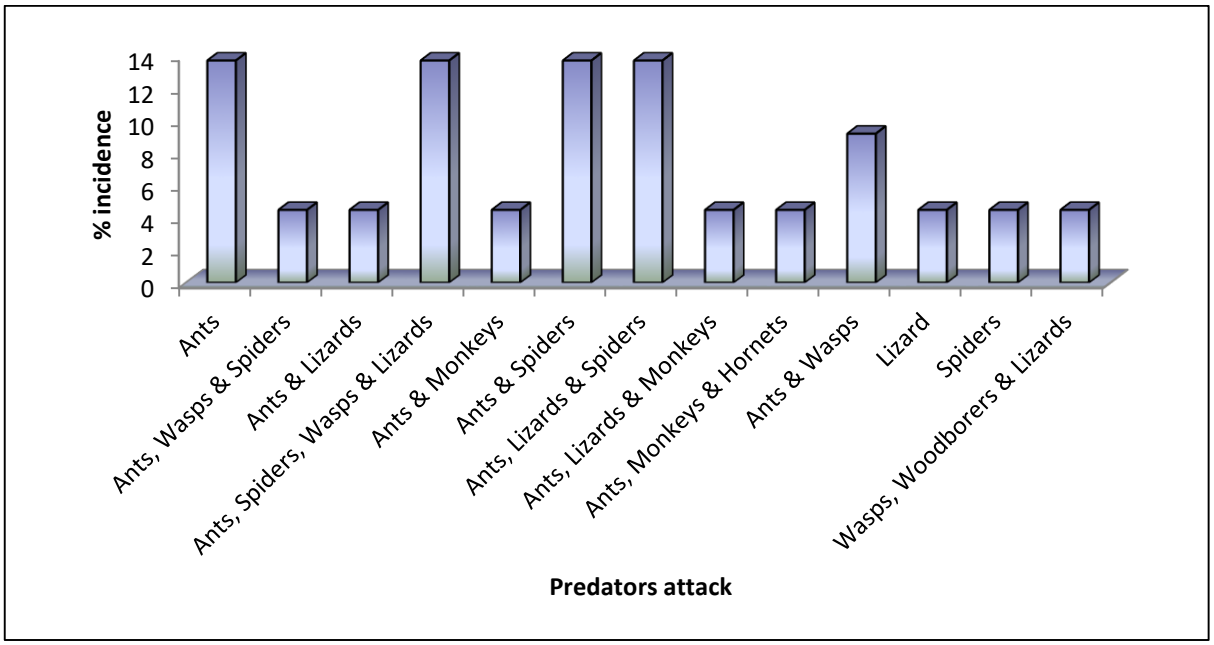

Figure 13. Incidence of predators attack to stingless bee colonies

Table 1. Published reports on stingless bees and Meliponiculture activities at different countries in the world

Sl. No.	Researched on	Country	Reference
1.	Nest and colony characteristics of stingless bees	Panama	Roubik, 1983
2.	Biology of stingless bees	Costa Rica	Wille, 1983
3.	Status of beekeeping with stingless bees	Brazil	Crane, 1992
4.	Tropical beekeeping and tropical bees	Costa Rica	Sommeijer, 1996
5.	Role of stingless bees in crop pollination	Australia	Heard, 1999
6.	Stingless beekeeping	Australia	Heard & Dollin, 2000
7.	Use of stingless bees for commercial pollination	United Kingdom	Slaa *et al*., 2000
8.	Bees of the World: The tribe Meliponini	California	Michener, 2000
9.	Stingless bees nest density in lowland Dipterocarp forests	Malaysia	Eltz *et al*., 2002
10.	Emergency queen rearing in stingless bees	Malaysia	Faustino *et al*., 2002
11.	Nesting sites and abundance of Meliponini in heterogeneous habitats of the Atlantic rain forest	Brazil	Batista *et al*., 2003
12.	Nesting and nest trees of stingless bees	Malaysia	Eltz *et al*., 2003
13.	Stingless bees of Bwindi impenetrable forest	Uganda	Byarugaba, 2004
14.	Comparison of the antimicrobial activity of honey produced by *Tetragonisca angustula* and *Apis mellifera*	Costa Rica	DeMera &Angert, 2004
15.	Production of queens and drones in *Melipona beecheii*	Netherland	Van-Veen *et al*., 2004
16.	Breeding, conservation and economic value of bees	Brazil	Velthuisand van-Doorn, 2004
17.	Stingless bees	Angola	Armor, 2005
18.	Production of sexual in the stingless bees	Vietnam	Chin and Sommeijer, 2005
19.	Taxonomic revision of the African stingless bees	Africa	Eardley, 2005
20.	Global Meliponiculture: Challenges and opportunities	Brazil, South Africa, Australia	Marilda *et al*., 2006
21.	Stingless bees practice and perspectives	United Kingdom	Slaa *et al*., 2006
22.	Composition of stingless bee honey	Australia	Souza *et al*., 2006
23.	South-east Asian stingless bees of the genus *Tetragonula*	Thailand	Engel *et al*., 2017
24.	Body size influences stingless bee	Brazil	Mayes *et al*., 2019

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Table 2. Published reports on stingless bees and Meliponiculture activities in India

Sl. No.	Researched on	Place	Reference
1.	Dammer bees or stingless bee, *Trigona iridipennis*	Kerala	Mohan & Devanesan, 1999
2.	Behavior of *T. iridipennis*	India	Raakhee & Devanesan, 2000
3.	Stingless bees	Tamil Nadu	Swaminathan, 2000
4.	Natural enemies of *T. iridipennis*	Kerala	Devanesan *et al.*, 2003
5.	Apiculture resource biodiversity and management	Kerala	Nair, 2003
6.	Nesting behavior of *T. iridipennis*	India	Patnaik & Prasad, 2006
7.	Stingless bee, *Trigona iridipennis* foraging behavior and melissopalynology	Dharwad	Danaraddi, 2007
8.	Nesting ecology and flora of *T. iridipennis*	Mysore	Sheetal, 2009
9.	Spatial distribution of *T. iridipennis*	Mysore Karnataka	Sheetal & Basavarajappa, 2009
10.	Morphometric study of *T. iridipennis*	Karnataka	Danaraddi & Shashidhar, 2009
11.	Foraging sources of honey bees and stingless bees	India	Raju *et al.*, 2009
12.	Nesting behavior and floral resources of *T. laeviceps*	Pantnagar	Velmurugan, 2011
13.	Antimicrobial activity of stingless bee, *Trigona* sp., propolis	Maharashtra	Choudhari *et al*., 2012
14.	Foraging activity of *T. laeviceps*	Pantnagar	Managanvi *et al*., 2012
15.	Morphometric study of *T. iridipennis*	India	Danaraddi *et al*., 2012
16.	Bio-ecology and management of stingless bees for crop pollination	Haryana	Muthuraman *et al.*, 2012
17.	Traditional beekeeping with *Trigon* sp.	Tamil Nadu	Suresh Kumar *et al*., 2012
18.	Nesting pattern of *T. iridipennis*	Karnataka	Pavithra *et al*., 2013
19.	Floral diversity of stingless bees	Bangalore	Shwetha, 2013
20.	Domestication of *Trigona iridipennis*	India	Singh, 2013
21.	Nesting pattern of *T. iridipennis*	Karnataka	Nayak *et al*., 2013
22.	Anticancer activity of Indian stingless bee propolis	India	Choudhari *et al.*, 2013
23.	Infestation of *Carpoglyphus lactis* on *T. iridipennis*	India	Vijayakumar *et al*., 2013
24.	Stingless bees	India	Rasmussen, 2013
25.	Nest duplication of *T. iridipennins*	India	Virkar *et al*., 2014
26.	Taxonomic notes on *Trigona* (*Tetragonula) iridipennis*	India	Vijayakumar & Jeyaraaj, 2014
27.	Nesting characteristics and biology of *T. iridipennis*	Bangalore	Roopa *et al.*, 2015
28.	Comparative foraging activity in queen right and queen less colony of *T. iridipennis*	Pantnagar	Pooja & Khan, 2015
29.	Stingless bees diversity and distribution	India	Rahman *et al*., 2015
30.	Traditional Meliponiculture	Nagaland	Singh, 2016
31.	Wing morphometric of *T. iridipennis*	India	Francoy *et al*., 2016
32.	Prospects and challenges in Meliponiculture	Tamil Nadu	Karthick *et al*., 2018
33.	Nesting characteristics, floral resources and foraging activity of *T. iridipennis*	West Bengal	Layek & Karmakar, 2018
34.	Flight range and resource loading-unloading behavior of *T. iridipennis*	India	Layek *et al*., 2021
35.	Supplemental stingless bee pollination	India	Layek *et al*., 2022
36.	Current status of Meliponiculture	Western Ghats	Charanakumar *et al.*, 2022
37.	Description of five new species of *Tetragonula* sp.	India	Viraktamath & Roy, 2022
38.	Spatio-temporal distribution of stingless bee	Karnataka	Gopinatha & Basavarajappa, 2023
39.	Morphometric studies of *T. iridipennis*	Gujarat	Sharma *et al*., 2023
40.	Eduction of stingless bees	Karnataka	Shaguftha & Basavarajappa, 2023

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Table 3. Physiographic details and environmental factors of few districts of Karanataka

Sl. No.	District	Latitude	Longitude	Altitude (in meters)	Tempr. (^{0}C)	RH (%)	Rain fall (mm)	Major Crops Grown
1.	Chamarajanagar	11°55'41"N	76°56'37"E	730.0	28.0 to 29.0	42.0	2.62	**Fruits:** Banana, Mango, Sapota, Papaya & Pomegranate. **Vegetables:** Tomato, Beans, Brinjal, Green Chilies & Leafy vegetables. **Plantation crops:** Coconut, Pulses & Horse gram. **Oilseed crops:** Groundnut, Sunflower & Sesame.
2.	Kodagu	12°22'14"N to 12°13'17"N	75°48'21"E to 75°48'08"E	1,216	30.0 to 32.0	58.0	2.08	**Agricultural crops:** Paddy and Pepper **Commercial crops:** Coffee. **Fruits:** Orange Pepper as agro-forestry crops. **Plantation:** Agro-forestry
3.	Bangalore	12°59'16"N to 12°58'56"N	77°35'42"E to 77°35'30"E	913.0	29.0 to 32.0	29.0	2.18	**Agricultural crops:** Paddy, Rice, Ragi, Corn, Pulses & Peanut **Commercial crops:** Sugarcane & Mulberry **Fruits:** Grapes. **Oilseed crops:** Castor
4.	Mysore	12°17'57"N to 12°06'52"N	76°38'18"E to 76°40'25"E	778.0	29.0 to 31.0	22.0	1.93	**Agricultural crops:** Paddy, Ragi & Jowar **Commercial crops:** Tobacco, Cotton, Sugarcane, Ginger & Turmeric **Plantation crops:** Coconut, Mango, Sapota & Banana **Vegetables & other crops:** Mysorumallige & Mysoruchigurele. **Fruits:** Nanjungud Rasabale,
5.	Chikmagaluru	13°19'11"N to 13°14'07"N	75°46'18"E to 75°47'16"E	1,059	32.0 to 35.0	50.0	2.05	**Agricultural crops:** Paddy, Ragi & Jawar **Commercial crops:** Coffee, Spices, Black Pepper, Cardamom, Cinnamon, Clove & Nutmeg.
6.	Ballary	15°08'38"N	76°56'16"E	480.0	42.0 to 42.0	14.0	1.13	**Commercial crops:** Cotton. **Agricultural crops:** Paddy, Jowar & Cereals **Oilseed crops:** Sunflower & Ground nut
7.	Uttara Kannada	14°52'14"N	74°40'42"E	524.0	38.0 to 39.0	22.0	1.32	**Agricultural crops:** Paddy **Plantation crops:** Orchards of Betel nut, Betel vines, Pepper, Cardamom & Nutmegs. **Fruits:** Banana
8.	Dakshina Kannada	12°52'36"N to 12°48'56"N	75°14'52"E to 75°11'37"E	121.0	26.0 to 27.0	94.0	3.21	**Plantation crops:** Coconut, Areca nut, Cashew nut, Rubber, Coco & Black pepper. **Fruits:** Banana, Sapota, Papaya & Jackfruit. **Vegetables:** Okra, Gourds, Cowpea, Brinjal & Leafy vegetables.
9.	Shivmoga District	13°55'53"N to 13°55'42"N	75°34'05"E to 75°33'57"E	611.0	23.0 to 27.0	83.0	1.27	**Plantation crops:** Sandalwood, Rosewood, Teak, Tamarind & other exotic timber yielding trees. Areca nut, Cashew nut & Pepper **Fruits:** Mango and Jackfruit. **Agricultural crops:** Paddy, Cotton, Maize, Oil seeds, Chili, Ginger & Ragi.

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Table 4. Meliponiculture activity recorded at different districts of Karnataka

Sl. No.	Place	No. of Meliponiculturists	Meliponiculture activity			Practicing Meliponiculture by			Level of Meliponiculture activity			
			Sl. No.	Type	No's.	Sl. No.	People	No's.	Sl. No.	Level	No. of Colonies	No's.
1.	Bellary	1	1.	Full-time	11	1.	Doctors	2	1.	Large scale	200 and above	3
2.	Bangalore	4	2.	Part-time	12	2.	Govt. Employees	3	2.	Medium scale	100 to 199	3
3.	Chamaraja nagara	1	3.	Hobby	2	2.	Non-Govt. Employees	10	3.	Small scale	11 to 99	17
4.	Hoskote	1				3.	Others	10	4.	House hold purpose	5 to 10	2
5.	Kalasa	4										
6.	Kodagu	2										
7.	Maddur	1										
8.	Nanjangudu	1										
9.	Sagar	2										
10.	Sirsi	1										
11.	Satnur	1										
12.	Shimoga	1										
13.	Subramanya	1										
14.	Suliya	1										
15.	Uppinagadi	1										
16.	Puttur	1										
17.	Thirthallai	1										
Total		25	Total		25	Total		25	Total			25
			Mean ± SD		8.3 ± 5.5	Mean ± SD		6.3 ± 4.4	Mean ± SD			6.3 ± 7.2

Note: Each value is a mean of three observations.

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Table 5. Stingless bee species, hive box materials and honey production in Karnataka

Honeybee species used			Materials used to rear stingless bees			Quantity of stingless bee honey produced			Stingless bee honey produced for			Income Generated from stingless bee honey sale		
Sl. No.	Honeybee species	No. of Beekeepers	Sl. No.	Name of Material	No's.	Sl. No.	Honey production (in gm.)	No's.	Sl. No.	Purpose	No's.	Sl. No.	(Kg/Rs.)	No's.
1.	*Apis cerana*	16	1.	Wooden box	22	1.	100 to 300	13	1.	Self-income	20	1.	2000/-	3
2.	*A. cerena* & *A. mellifera*	5	2.	Both wooden box & Bamboo logs	2	2.	100 to 500	4	2.	Education/ Research purpose	4	2.	2000/- to 2,500/-	3
3.	*A. dorsata*	1	3.	Bamboo logs only	2	3.	200 to 400	4	3.	House hold	1	3.	2,000/- to 2,500/-	6
4.	*A. mellifera* alone	1	4.	Wood logs	1	4.	500 to 1000	4				4.	3,000/-	2
5.	Stingless bees	2	5.	PVC Pipes	2							5.	2,500/-	1
Total		25	6.	Arecanut & Bamboo logs	5							6.	1,000/- to 2,000/-	2
			7.	PVC-thermacoal coating pipes	1							7.	1,000/- to 1,500/-	4
			8.	Glass boxes	2							8.	3,800/- to 3,900/-	2
			9.	Coconut shell	1									
			10.	Mud pots	1									
			11.	Clay pot	1									
			12.	Acacia wood logs	1									
			13.	Arecanut logs	1									
			14.	Wood polymer composite	1									
			15.	Plywood boxes	2									
			16.	Terra-cotta-clay pot	1									
			Total		46	Total		25	Total		25	Total		23
Mean ± SD		5.0 ± 2.8	Mean ± SD		2.9 ± 5.2	Mean ± SD		6.3 ± 4.5	Mean ± SD		8.3 ± 10.2	Mean ± SD		2.9 ±1.5

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Table 6. Incidence of pests and predators interferences to stingless bees during their culture in Karnataka

Pests incidence			Predators incidence		
Sl. No.	Name of Pest	No's.	Sl. No.	Name of Predator	No's.
1.	Small Hive Beetle	2	1.	Ants	3
2.	Wax Moth	18	2.	Ants, Wasps & Spiders	1
3.	Resin bees, Wax Moth and Hive Beetles	1	3.	Ants & Lizards	1
4.	Both small Hive beetles & Wax Moth	2	4.	Ants, Spiders, Wasps & Lizards	3
			5.	Ants & Monkeys	1
			6.	Ants and Spiders	3
			7.	Ants, Lizards & Spiders	3
			8.	Ants, Lizards & Monkeys	1
			9.	Lizards	1
			10.	Ants, Monkeys & Hornets	1
			11.	Ants & Wasps	2
			12.	Wasps, Wood borers & Lizards	1
			13.	Spiders	1
Total		23	Total		23
Mean ± SD		5.8 ± 8.2	Mean ± SD		1.8 ± 0.9

Note: Each value is a mean of three observations.