DISCUSSION

Worker bees nursing a queen cell
The results of the investigations carried out on the morphometry, behavioural traits and melissopalynology of Indian honeybee, *Apis cerana indica* F. are discussed here under.

5.1 Morphometric characters of *Apis cerana indica* F.

Morphometric studies are important research tools that are now being used extensively for the identification of subspecies/geographic ecotypes among different species of honeybees. These methods involve the measurement and analysis of different morphological parts of honeybees which directly or indirectly influence the economic and biological characters such as, honey productivity, wax secretion and pollination activities. Hence, the studies were carried out on Indian honeybee, *Apis cerana indica* F. in different seasons at different locations in Shimoga district. The data were analysed statistically in order to have quantitative estimates of the characters of *Apis cerana indica* F. worker bees collected from different locations in different seasons.

5.1.1 Body length

Biometrical data on body length revealed that the bees from higher elevation places like Megaravalli (12.26 mm) and Bheemanakone (Black Strain) (12.16 mm), were recorded more length compared to those bees collected from lower altitude location like Nittur (10.94 mm). This may be due to variations in climatic conditions and floral variability.
5.1.2 Head

5.1.2.1 Antenna

Antenna is the center of different types of sense perception in all most all insects. In the present study the antennal length increased with increase in altitude. Higher altitude places like Megaravalli (3.86 mm) and Bheemanakone (Black Strain) (3.80 mm), which were recorded longer antenna compared to lower altitude place like Nittur (3.08 mm), was recorded shorter antennal length. The observations are in agreement with the reports of Mattu and Verma (1983) who reported longer antennal length at higher altitude. On the contrary, Akahira and Sakagami (1959b) did not find any relationship between the altitude and antennal length in the Japanese bee *Apis cerana japonica*.

The bees collected during summer season had longer antenna length than the bees collected during winter season. This is in confirmation with the reports of Mattu and Verma (1983). The length of antenna was greater in worker bees during summer than in other seasons of the year. This may be due to variations in climatic conditions and floral availability.
5.1.2.2 Tongue

Tongue length is an important character upon which depends on the quantity of nectar to be gathered by the bees from flowers. It was observed that bees at higher altitude locations like Megaravalli (4.56 mm) and Bheemanakone (Black Strain) (4.42 mm), had longer tongue length than those from bees of lower altitude region like Nittur (4.06 mm). The results are in agreement with the findings of Narayanan et al., (1961a, 1961b), Fernando (1979) and Singh et al., (1989). On the contrary, Mattu and Verma (1983) could not establish any significant positive relationship between the altitude and tongue length of worker bees of *Apis cerana* from the Himachal region of the North-West Himalaya. According to them, the tongue length was influenced by flower morphology than altitude. Further, Jagannadham and Goyal (1980) recorded an increase in tongue length of worker bees reared in combs with larger sized cells. It was also observed that the worker bees collected during summer months had slightly longer tongue length than the bees collected during winter months. The reasons may be due to availability of flora and variation in morphological structure of the flower. However, this needs further investigation.

Bees from higher altitude locations like, Megaravalli (0.32 mm) and Bheemanakone (Black Strain) (0.29 mm) were recorded longer postmentum compared to lower altitude locations viz, Nittur (0.17 mm) and Halasinahalli (0.18 mm) that were recorded shorter postmentum. The reason may be due to climatic variations and type of floral availability in that locality.
The size of the postmentum decreased with decrease in altitude. The results were corroborated with Akahira and Sakagami (1959a) who established significant difference between altitude and length of postmentum in *Apis cerana*.

The prementum length was found longest in bees collected from the higher altitude areas like Megaravalli (1.37 mm) and Bheemanakone (Black Strain) (1.34 mm) than that of the bees obtained from the lower altitude area like Nittur (1.18 mm).

5.1.3 Thorax

5.1.3.1 Forewing length and breadth

Size of the forewing directly affects the flight ability of bees. The biometrical data on the forewings of *Apis cerana indica* F. collected from different locations in different seasons showed that the bees at higher altitude had greater forewing length than those at lower elevations. Similar trend was reported by different workers (Kapil, 1956; Kshirsagar, 1976; Mattu and Verma, 1984c; Singh, 1989). On the contrary, Akahira and Sakagami (1959b) found no relationship between altitude and size of the forewing in the Japanese bees *Apis cerana japonica*. Length of forewing of bees collected during summer season was different with the bees collected during winter season, although bees from summer season recorded higher forewing length (7.80 mm) compared to those from winter season (7.74 mm).
The breadth of forewing of bees from different locations were varied with the altitude. The bees from higher altitude places like Megaravalli (3.22 mm), Bheemanakone (Black Strain) (3.19 mm) and Bheemanakone (Yellow Strain) (3.16 mm) were recorded greater forewing breadth compared to those at lower elevation places like Nittur (3.03 mm) and Halasinahalli (3.09 mm). Bees collected during summer were recorded slightly higher mean forewing breadth (3.15 mm) compared to those from winter season (3.12 mm). This may be due to variations in availability of flora in that locality during different seasons and also due to climatic variations and difference in altitude.

5.1.3.2 Hindwing

The hindwing especially the number of hooks affect the flight ability of bees. In the present investigation, bees from lower altitude were characterized by smaller hindwing compared to that of higher elevations. The results are in agreement with the observations of Jain (1967), Kshirsagar (1976 and 1981) and Mattu and Verma (1984c) who observed that the bees in hilly areas had broader and longer hindwings compared to the bees from plain area. Further, they also noticed a significant difference between altitude and length and breadth of hindwing. The present data showed that the bees collected during summer were recorded higher forewing length and breadth compared to those from winter season. This is in contradictory to the report of Mattu and Verma (1984a) who
reported that the breadth of hindwing was significantly broader in bees collected during different seasons.

The bees from higher altitude usually travel more distance for foraging. The present data indicates that bees from higher elevations like Megaravalli (16.15) and Bheemanakone (Black Strain) (15.85) possessed more number of hooks as compared to the bees from lower region like Nittur (15.10). This is corroborated with the findings of Rayment (1932 and 1935) who reported that the hive bee with 20 hooks could easily return from a distance of 7 miles. However, there was no similar trend in the number of hooks in the bees from North to South India (Kapil, 1956; Jain, 1967; Kshirsagar, 1976; Mattu and Verma, 1984c; Singh, 1989). Further, Alpatov (1929) opined that the honeybee needs more effective wings to fetch nectar from a longer distance. Again the present investigations corroborated with the findings of Sakagami (1959) who reported that no significant difference was found between altitude and number and extent of hamuli for *Apis cerana japonica*. The bees collected during summer season recorded slightly higher number of hooks (15.62) compared to the bees collected during winter season (15.53) and no significant difference was observed between summer and winter bees. This is corroborated with Mattu and Verma (1984a) who claimed that numbers of hamuli were not affected by seasonal variations. Higher altitude bees of the places like Megaravalli (1.18 mm) and Bheemanakone (Black Strain) (1.14 mm) recorded higher extent of hamuli compared to lower
altitude bees of the place like Nittur (1.03 mm) and Halasinahalli (1.05 mm). This may be due to variation in climatic conditions.

5.1.3.3 Corbicula length and breadth

Size of the corbicula directly affects the pollen load carrying capacity of the bees. The biometrical data on the corbicula of *Apis cerana indica* collected from different locations in different seasons showed that the bees at higher altitude had longer and broader corbicula than at lower altitude. In the present investigations, the corbicula length was longest in bees of higher altitude places like Megaravalli (1.16 mm) and Bheemanakone (Black strain) (1.11 mm) and shortest length was recorded in the bees collected from lower altitude place like Nittur (0.90 mm). The corbicula breadth was found highest in the bee samples collected from higher altitude areas like Megaravalli (0.97 mm) and least value was recorded in the bee samples obtained from lower altitude area like Nittur (0.74 mm). This may be due to climatic variations and type of flora availability.
5.1.4 Abdomen

5.1.4.1 Sternite

The morphological characters serve as indices of abdominal size where crop is located in which honey is stored. Higher altitude areas like Megaravalli and Bheemanakone possess abundant floral sources. Studies indicated in these locations that the honeybees possessed larger sized sternites to accommodate larger crop in the abdomen to store more honey. This is in confirmation with Kshirasagar (1976) who reported a definite trend in the size of sternite of *Apis cerana indica* from north to south India. Further, the worker bees of *Apis cerana indica* collected from Kashmir region had significantly bigger sternite and those from Himachal region of North-West Himalaya also established significant difference between altitude and size of sternite.

5.1.4.2 Sting

Each organism on the earth is having its own protective mechanism to survive and continue its generation. Honeybees irrespective of the species possess a sting to protect themselves against natural enemies. The morphological data of sting of *Apis cerana indica* collected from different places in different seasons showed that bees at higher altitudes had longer sting compared to lower altitudes. The results are in agreement with Kshirsagar (1980) who noticed variation in sting characters from 1.02 to 1.67 mm at different elevations. Worker bees collected
during summer season was recorded slightly longer sting (1.69 mm) compared to those bees collected during winter season (1.65 mm).

5.2 Behavioural traits of Indian honey bee *Apis cerana indica* F.

The behaviour of honeybees depends on racial characters of queen bee and the availability of bee flora. The present investigations were undertaken to assess the various behavioural characters of black strain and yellow strain bees of *Apis cerana indica* F. in relation to seasonal variations under the different conditions of Shimoga district.

5.2.1 Pollen load carrying capacity of black and yellow strains of *Apis cerana indica* F.

5.2.1.1 Pollen load carrying capacity during rainy season

Studies indicated that the worker bees of black strain and yellow strain carried less quantum of pollen during June-July months of study period. The amount of pollen carried by both black and yellow strain bees was progressively increased from the beginning of August (3.67 and 3.45 mg, respectively) to the end of the season (5.83 and 5.60 mg, respectively). The reason may be attributed to the availability of pollen grains. The availability of bee flora was very less during early period of rainy season. This is in agreement with the observations of Sharma (1989) who reported less amount of pollen pellets carried by worker bees during rainy season.
Pollen load carried by both black strain and yellow strain bees at 09.00 hr, 12.00 hr and 15.00 hr, were recorded during the rainy season. The both black and yellow strains carried higher amount of pollen (4.75 and 4.53 mg, respectively) at 09.00 hr, than other periods. Verma and Dulta (1986) reported that worker bees carried an average of 9.25, 9.06 and 8.64 mg, pollen from apple blossom in Shimla. Punjabi et al., (1969) recorded that the maximum load of pollen carried by *Apis cerana indica* F. was 0.033 gm from mustard, 0.007 gm from apple. However, Cherian et al., (1946) reported that worker bee of Southern strain carried 0.0106 gm pollen per trip. The reason for more pollen at early hours of the day may be due to high moisture content of the pollen and also source of pollen. In the present study the pollen load carrying capacity of black strain was recorded more compared to that of yellow strain bees. The reason for this may be due to variations in genetic character, pollen preference, foraging efficiency, foraging distance and competition between the species.

5.2.1.2 Pollen load carrying capacity during winter season

The weight of pollen load carried by both black strain and yellow strain was maximum during second half of January, (7.95 and 7.77 mg, respectively) and minimum during second half of March during the entire study period (6.43 and 6.24 mg, respectively). Dhaliwal (1970) reported that average 10.91 mg of pollen is collected by the hill strain of *Apis cerana* and stated that weight of pollen load depends upon the sources of pollen and weather conditions prevailing
during the season. This view also is in agreement with the observations of Sharma (1989).

The weight of the pollen load carried by both black and yellow strain at 09.00 hr (7.30 and 7.07 mg, respectively) was more than at 12.00 hr, (7.09 and 6.90 mg, respectively) and 15.00 hr, (6.95 and 6.79 mg, respectively). Verma and Dulta (1986) reported that the worker bee of *Apis cerana* carried 9.26, 9.06 and 8.64 mg, at 09.00 hr, 12.00 hr and 15.00 hr, respectively. This variation may be due to low temperature, higher humidity and high moisture content in the pollen prevailing in the early hours of the day. Moreover, the worker bees’ efficiency may also be decreased at lower hours of the day due to continuous foraging. The pollen availability may be maximum in the morning hours and bees brought more pollen in the early hours of the day. Among the bee strains, black strain had higher pollen load carrying capacity than yellow strain in the present study. The reason may be due to variations in pollen preference, flora availability, genetic character, foraging distance and competition for pollen between the species.

5.2.1.3 Pollen load carrying capacity during summer season

The results showed that both black and yellow strain bees carried lesser amount of pollen in summer compared to that of winter season. The maximum weight of pollen carried by black strain was 5.30 mg, and by yellow strain bee was 5.12 mg, during first fortnight of April. Bisht and Naim (1979) reported that the average weight of pollen collected from mustard crop was 8.00 mg, per trip.
Dhaliwal (1970) observed that a worker bee of *Apis cerana* carried 10.91 mg. The difference in the amount of pollen carried by the bees at different places might be due to variations in the availability of pollen source and difference in weather conditions. The data on pollen load carried by both black strain and yellow strain bees during different hours of a day during summer season indicated that the bees carried heavy pollen load during morning hours. The weight of pollen pellets carried by black and yellow strain was highest (5.09 and 4.92 mg, respectively) at 09.00 hr, compared to 12.00 hr (4.80 and 4.73 mg, respectively) and at 15.00 hr, (4.71 and 4.61 mg, respectively) during the four years of study period. Verma and Dulta (1986) recorded 9.25, 9.06 and 8.64 mg, of pollen at 09.00 hr, 12.00 hr and 15.00 hr, respectively. These differences in weight of pollen might be due to high humidity, low temperature and more moisture content in the pollen at morning hours. Further, bees' efficiency may be decreased due to continuous foraging as the day advances. In the present studies the black strain had highest (4.87 mg, per trip) pollen load carrying capacity compared to yellow strain bee (4.75 mg, per trip) during the four years of study period. This may be due to availability of pollen source, variation in genetic character, preference for pollen, foraging efficiency, foraging distance and competition for pollen between the species.
5.2.2 Pollen and Honey stores of black and yellow strains of *Apis cerana indica* F.

5.2.2.1 Pollen and Honey stores during rainy season

The area under honey and pollen stores was very much reduced during rainy season (June-November). However, pollen and honey stores progressively increased from August onwards. The highest area under pollen and honey store was observed in both black strain colony (298 and 600 cm², respectively) and yellow strain colony (273 and 586 cm², respectively) during November. Pollen and honey stores will be associated with foraging activity of honeybees and availability of bee flora. Naim and Phadke (1976) observed maximum honey and pollen stores from March to April at Pusa, Bihar. Ramchandran and Mahadevan (1950) reported reduced area under pollen and honey stores at Coimbatore during rainy season with maximum in February. Reddy (1980) recorded greater amount of pollen and honey stores in February at Bangalore. Verma *et al.*, (1988a) reported greater pollen and honey stores in summer and autumn, while minimum in the rainy season. These variations in the results are attributed to availability of bee flora in the various parts of India at different periods. The present study indicates that the black strain colony stored more pollen and honey than the yellow strain colony. The reason may be due to variations in genetic characters, tongue length, floral preference, floral availability and competition in foraging between the species.
5.2.2.2 Pollen and Honey stores during winter season

Mean area under pollen and honey stores was higher in both black strain (303 and 857 cm$^2$, respectively) and yellow strain (279 and 810 cm$^2$, respectively) during winter season than during rainy season (pollen and honey stores in black strain was 133 and 366 cm$^2$, respectively and in yellow strain was 117 and 347 cm$^2$, respectively). Honey and pollen stores were greater in both black strain (391 and 1045 cm$^2$, respectively) and yellow strain (369 and 984 cm$^2$, respectively) during January followed by February (Pollen and honey stores in black strain was 320 and 988 cm$^2$, respectively and in yellow strain was 288 and 901 cm$^2$, respectively) and minimum in March (pollen and honey stores in black strain was 144 and 731 cm$^2$, respectively and in yellow strain was 126 and 705 cm$^2$, respectively). Nairn and Phadke (1976) reported maximum pollen stores during March to April at Pusa (Bihar); Ramachandran and Mahadevan (1950) recorded greater amounts of pollen and honey stores in February at Coimbatore; Reddy (1980) recorded minimum and maximum pollen stores in January and April, respectively at Bangalore. Verma et al., (1988a) recorded greater quantity of pollen and honey stores in autumn at Shimla, Himachal Pradesh. These variations in pollen and honey stores were possibly due to increased foraging activity and availability of pollen and nectar in these places. In the present investigations the results indicate that the black strain colony stored more pollen and honey (303 and 857 cm$^2$, respectively), compared to yellow strain colony (279 and 810 cm$^2$, respectively) during winter season. The reason for this may be due to variations in
genetic characters, tongue length, pollen load carrying capacity, floral preference and availability, population of the colony, competition in foraging between the species.

5.2.2.3 Pollen and Honey stores during summer season

The quantum of pollen and honey stores was lesser in summer than during winter season. The average pollen and honey stores was greater in the beginning of summer in both black strain colony (126 and 504 cm$^2$, respectively) and yellow strain colony (114 and 489 cm$^2$, respectively), which progressively decreased by the end of May (pollen and honey stores in black strain was 94 and 317 cm$^2$, respectively and in yellow strain was 91 and 302 cm$^2$, respectively). The minimum area under pollen and honey stores in black strain (94 and 317 cm$^2$, respectively) and in yellow strain (91 and 302 cm$^2$, respectively) was observed during last fortnight of May. The reduction in pollen and honey stores was due to lack of sufficient bee flora. Ramachandran and Mahadevan (1950) reported greater pollen store in February and April at Bangalore. The bee flora during this period was less at the place of study. Hence, observations do not agree with the findings of Reddy (1980). Naim and Phadke (1976) observed maximum pollen store in April, at Pusa, Bihar. Verma et al., (1988a) recorded 509 cm$^2$ and 290 cm$^2$ area of pollen in April and May, respectively. These variations in pollen and honey stores may be due to weather and floral conditions at different regions. In the present study the findings indicate that the black strain colony stores more
honey and pollen than the yellow strain colony during summer season. The reason for less storage may be due to variations in genetic characters, tongue length, pollen load carrying capacity, efficiency of foraging, floral availability and their preference, population of the colony, competition in foraging between the strains and between other foragers.

5.2.3 Bee population of black and yellow strains of *Apis cerana indica* F.

5.2.3.1 Bees’ population during rainy season

The honeybees’ populations are measured in terms of number of bees per colony. In the present study the population of black and yellow strain bees was decreased from June month (4438 and 4200 bees, respectively) to July month (3981 and 3798 bees, respectively), afterwards which was progressively increased and reached peak during November month (8044 and 7598 bees, respectively) with the availability and abundance of bee flora. Similar results were reported by Ramachandran and Mahadevan (1950) at Coimbatore. However, Reddy (1980) reported maximum population from April to October and minimum in January at Bangalore. However, in the present study bee population in both black strain and yellow strain bees was highest during November month (8044 and 7598 bees, respectively) due to availability of pollen and nectar yielding plants around apiary. Verma *et al.*, (1988a) reported maximum population of bees in summer and autumn and minimum in the rainy season at Shimla. Thus, bee population varies at different places. These variations may be due to availability of flora at different
regions. In the present investigations black strain recorded highest bees' population compared to yellow strain throughout the rainy season. This may be due to variations in genetic characters, pollen and nectar gathering capacity and brood rearing activities.

5.2.3.2 Honeybees' population during winter season

The present study showed that the bee population was maximum in both black strain and yellow strain colonies during January month (11534 and 10990 bees, respectively) and was minimum during March (8822 and 8399 bees, respectively). Ramachandran and Mahadevan (1950) reported maximum population of bees during January - March at Coimbatore. According to the report of Verma et al., (1988a) maximum bee population was in February at Shimla. These differences may be due to different floral conditions. In the present investigations population of black strain colony was highest throughout the season compared to yellow strain colony. This may be due to variations in genetic character, pollen and nectar gathering capacity and brood rearing activities.
5.2.3.3 Honeybees’ population during summer season

The population of bees in both black and yellow strain colonies during summer season was low (6642 and 6154 bees, respectively) compared to that of winter season (10169 and 9362 bees, respectively).

The results of this study indicated maximum bees’ population during April in both black and yellow strain colonies (7369 and 6930 bees, respectively) and minimum during May month (5915 and 5377 bees, respectively). The reason for decrease in bees’ population may be due to low foraging activity and lack of bee flora. However, Reddy (1980) reported that adult bee population was high from April to October at Bangalore due to availability of bee flora. The present study is not in agreement with the observations of Reddy (1980) because there was no bee flora around apiary during this period. In the present study the black strain colony was recorded more bee population throughout the season compared to yellow strain colony. This may be due to variations in genetic characters, pollen and nectar gathering capacity and brood rearing activities.
5.3 Bee flora and Melissopalynological studies

The results of the investigations carried out on bee flora, foraging behavior and melissopalynological studies of *Apis cerana* honey samples collected from three different locations of Shimoga district are discussed hereafter.

5.3.1 Bee flora

Many plant species were recorded and reported as food plants of *Apis cerana* from different regions. Singh (1962) classified the nectar and pollen yielding plants based on their economical and botanical status. 114 plant species from hilly regions of Punjab (Rahman, 1941), 47 species from Ludhiana (Atwal *et al.*, 1970), 80 species from Pathankot and Punjab (Chaudhary, 1977), 219 species (Gachhinamath, 1983) and 165 species (Sattigi, 1997) as pollen and/or nectar yielding plants from Dharwad region. During the present investigations 139 plant species were recorded as nectar and/or pollen sources for *Apis cerana indica* in Shimoga district. Divan and Vartak (1983) identified 450 bee forage plants in Western Ghats of India. Shah and Melkania (1982) recorded 99 important bee forage plants in Uttarkashi, Uttar Pradesh. A survey was conducted (Sivaram and Reddy, 1994) in plain regions of Bangalore recorded 24 plant species as major pollen yielding, 7 as major nectar yielding and 9 as both pollen and nectar yielding plants.
Among 139 forage plants of *Apis cerana indica* studied in Shimoga district, the members of the family Fabaceae have topped the list (18 species) followed by Asteraceae (15 species) Caesalpiniaceae (8 species) and Cucurbitaceae (6 species). The members of these families being highly cross-pollinated plants, they seem to have co-evolved with the bees by providing nectar and pollen and in turn getting pollinated by them.

The present study revealed 27 species of field crops, 23 vegetable crops, 17 fruit and plantation crops, 21 ornamental plants, 25 herbs, shrubs, and bushes and 29 species of trees as the important bee flora of *Apis cerana* in Shimoga district. From Dharwad region 39 agricultural crops, 33 fruit and plantation crops, 34 vegetable crops, 33 ornamental plants, 24 herbs, shrubs and bushes and 51 forest trees were reported to yield nectar and/or pollen for *Apis cerana* (Gacchinamath, 1983) and among all the plant groups, field crops play a major role in supplying pollen and nectar to bees (Sattigi, 1997).

5.3.2 Floral calendar of bee forage plants of Shimoga District

Melissopalynological studies are important in identifying the bee forage plant species and poisonous plants in a particular locality and are compiled for preparation of a bee floral calendar. The bee floral calendar can be used to identify the floral distribution and bee forage availability in the locality. This in turn can be utilized for the judicious planning of supplementary feeding and migratory bee keeping of the colonies. The microscopic analysis of the honey samples and pollen
loads from the honeybees and botanical survey of the region has been used for the formulation of a bee floral calendar. Studies on bee flora of various places have been carried out by Naim and Phadke (1976), Sivaram and Reddy (1994) and Kuberappa et al., (1996).

The present study gives a bee floral calendar with 116 important plants out of 139 recorded as bee forage for both nectar and pollen source. Chaudhary (1977a) listed 84 plant species of Pathankot, Rahman (1990), Sharma and Gupta (1993) identified 126 and 138 bee forage plants in and around the Assam and Himachal Pradesh, respectively. Chaubal and Kotmire (1980) studied the bee forage plants of Sagarmal. Investigations of bee forage plants of Coorg district was initiated by Suryanarayana (1975). Floral calendar of different plant species flowering in Chickmagalur district, Karnataka state has been prepared by Krishnaswamy (1981).

5.3.3 Melissopalynological studies

5.3.3.1 Identification of pollen sources

Palynological investigations made on 139 pollen loads of *Apis cerana* collected from June 2000 to May 2001 in Shimoga district indicated that 73.61 per cent of pollen loads were unifloral and remaining 26.39 per cent were multifloral pollen types. The present investigations are in agreement with the findings of Chaturvedi (1977), Chaudhary (1978), Garg and Nair (1994) and Agashe and Scinthia (1997) who reported that most of the pollen loads were unifloral. This may be due to the high floral fidelity of *Apis cerana* in different plants.
Among the 139 plants recorded, 14 were major pollen yielders, 36 were belonging to medium source and 68 were minor pollen sources. These results indicated that *Apis cerana* exploited several species of plants for collection of pollen and nectar, which is an indication of polylectic nature of the bee.

In Bangalore *Helianthus annuus, Cocos nucifera, Eucalyptus, Syzygium* sp. were reported as pollen and nectar sources (Veeresh and Sangappa, 1994). Similarly, maize was recorded as a pollen source by Sihag (1990) and Suryanarayana (1992) and coconut was recorded as a major pollen source by Chaudhary (1997).

### 5.3.3.2 Pollen spectrum of Shimoga District

A pollen spectrum of Shimoga district was prepared during the period of June 2000 to May 2001. The spectrum revealed the dominant pollen sources in Shimoga district to be *Cocos nucifera, Eucalyptus globosa, Callesteemon lanceolus, Azadirachta indica, Pongamia pinnata, Peltophorum, Brassica nigra, Antegonon leptopus* and *Mimosa pudica*. The present investigations corroborate with the findings of Kitazima (1973), Mary Scinthia (1994), Sivaram and Reddy (1994) and Agashe (1997).
5.3.3.3 Identification of nectar source

Pollen analytical studies of honey samples collected from *Apis cerana* colonies revealed that *Callistemon, Artocarpus* and *Canthium* were the important secondary pollen types in June and July, but *Callistemon* became the ‘predominant’ source in the honey samples collected from first fortnight of July. *Cocos* and *Anacardium* were the important secondary pollen types in August and September. But *Cocos* acts as a predominant pollen type in second fortnight of August and first fortnight of September. The ‘important minor and minor pollen types’ present in the monsoon honey samples were *Delonix, Antegonon, Bauhinia, Zinnia, Tridax, Arachis, Aster, Sesamum, Bidens, Psidium, Calendula, Manilkera, Citrus* and *Coccinia*. (Fig: 45).

*Eucalyptus* was the predominant pollen type in all the winter honeys (October-December). Important secondary pollen types present in the honey samples collected in winter were *Cocos, Mimosa, Antegonon, Mangifera, Helianthus* and *Brassica nigra*. The important minor pollen types present in winter honeys were *Santalum, Bauhinia, Sesamum, Coffea, Euphorbia, Cajanus, Lagascea* and *Bidens* (Fig: 46).
Pongamia, Azadirachta and Peltophorum (April and May, respectively) were the predominant pollen types present in summer honeys. The important secondary pollen types present in the summer honeys were Brassica, Pithecollobium, Pongamia, Ageratum and Syzygium and also the important minor pollen types like Abelmoschus, Rosa, Anacardium, Mangifera, Citrus, Gliricidia, Syzygium fruticosum, Parthenium and Mimosa were present in the honey samples collected from Apis cerana colonies during summer season (Fig: 47).