DISCUSSION

In the present investigations, studies were made on the melissopalynology of honey samples and pollen loads of *A. cerana*. Eco-physiological studies were conducted on *Plectranthus* spp. and other major honey sources of Himachal Pradesh. Comparative foraging behaviour of *A. cerana* and *A. mellifera* was also studied on *Plectranthus* bloom.

MELISSOPALYNOLOGICAL STUDIES

Melissopalynological studies are helpful not only in quantitative but also in qualitative pollen analysis of honey. Any final confirmatory evaluation of the bee plants is utterly incomplete without the study of melissopalynology. Pollen analysis of honey samples enables to infer the botanical source of a given honey sample, on the basis of characteristics associations of component species as presented in the spectrum of pollen variability (Deodikar, 1965; Louveaux *et al.*, 1978).

In the present melissopalynological studies, the pollen analysis of honey samples and pollen loads from different parts of Himachal Pradesh revealed several sporomorphs which are discussed as follows:

*Adhatoda* sp. (Acanthaceae)

Pollen analysis of the honey samples collected during summer season revealed *Adhatoda* sp. as the secondary
pollen source in Sabathu (36.41%) and Arki (17.41%) honeys (Tables 2, 5, 7; Fig. 10).

*Adhatoda* sp. is a milky shrub that acts as a medium source of pollen and nectar to the honeybee (Table 12). However, Chaudhari (1977 a, b) and Chaubal and Kotmire (1980) have reported it as the minor source of pollen and nectar in Pathankot (Punjab) and Sagarmal (Maharashtra) respectively. But, it has been observed as important honey plant in Pakistan by Makhdoomi and Chohan (1980).

*Amaranthus* sp. (*Amaranthaceae*)

Microscopical analysis of the honey samples collected during summer season revealed *Amaranthus* sp. as the important minor pollen source in Jubbal (5.83%) and as the minor pollen source in Shimla (0.94%) honeys (Tables 9, 11). Chanda and Ganguly (1981) and Suryanarayana *et al.* (1981) has also reported *Amaranthus* as the important minor pollen source in Narsipatnam (Andhra Pradesh, 7.5%), Bariupur (West Bengal, 12.31%), Muzaffarpur (Bihar, 4.88%) and Haldwani (Uttar Pradesh, 3.74%) honeys.

*Amaranthus* sp. is a short season herb that acts as a minor source of pollen in Himachal Pradesh (Table 12). Similar honey potentiality have also been reported for this plant by Chandran and Shah (1974) in Tamilnadu, Chaudhari (1977 a, b) in Punjab and Chaubal and Kotmire (1980) in Maharashtra.
Phoenix sp. (Arecaceae)

Pollen analysis revealed Phoenix sp. as the secondary pollen source in Bajnath (18.38%) honey of summer season (Tables 2,7). It was also present as a secondary pollen source in Kangra (22.03%) and as a minor pollen source (4.71%) in Bilaspur honey of autumn season (Tables 3,6). Seethalakshmi (1980) has also reported Phoenix sp. as the important minor pollen source in Muzaffarpur (Bihar, 4.97%) and Tenali (Andhra Pradesh, 8.59%) honeys.

Phoenix sp. is a wild shrub that acts as the medium source of nectar and minor source of pollen to the honeybees in Himachal Pradesh (Table 12). Naim and Phadke (1976) also found it as a minor source of pollen in Pusa (Bihar). It has also been reported as a honey plant from Bangladesh (Dewan, 1980; Alam and Zannat, 1980).

Ageratum sp. (Asteraceae)

Microscopical analysis of honey samples collected during autumn season revealed Ageratum sp. as secondary pollen source in Banjar (18.53%), whereas, it was found as an important minor pollen source in Mandi (7.58%) honey (Tables 3,6,10). In Shimla honey, it was represented as an important minor pollen source during summer (8.08%) and autumn (9.56%) seasons (Tables 4,11; Fig. 11). Ageratum was also reported as the important minor pollen source in Parathode (Kerala, 4.65%) and Surulipathy (Tamilnadu, 8.96%) honeys. (Seethalakshmi, 1980).
Ageratum sp. is an erect, annual ornamental plant found in different parts of Himachal Pradesh. It is a minor source of pollen and nectar to honeybees in Himachal Pradesh (Table 12). Different investigators have reported it as a minor pollen and nectar source in various parts of the country. Kashmir (Shah and Shah, 1976); Punjab (Chaudhari, 1977 a,b); Maharashtra (Chaubal and Kotmiie, 1980); Uttar Pradesh (Singh, 1983). However, Chandran and Shah (1974) observed it as a major pollen source in Kodai hills of Tamilnadu.

Artemisia sp. (Asteraceae)

Pollen analysis of the honey samples collected during autumn season revealed Artemisia sp. as a secondary pollen source in Chopal (22.72%) and Jubbal (16.08%) honeys (Tables 3,10; Fig. 12). Sharma and Nair (1965) and Chaturvedi (1983) have reported it as a minor pollen source in Pithoragarh (0.30%) and Almora (1.3%) honeys of Uttar Pradesh. Similarly, Nair (1964, 1985) also found Artemisia as the minor pollen source in Himalayan (1.2%) honey samples.

Artemisia sp. is a perennial ornamental herb occurring widely in the subtemperate and temperate zones of Himachal Pradesh and is a minor source of nectar and pollen to the honeybees (Table 12). Saraf (1972) also found it as the minor honey plant in Kashmir valley. In Britain, it is not very attractive to honeybees for nectar (Howes, 1979).
Aster sp. (Asteraceae)

Aster sp. was present as secondary pollen source in Banjar (16.71%) honey, whereas, it was present as an important minor pollen source in Rampur (9.81%) and Baijnath (9.06%) honeys of autumn season (Tables 3, 8, 10; Fig. 13).

Aster sp. is an erect and branched ornamental herb which acts as minor source of pollen and nectar to honeybees in Himachal Pradesh (Table 12). Similar honey potentiality has also been reported by Saraf (1972) for this plant in Kashmir Valley.

In United states and Canada, there are about 200 species of asters. In the northern parts of these countries, asters are imported to produce a white honey with a mild delicate flavour, while in the southern states, honey colour varies from light to dark amber with a strong flavour (Crane, 1975; Robinson and Oertel, 1979). Some of the North American asters are now naturalized in Britain (Howes, 1979).

Bidens sp. (Asteraceae)

Pollen analysis indicated Bidens sp. as secondary pollen source in Nahan (20.61%) honey of autumn season (Tables 3, 6, Fig. 14). Chaturvedi (1983) observed Bidens as the important minor pollen source in Almora (13.0%) honey of Uttar Pradesh.

Bidens sp. is a wild herb that acts as a minor source of nectar to honeybees in Himachal Pradesh (Table 12).
Chaudhari (1977 a,b) and Chaubal and Kotmire (1980) also reported similar honey potentiality for this plant in Punjab and Maharashtra respectively. However, Chandran and Shah (1974) found it as the major source of pollen in Kodai hills of Tamilnadu.

Bidens spp. are common throughout United States and some parts of Canada in wet and swampy areas to dry sandy soils. In these countries this plant is important mainly as a supplemental nectar source, but surplus crops are frequently obtained in some of the Central states. Honey of this plant is reddish or golden yellow coloured and have a mild pleasant flavour (Crane 1975; Robinson and Oertel, 1979). In Britain, it is not a good source of nectar (Howes, 1979; Crane, 1980).

Carduus sp. (Asteraceae)

Microscopical analysis of the honey samples collected during summer season revealed Carduus sp. as the minor pollen source in Narkanda (3.64%) honey (Tables 2,9).

Carduus sp. is a troublesome weed that acts as a minor honey source in Himachal Pradesh (Table 12). Shah and Shah (1976) also reported it a minor honey plant in Kashmir, but Saraf (1972) found it as the major source of pollen and nectar to honeybees in this valley.

This is a minor source of nectar in Britain with honey of excellent flavour (Howes, 1979; Crane, 1980).
**Cichorium** sp. (Asteraceae)

Pollen analysis indicated *Cichorium* sp. as the minor pollen source in Sabathu (2.94%) honey of summer season (Tables 2,7).

*Cichorium* sp. is a perennial herb with milky juice distributed in different parts of Himachal Pradesh. This is a minor source of pollen and nectar in Himachal Pradesh (Table 12). Similar honey potentiality was also reported by Saraf (1972) and Chaudhari (1977 a,b) for this plant in Kashmir and Punjab respectively.

In Britain, this beautiful plant is grown for many uses such as a crop from the roots, as a garden vegetable and as a forage plant for stock. It also occurs as a weed in waste places. Honey is of yellow colour, slightly greenish even when granulated and with a strong flavour (Howes, 1979).

**Helianthus** sp. (Asteraceae)

*Helianthus* sp. was present as the predominant pollen source in Raipur (45.03%), secondary pollen source in Sundernagar (25.38%), Kasauli (22.49%) and Bilaspur (21.62%) honeys of autumn season (Tables 3,6,10; Fig.15). It was also found as important minor pollen source in Nahan (6.13%) honey of summer season (Tables 2,5). In Shimla honey, it was found as an minor pollen source during summer (0.76%) and rainy (0.93%) seasons (Tables 4,11). Seethalakshmi
(1980) also found *Helianthus* sp. as secondary pollen source in Kodaikanal hills of Tamilnadu (15.39%). Chaturvedi (1983) reported it as a predominant pollen source in south Ranikhet (34.4%) and secondary source in east Ranikhet (18.6%) honey of Uttar Pradesh.

*Helianthus* sp. is an important fodder crop of Himachal Pradesh that is a medium source of pollen and nectar to various *Apis* species in this region (Table 12). It has also been reported as a good honey source from different parts of the country: Punjab (Atwal et al., 1970; Chaudhari, 1977 a,b); Kashmir (Saraf, 1972; Shah and Shah, 1976); Maharashtra (Chaubal and Kotmire, 1980) and Uttar Pradesh (Mohana Rao and Suryanarayana,1983; Singh, 1983).

These are annuals of North American origin, widely grown as oilseed crops in warmer pockets of United States, Canada, England and Africa (Crane, 1975; Robinson and Oertel, 1979; Vorwohl, 1981, Crane and Walker, 1984). Honey is amber coloured with a characteristic flavour (Howes, 1979).

*Senecio* sp. (Asteraceae)

*Senecio* sp. was found as the minor pollen source in Rajgarh (1.60%) honey of summer season (Tables 2,9;Fig.16).

*Senecio* sp. commonly called "Ragwort" is a minor source of nectar and pollen to honeybees in Himachal Pradesh (Table 12). Similar reports have also been made by Saraf (1972) and Chandran and Shah (1974) from Kashmir and Tamilnadu respectively.
Ragwort is frequently a troublesome weed in Britain as well as in many other European countries. It is common in waste places and meadow lands and acts as a prolific source of nectar and pollen, when other sources are over (Crane, 1975; Vorwohl, 1981). Honey is deep yellow in colour with a strong flavour (Howes, 1979).

**Solidago** sp. (Asteraceae)

Pollen analysis revealed *Solidago* sp. as the minor pollen source in Sabathu (4.09%) and Rampur (4.02%) honeys of autumn season (Tables 3, 8, Fig. 17). Similar results were also reported by Seethalakshmi (1980) for Bhattind (4.46%) honey of Kashmir.

*Solidago* sp. is a perennial herb which acts as a minor source of pollen to honeybees in Himachal Pradesh (Table 12). Singh (1962) also reported it as a minor source of pollen to *Apis* spp.

Goldenrods are very widely distributed in Europe and North America with about 80 native species in these continents (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980). Honey is of golden yellow colour, granulates very quickly and has a strong aroma (Crane, 1975).

**Tagetes** sp. (Asteraceae)

*Tagetes* sp. was found as the minor pollen source in Shimla honey of autumn (1.93%) season (Tables 4, 11; Fig. 18).
Tagetes sp. is an ornamental, aromatic herb cultivated in the various parts of Himachal Pradesh. Present results showed it as a minor source of pollen and nectar to honeybees (Table 12). In Kashmir valley also, it is a minor honey source during rainy and autumn seasons (Shah and Shah, 1976).

**Taraxacum sp. (Asteraceae)**

Taraxacum sp. was found as the secondary pollen source in Mandi (17.87%), important minor pollen source in Arki (11.35%) and minor pollen source in Nirmand (4.46%) honey of summer season (Tables 2, 5, 9; Fig. 19). It was found as the secondary pollen source in Nalagarh (31.12%), Narkanda (19.21%) and Sabathu (17.26%) honeys and important minor pollen source in Chopal (18.57%) and Rajgarh (3.56%) honeys of autumn season (Tables 3, 6, 8, 10). In Shimla honey, it was found as minor pollen source during summer and rainy (6.24 and 9.03%) seasons and was secondary pollen source in autumn (43.85%) honey (Tables 4, 11).

**Taraxacum** sp. commonly called 'Dandelion' is a perennial weed widely distributed in different parts of Himachal Pradesh. It bears yellowish white flowers, secretes milky juice and is major source of honey (Table 12). Deodikar (1970) and Shah and Shah (1976) also reported it as a major source of pollen and nectar to honeybees in Kashmir valley. However, in Punjab, it is a minor honey source during summer season (Chaudhari, 1977 a,b).
The dandelion is a widespread weed in cool temperate regions of the world especially United states, Canada, Central Europe and Argentina (Robinson and Oertel, 1979; Crane, 1980, Vorwohl, 1981; Battaglini and D'Albore, 1981). Honey is of deep or pale yellow colour and crystallizes soon (Crane, 1975; Howes, 1979).

**Vernonia** sp. (Asteraceae)

*Vernonia* sp. was important minor pollen source in Chamba (6.80%) honey of summer season (Tables 2, 7).

Seethalakshmi (1980) reported *Vernonia* as the secondary pollen source in honey samples of Putter (Karnataka, 17.1%), whereas, Nair (1964, 1985) found it as the minor pollen source in Himalayan (less than 1%) honeys.

*Vernonia* sp. commonly called "Ironweed" is a minor honey source in Himachal Pradesh (Table 12). Chandran and Shah (1974) also reported this as a minor source of pollen in Kodai hills of Tamilnadu, however, in West Coorg (Karnataka) it is a major source of nectar to honeybees (Divan and Rao, 1971).

Ironweeds are annuals or perennials, distributed in tropical upland areas of Africa, Brazil, Argentina and Britain (Crane, 1980; Vorwohl, 1981; Imperatriz-Fonseca et al., 1985). Honey is light coloured with a fine flavour (Crane, 1975; Howes, 1979).
Impatiens sp. (Balsaminaceae)

Impatiens sp. was found as the predominant pollen source in Chail (45.27%); secondary pollen source in Mandi, Raipur, Kalpa, Bilaspur, Hamirpur and Kangra (22.59, 20.66, 19.50, 18.84, 17.17 and 17.03% respectively) and important minor pollen source in Jubbal (13.40%) and Chopal (6.88%) honeys of autumn season (Tables 3, 6, 10; Fig. 20). In Shimla honeys, it was present as secondary pollen source in rainy (43.03%) and as the predominant pollen source in autumn (50.15%) season (Tables 4, 11). Nair (1964, 1985) have reported it as a minor source in honey samples (less than 1%) of Himalayan, Indogangetic and eastern regions of India.

Impatiens sp. commonly called "Balsam" is an erect succulent herb that acts as a major honey source in different parts of Himachal Pradesh (Table 12). Earlier investigators have also reported this as the major source of nectar to honeybees in Maharashtra (Chaubal and Deodikar, 1965; Chaubal and Kotmire, 1980); Karnataka (Divan and Rao, 1971; Divan and Vartak, 1980); Kashmir (Saraf, 1972; Shah and Shah, 1976). However, Chandran and Shah (1974) found it as the minor source in Kodai hills of Tamilnadu.

Balsams are major honey plants distributed in Europe, United States, Canada and Africa (Howes, 1979; Adams et al., 1979; Crane, 1980; Adams and Smith, 1981; Crane and Walker, 1984). Honey is light, sweet and with no noticeable aroma (Crane, 1975).
**Berberis** sp. (Berberidaceae)

*Berberis* sp. was present as a secondary pollen source in Banjar (18.69%) and Rohru (16.85%); important minor source in Kullu (5.51%) and minor pollen source in Arki (4.12%) honeys of summer season (Tables 2, 5, 7, 9; Fig.21). Nair (1964, 1985) have reported this as the minor pollen source in Himalayan honeys (below 1%).

*Berberis* sp. commonly called 'Barberry' is a wild shrub which acts as a major source of pollen and nectar in Himachal Pradesh (Table 12). It has also been reported as the major source of pollen and nectar in Punjab (Atwal et al., 1970); Kashmir (Saraf, 1972) and Uttar Pradesh (Verma, 1983; Singh, 1983).

Barberry shrubs are widespread in United States, Canada and Britain (Robinson and Oertel, 1979; Crane, 1980). The nectar is secreted by thickened tissues of nectaries at the base of each petal (Howes, 1979). Honey is light amber coloured with a fine flavour (Crane, 1975).

**Alnus** sp. (Betulaceae)

*Alnus* sp. was present as minor pollen source in Baijnath (3.06%) and Kullu (2.75%) honeys of autumn season (Tables 3, 8).

Earlier investigators revealed it as the secondary pollen source in North (18.5%) and South (17.8%) Ranikhet and
Bhowali (17%) honeys and as a minor source in Fithoragarh (0.7%) honeys of Uttar Pradesh (Sharma and Nair, 1965; Chaturvedi, 1983). Nair (1964) also observed it as the secondary pollen source in the Himalayan (20.3%) honeys.

*Alnus* sp. is a timber tree that acts as a minor source of nectar to honeybees in Himachal Pradesh (Table 12). Similar honey potentiality was also reported by Nair (1985) for this plant.

In United States and Britain, it is a useful source of fresh pollen for early brood rearing (Howes, 1979; Robinson and Oertel, 1979, Adams and Smith, 1981).

*Brassica* sp. (*Brassicaceae*)

*Brassica* sp. was found as the secondary pollen source in Raipur (25.10%) Rajgarh (19.41%), Nalagarh (18.63%) and Narkanda (16.92%) as an important minor pollen source in Hatkoti (12.14%) and Nahan (5.58%) and as minor pollen source in Solan (2.51%) honeys of summer season (Tables, 2, 5, 7, 9). In Shimla honey, it was predominantly present during spring (54.74%) season (Tables 4, 11). Earlier melissopalynological studies have revealed it as the predominant pollen source in eastern regions of India (65.5%) and Haldwani and Almora (69.02% and 56% respectively) areas of Uttar Pradesh, secondary pollen source in Tehri Garhwal (Uttar Pradesh, 23.6%) and Bhattind (Kashmir, 16.94%) and as an important minor pollen source in Kasauli (Uttar Pradesh, 4.6%) honey (Nair, 1964;
Brassica spp. are grown as vegetable oil seed and fodder crops in different parts of Himachal Pradesh. They are major sources of pollen and nectar to honeybees (Table 17). Various researchers have reported them as the major honey sources from different parts of the country. For example, Punjab (Atwal et al., 1970); Kashmir (Deodikar, 1970; Shah and Shah, 1976); Bihar (Naik and Phadke, 1976); Maharashtra (Chaubal and Kotmire, 1980) and Uttar Pradesh (Singh, 1983, Singh et al., 1983). They have also been reported as major sources of nectar and pollen from Japan, Pakistan, and Bangladesh (Inoue, 1957; Shahid and Qayyum, 1977; Dewan, 1980).

These crops are widely grown in the United States, Canada, Italy, Britain, and Africa because of their importance as oilseed crops (Adams et al., 1979; Robinson and Cervel, 1979; Crane, 1980; Battaglini and D’Alboire, 1981; Crane and Walker, 1984). Honey is light yellow coloured with a sweet flavour and granulates very rapidly (Crane, 1975; Howes, 1979).

Bauhinia sp. (Caesalpiniaceae)

Pollen analysis revealed Bauhinia sp. as the secondary pollen source in Mandi (20.40%), Kumarsein (19.05%), Hamirpur (17.45%), Kangra (16.66%) and Nalagarh (16.07%) honeys and as an important minor pollen source in Bilaspur (6.42%) honey of autumn season (Tables 3, 6, 8; Fig. 22). Nair (1964, 1985) also observed it as the minor pollen source in Indoganggetic (below 1%) honey.
These trees are commonly cultivated for their broad leaves and buds which are eaten as vegetables. These are medium sources of nectar for honeybees in Himachal Pradesh (Table 17). Similar honey potentiality was also reported by Kohli (1958) in Punjab; Deodikar (1970) in Kashmir and Singh (1983) in Uttar Pradesh. In Bangladesh also, it is a medium source of pollen and nectar to honeybees (Dewan, 1980).

**Cassia sp.** (Caesalpiniaceae)

*Cassia sp.* was present as secondary pollen source in Hamirpur (16.96%) and Baijnath (16.37%) honeys of summer season (Tables 2, 5, 7). Nair (1964, 1985) observed it as the minor pollen source in Indogangetic (1.9%) and eastern (below 1%) honeys, but in one honey sample (56.6%) from Indogangetic region, *Cassia sp.* was predominantly represented.

*Cassia sp.* is a medium sized avenue tree which acts as a medium source of pollen and nectar to honeybees (Table 12). In Kashmir and Uttar Pradesh, it is a major honey source during summer and rainy seasons (Deodikar, 1970; Saraf, 1972; Singh, 1983; Verma, 1983).

**Delonix sp.** (Caesalpiniaceae)

Pollen analysis revealed *Delonix sp.* as the important minor pollen source in Kangra (7.59%) honey of autumn season (Tables 3, 6). Nair (1964) reported this as the minor pollen
source in Indogangetic (below 1%) honeys.

*Delonix* sp. is an avenue tree that acts as a minor source of nectar to honeybees in Himachal Pradesh (Table 12). Atwal *et al.* (1970) and Chaubal and Kotmire (1980) also reported it as the minor source of pollen and nectar in Punjab and Maharashtra respectively.

**Chenopodium** sp. (*Chenopodiaceae*)

*Chenopodium* sp. was present as the important minor pollen source in Bagi (10.57%) and minor pollen source in Jubbal (1.22%) honeys of autumn season (Tables 3, 10). Similar results were also reported by Chanda and Ganguly (1981) and Nair (1964, 1985) for the honey samples of Bashirhat (West Bengal, 1.5%) and the Himalayan region (Below 1%) respectively.

*Chenopodium* sp. is the minor source of pollen and nectar to honeybees in Himachal Pradesh (Table 12). In Kashmir and Maharashtra also, it is the minor source of pollen and nectar to bees (Shah and Shah, 1976; Chaubal and Kotmire, 1980).

This weed is also a minor honey source in United States and Canada (Adams and Smith, 1981).

**Terminalia** sp. (*Combretaceae*)

*Terminalia* sp. was found as the secondary pollen source in Sundernagar (24.88%) and as important minor pollen source in Nahan (11.28%) honey of summer season (Tables 2, 5).
Seethalakshmi (1980) also reported it as the predominant pollen source in Gavas (Maharashtra, 44.65%) and important minor pollen source in Bhimashanker (Maharashtra, 5.67%) honey.

Terminalia sp. is a large avenue tree which acts as a medium source of pollen and nectar to bees in Himachal Pradesh (Table 12). Other investigators have reported it as the major honey plant in Maharashtra (Chaubal and Deodikar, 1965); Punjab (Atwal et al., 1970); Karnataka (Divan and Rao, 1971) and Uttar Pradesh (Singh, 1983; Singh et al., 1983). However, Chandan and Shah (1974) observed it as a minor source of pollen and nectar in Kodai hills of Tamilnadu. In Bangladesh and Sri Lanka also, it is a good source of pollen and nectar to bees (Dewan, 1980; Baptist and Punchihewa, 1980). Honey is of dark amber colour with a pungent flavour (Singh, 1962).

Origanum sp. (Lamiaceae)

Pollen analysis revealed Origanum sp. as the secondary pollen source in Rajgarh (16.54%), Kangra (16.18%) and Mandi (16.02%) and as minor pollen source in Narkanda (2.02%) honey of autumn season (Tables 3, 6, 10). Chaturvedi (1983) also reported it as secondary pollen source in Jeolikote (Uttar Pradesh, 37.0%) honey.

Origanum sp. is an erect, wild aromatic perennial herb distributed in different parts of Himachal Pradesh. It
is a medium source of pollen and nectar to bees during rainy and autumn seasons in Himachal Pradesh (Table 12). Deodikar (1970) also reported it as a good honey source in Kashmir valley.

*Origanum* is also a good source of nectar and pollen in Britain and Russia (Howes, 1979; Crane, 1980) and honey is of fine quality with a distinct flavour (Crane, 1975).

**Plectranthus** sp. (Lamiaceae)

*Plectranthus* sp. was present as predominant pollen source in Jubbal (45.61%), Rampur (45.28%), Hatkoti (45.24%) and Kullu (45.0%) honeys and as secondary pollen source in Kalpa, Kumaursein, Nirmand, Kohru, Narkanda, Chopal, Bagi and Chail, (25.61, 25.27, 25.21, 25.04, 23.81, 22.31% and 16.03% respectively) honeys of autumn season (Tables 3, 8, 10; Fig. 23). Nair (1964, 1985) reported it as secondary pollen source in Himalayan honeys (28.9%), whereas, Chaturvedi (1983) found *Plectranthus* as the important minor pollen source in Bhowali (10.2%) and east Ranikhet (3.7%) honeys of Uttar Pradesh.

*Plectranthus* sp. commonly known as "Shain" is one of the commonest gregarious shrubs met within the stony hillsides in Himachal Pradesh. It is an excellent source of nectar during autumn season in hilly areas (Table 12; Figs. 7 to 9). It is also a major source of nectar in
Kashmir (Saraf, 1972; Shah and Shah, 1976); Kullu (Atwal and Dhaliwal, 1974); Maharashtra (Chaubal and Kotmire, 1980); Karnataka (Divan and Vartek, 1980) and Uttar Pradesh (Singh, 1983; Singh et al., 1983; Verma, 1983). In Pakistan also, it is an excellent honey source (Shahi and Qayyam, 1977; Makhdoomi and Chohan, 1980).

**Salvia sp. (Lamiaceae)**

Microscopical analysis of the autumn honey samples revealed *Salvia* sp. as predominant pollen source in Hamirpur (45.04%), secondary pollen source in Sundernagar (21.42%), Solan (20.75%), Chamba (19.61%) and Nalagarh (16.28%) and as important minor pollen source in Baijnath (15.48%) and Janot (9.97%) honeys (Tables 3, 6, 8). In Shimla honey, it was present as minor pollen source in autumn (0.51%) and early winter (0.98%) honeys (Tables 4, 11).

*Salvia* sp. commonly called "Sage" is a medium source of pollen and nectar during rainy and autumn seasons (Table 12). In Kashmir valley also, it is a good source of pollen and nectar (Deodikar, 1970; Saraf, 1972).

*Salvia* sp. is also a medium source of nectar in Canada, Brazil and Africa and more than 500 species of sage are widely distributed in these countries (Demianowicz, 1963; Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Crane and Walker, 1984; Imperatriz-Fonesca et al., 1985). Honey is waterly white, mild in flavour, granulates slowly and is of a fine quality (Crane, 1975).
Toona sp. (Meliaceae)

Toona sp. was present as predominant pollen source in Hamirpur (45.12%), secondary pollen source in Sundernagar (19.23%) and Kangra (18.93%) and as important minor pollen source in Nahan (12.14%) honeys of summer season (Tables 2,5). Suryanarayana et al. (1981) found it as secondary pollen source in Kodaikanal (Tamilnadu, 26.47%) honey. However, Nair (1964) and Sharma and Nair (1965) reported it as the minor pollen source in Indogangetic (2.2%) and Pithoragarh (Uttar Pradesh, 0.5%) honeys.

Toona sp. is a large deciduous tree, valued for its red, evergreen, durable and white ant proof wood that is used for furniture. It is a major source of nectar to honeybees in lower hills of Himachal Pradesh (Table 12). Different researchers have reported it as the major source of nectar from different parts of the country. For example, Punjab (Chaudhari, 1977); Kashmir (Deodikar, 1970; Saraf, 1972); Maharashtra (Chaubal and Deodikar, 1965); Uttar Pradesh (Kohli, 1958; Singh, 1983). However, Chandran and Shah (1974) observed it as the minor honey source in Tamilnadu. In Pakistan and Bangladesh also it is a good source of nectar to bees (Makhdoomi and Chohan, 1980; Dewan, 1980).

Honey is of white to light amber colour with a pronounced flavour (Singh, 1962).

Acacia sp. (Mimosaceae)

Acacia sp. was found as the secondary pollen source
in Raipur (18.67%), Hamirpur (17.28%) and Bilaspur (16.05%) honeys of autumn season (Tables 3, 6). Seethalakshmi (1980) reported it as an important minor pollen source in Kodaikanal (Tamilnadu, 12.82%) honey.

**Acacia** sp. commonly called 'Babul' is a tree that acts as a medium source of pollen and nectar to bees in lower hills of Himachal Pradesh (Table 12). It is a good source of pollen and nectar in Karnataka (Divan and Rao, 1971); Maharashtra (Chaubal and Kotmire, 1980) and Uttar Pradesh (Singh, 1983; Verma, 1983). However, Chandran and Shah (1974) and Chaudhari (1977) reported it as the minor honey source in Tamilnadu and Punjab respectively. It is also an important honey plant in Israel, Japan, Pakistan, Bangladesh and Oman (Grindel, 1956; Okada et al., 1976; Shahid and Qayyam, 1977; Alam and Zannat, 1980; Manley, 1980).

**Acacia** sp. has also been reported as the important honey plant from various parts of Europe, Australia, North America and Africa (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Vorwohl, 1981). Honey is light amber coloured with a delicious flavour and granulates slowly (Crane, 1975; Howes, 1979).

**Albizia** sp. (Mimosaceae)

Pollen analysis indicated **Albizia** sp. as the secondary pollen source in Kangra (16.07%) and as important minor pollen source in Raipur (10.18%) and Mandi (8.09%)
honeys of summer season (Tables 2, 5; Fig. 24). Nair (1964; 1985) found it as the minor pollen source in the Indogangetic (below 1%) honeys.

**Albizzia** sp. commonly called "Siris" is a small deciduous tree that acts as a medium honey source in Himachal Pradesh (Table 12). It is a medium source of pollen and nectar to honeybees in Punjab, Karnataka and Uttar Pradesh (Atwal et al., 1970; Divan and Vartak, 1980; Singh, 1983), however, it is a minor source in Maharashtra (Chaubal and Kotmire, 1980). Alam and Zannat (1980) also reported it as a good source in Bangladesh.

**Albizzia** sp. is also an important source of nectar in Britain and Africa (Cranq, 1980).

**Eucalyptus** sp. (Myrtaceae)

**Eucalyptus** sp. was predominantly present in Nahan (46.66%), as secondary pollen source in Nalagarh (24.01%) and Bilaspur (20.74%) honeys of summer season (Tables 2, 5). Different investigators have reported different pollen frequency percentages from various parts of the country. For example, Lucknow (96.5%), Ranikhet (12.5%), Jeolikote (2.5%), Haldwani (1.7%), Kodaikanal (55.12%), Baruipur (4%), Kerala (2%) and Indogangetic region (1.3%) (Nair, 1964; Sharma and Nair, 1965; Seethalakshmi, 1980; Chanda and Ganguly, 1981; Chaturvedi, 1983).

**Eucalyptus** sp. is an exotic, evergreen tree that
acts as a major source of pollen and nectar to honeybees in Himachal Pradesh (Table 12). It is also an excellent honey source in Punjab (Atwal et al., 1970; Salvi, 1975); Tamilnadu (Chandran and Shah, 1974); Maharashtra (Chaubal and Kotmire, 1980); Bihar (Srivastva and Tripathi, 1980); Karnataka (Rajan, 1980); Uttar Pradesh (Singh, 1983; Singh et al., 1983). In other parts of the Indian subcontinent also, it is a major source of nectar to bees. For example; Israel (Grindel, 1956; Eisikowitch and Masad, 1980), Pakistan (Makhdoomi and Chohan, 1980), Sri Lanka (Baptist and Punchihewa, 1980); Bangladesh (Dewan, 1990).

Wotton et al. (1978) reported that 500 species of *Eucalyptus* are native to Australia, where it comprises a three-quarter or more of total vegetation. They are now cultivated in nearly all the countries except northern Europe and Canada, and are important in the whole Mediterranean region as well as warm temperate parts of Africa, Asia and the America (Santos, 1961; Persano et al., 1974; Maurizio, 1979; Robinson and Oertel 1979; Crane, 1980; Vorwohl, 1981; Battaglini and D'Albore, 1981; Imperatriz-Fonseca et al., 1985). Honey is of amber colour, granulates finely and has excellent flavour (Crane, 1985).

**Syzygium** sp. (Myrtaceae)

*Syzygium* sp. was present as the secondary pollen source in Sundernagar (16.74%), Kangra (16.28%) Nahan (13.98%)
and as the important minor pollen source in Bilaspur (7.44%) honey of summer season (Tables 2,5).

Similarly, different pollen frequencies have been observed by different investigators in honey samples from various parts of country. For example, 87.30% (Mahabaleshwar, Maharashtra), 74.42% (Castlerock, Karnataka), 66.2% (Bhimshanker, Maharashtra), 53.18% (Champaran, Bihar), 34.15% (Baruipur, West Bengal), 23.53% (Kodaikanal, Tamilnadu), 6.17% (Gavase, Maharashtra) and 5.35% (Haldwani, Uttar Pradesh) (Seethalakshmi, 1980; Suryanarayana et al., 1981).

*Syzygium* sp. commonly called "Jamun" is a large evergreen, avenue and fruit tree that acts as a major source of nectar to honeybees (Table 12). Many researchers have reported it as the major honey source in different parts of the country: Punjab (Atwal et al., 1970; Chaudhari, 1977 a,b); Bihar (Naim and Phadke, 1976; Srivastva and Tripathi, 1980); Maharashtra (Chaubal and Deodikar, 1965); Karnataka (Divan and Rao, 1971); Tamilnadu (Chandran and Shah, 1974) and Uttar Pradesh (Verma, 1983). It is also a major source of nectar in Bangladesh and Srilanka (Dewan, 1980; Baptist and Punchihewa, 1980).

*Dalbergia* sp. (Papilionaceae)

*Dalbergia* sp. was found as secondary pollen source in Janot and Hamirpur (17.54 and 16.60% respectively) honeys and as an important minor pollen source in Baijnath (11.96%)
and Bilapur (8.5%) honeys of summer season (Tables 2,5,7,9). Similar results were also reported by Seethalakshmi (1980) for the honey samples from Gavase (Maharashtra, 25.62%) and Bhagamandala (Karnataka, 9.55%).

*Dalbergia* sp. is a large deciduous shady tree of great economic value for its timber. It is a major source of nectar to honeybees during summer season (Table 12). Other investigators have also reported it as the major honey source in Punjab (Atwal *et al.*, 1980), Karnataka (Divan and Rao, 1971), Kashmir (Saraf, 1972) and Uttar Pradesh (Kohli 1958; Singh, 1983; Singh *et al.*, 1983). However, Chaudhari (1977 a, b) observed it as the minor source of pollen and nectar in Pathankot area of Punjab.

These trees are also major sources of nectar in Asia, Africa and Central America (Singh 1962; Shahid and Qayyam, 1977; Crane, 1980). Honey is dark amber with a strong flavour (Crane, 1975).

*Indigofera* sp. (Papilionaceae)

Pollen analysis revealed *Indigofera* sp. as the minor pollen source in Rajgarh (2.09%) honey of autumn season (Tables 3,10).

*Indigofera* sp. is a pink flowered shrub, flowering from June to August and is a medium honey source in Himachal Pradesh (Table 12). Deodikar (1970) also reported it as the good source of pollen and nectar in Kashmir valley.
Medicago sp. (Papilionaceae)

Medicago sp. was found as the predominant pollen source in Hatkoti (46.60%), secondary pollen source in Kumarsein and Sabathu (19.94 and 16.80% respectively) honeys of summer season (Tables 2, 7). It was represented as the secondary pollen source in Mandi (24.45%), Arki (16.51%) and Rajgarh (16.33%) honeys of autumn season (Tables 3, 6, 10). In Shimla honey, it was found as minor pollen source in rainy (5.49%) season (Tables 4, 11).

Medicago sp. commonly called 'Lucerne' is a perennial herb that acts as a major source of nectar during summer and rainy seasons in Himachal Pradesh (Table 12). Other investigators have also reported it as the major honey plant in Kashmir (Deodikar, 1970; Saraf, 1972; Shah and Shah, 1976); Punjab (Atwal et al., 1970; Salvi, 1975); Uttar Pradesh (Verma, 1963). However, in Punjab and Maharashtra, it is a medium source of nectar to bees (Chaudhari, 1977 a,b; Chaubal and Kotmire, 1980). It is a good source of honey in Pakistan and Cyprus (Makhdoomi and Chohan, 1980; White, 1980).

Medicago sp. is a major source of nectar in Europe, United states and Canada (Howes, 1979; Robinson and Oertel, 1979; Adams et al., 1979; Crane, 1980; Adams and Smith, 1981; Battaglini and D'Albore, 1981). Alfalfa honey is light greenish yellow, with a pleasing mild flavour and aroma (Crane, 1975; Robinson and Certel, 1979).
Melilotus sp. (Papilionaceae)

Pollen analysis indicated Melilotus sp. as the predominant pollen source in Kasauli (46.22%) and as secondary pollen source in Rajgarh (25.02%) and Nirmand (16.28%) honeys of summer season (Tables 2,5,9).

Melilotus sp. is an important fodder crop which acts as a major source of nectar to honeybees in Hiraachal Pradesh (Table 12). It is also a major honey source in Punjab (Chaudhari 1977); Kashmir (Saraf, 1972) and Uttar Pradesh (Verma 1983). However, Chaubal and Kotmire (1980) reported it as the minor source in Sagarmal area of Maharashtra.

Melilotus spp. are native to central Asia but are now widespread in Europe, America and Africa (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Adams and Smith, 1981). Honey is white or light greenish yellow with a delicate flavour (Crane, 1975).

Robinia sp. (Papilionaceae)

Robinia sp. was found as the predominant pollen source in Kullu (46.25%) honey and as secondary pollen source in Nalagarh, Solan, Chail and Rampur (34.16%, 21.78%; 20.45% and 19.04% respectively) honeys of summer season (Tables 2,5, 7,9; Fig. 25).

Robinia sp. commonly called 'Black Locust' is an ornamental and timber tree of Himachal Pradesh. It is a major
source of nectar during summer and rainy seasons (Table 12). In Kashmir valley also, it is a major honey source (Saraf, 1972; Shah and Shah, 1976, 1979). Robinia is an excellent source of nectar in other Asian countries also. For example: China (Focke, 1968); Cyprus (Church and White, 1980) and Korea (Kim, 1985).

Robinia tree is native to North America, where it is widely planted and is also found in poor dry soils of Europe, North America, Russia and New Zealand (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Battaglini and D'Albore 1981). Honey is watery white in colour, granulates slowly and has a fine flavour (Crane, 1975).

Trifolium sp. (Papilionaceae)

Pollen analysis indicated Trifolium sp. as the predominant pollen source in Bagi (46.86%), Arki (45.16%) and Janot (45.07%) and secondary pollen source in Kalpa (22.90%), Rampur (16.80%) and Nirmand (16.16%), honeys of summer season (Tables 2, 5, 7, 9). During autumn season, it was present as secondary pollen source in Rohru, Solan and Kangra (18.61, 18.59 and 18.14% respectively) and as important minor pollen source in Sabathu (9.97%) and Janot (6.08%) honeys (Tables 3, 6, 8). In Shimla honey, it was present as minor pollen source in Spring (2.06%), as secondary pollen source in summer (32.40%) and as important minor pollen source in rainy (10.08%) season honeys (Tables 4, 11). Nair (1964,
1985) have reported it as the minor pollen source in Himalayan (below 1%) honey

**Trifolium** sp. is a perennial herb grown as fodder and cover crop in the different parts of Himachal Pradesh. It is a major source of nectar during summer and rainy seasons (Table 12).

Different investigators have reported it as the major honey source from various parts of the country. For example: Punjab (Atwal *et al.*, 1970; Salvi, 1975; Chaudhari, 1977 a,b); Kashmir (Deodikar, 1970; Saraf, 1972; Shah and Shah, 1976); Uttar Pradesh (Singh, 1983; Singh *et al.*, 1983; MohanaRao and Suryanarayana, 1983); Bihar (Naim and Phadke, 1976). It is also an excellent source of pollen and nectar in Japan, China, Cyprus and Pakistan (Moriya, 1960; Focke, 1968; Church and White, 1980; Makhdoomi and Chohan, 1980).

The clovers are the most important honey producing plants in Britain and are considered to account for about 75 per cent of the yearly honey crop. These valuable bee plants are also the premier honey producers in many parts of the world such as United States, Canada, Europe, New Zealand, Australia and Africa (Howes, 1979; Robinson and Oertel, 1979; Adams *et al.*, 1979; Crane, 1980; Vorwohl, 1981, Battaglini and D’Albore, 1981, Crane and Walker, 1984). Honey of this plant is white or light amber, granulates rapidly and has a mild flavour (Crane, 1975).
**Plantago** sp. (Plantaginaceae)

*Plantago* sp. was present as the important minor pollen source in Nalagarh (8.00%) and as the minor pollen source in Raipur (2.58%) honey of summer season (Tables 2,5), whereas, it was found as the secondary pollen source in Baijnath (36.76%) honey of autumn season (Tables 3,8). In Shimla honey, it was present as the important minor pollen source in summer (8.56%) and rainy (13.93%) honeys (Tables 4,11). Nair (1964) and Sharma and Nair (1965) also reported it as the important minor and minor pollen source in Lucknow (9.1%) and Himalayan honeys (1.7%) respectively.

*Plantago* sp. is a wild herb that acts as a medium source of honey in Himachal Pradesh (Table 12). Saraf (1972) have reported it as the minor honey source in Kashmir valley.

This is a good source of nectar and pollen in Britain, Canada and Africa (Howes, 1979; Adams et al., 1979; Adams and Smith, 1981; Vorwohl, 1981).

**Zea** sp. (Poaceae)

Microscopical analysis revealed *Zea* sp, as the important minor pollen source in Janot (10.24%) and Rampur (6.16%) and minor pollen source in Sundernagar (2%) honey of summer season (Tables 2,5,7; Fig. 26). Similarly, Seethalakshmi (1980) also found *Zea* sp. as the important minor pollen source in honey samples from Puttur (Karnataka, 11.5%), Kodaikanal (Karnataka, 7.69%), Bhattind (Kashmir, 6.25%),
Gavase (Maharashtra, 6.14%), Tenali (Andhra Pradesh, 5.35%), Haldwani (Uttar Pradesh, 5.16%) and Surulipathy (Tamilnadu, 5.01%). However, Chanda and Ganguly (1981) reported it as a secondary pollen source in Bashirhat (West Bengal, 20%) honey. 

*Zea* sp. is widely grown in Himachal Pradesh for its grain and fodder value and is a medium source of pollen for honeybees (Table 12). Other investigators have also reported it as the medium source of pollen in Punjab (Atwal *et al.*, 1970; Salvi, 1975); Karnataka (Divan and Vartak, 1980); Kashmir (Deodikar, 1970; Saraf, 1972; Shah and Shah, 1976) and Uttar Pradesh (Singh, 1983; Verma, 1983). However, in Bihar, it is a minor pollen source to bees (Naim and Phadke, 1976). Chaudhari (1977 a,b) and Chauhal and Kotmi (1980) have reported it as the major pollen source in Punjab and Maharashtra.

Honeybees visit it eagerly for pollen in different countries of the world such as Europe, America and Asia (Howes, 1979; Robinson and Certel, 1979; Adams *et al.*, 1979; Adams and Smith, 1981; Villanueva, 1988).

**Fagopyrum** sp. (Polygonaceae)

*Fagopyrum* sp. was found as predominant pollen source in Arki (49.80%) and Banjar (45.43%) honeys, secondary pollen source in Solan (24.41%) and Kalpa (21.67%) and as important minor pollen source in Chamba, Kullu and Hatkoti (11.27, 10.62 and 10.53% respectively) honeys of autumn season.
(Tables 3, 6, 8, 10). In Shimla honey, it was present as the important minor pollen source in summer (5.34%) and autumn (8.76%) as secondary pollen source in rainy (28.67%) honeys (Tables 4, 11).

_Fagopyrum_ sp. commonly called "Buckwheat" is a short season, quick growing cover crop that acts as a major source of nectar to honeybees (Table 12). In Kashmir and Uttar Pradesh, it is a major honey source (Deodikar, 1980; Saraf, 1972; Shah and Shah, 1976; Singh, 1983). Kim (1985) reported it as a good source of nectar to bees in Korea.

This annual grain crop is cultivated in many parts of the world but in Britain it has never been cultivated to much extent. Buckwheat is one of the few plants that offer possibilities of being sown as artificial bee pasturage on economic basis (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980). Honey is dark brown, granulates freely and has a strong flavour. This honey is used for making cakes and wine in Europe (Crane, 1975).

_Polygonum_ sp. (Polygonaceae)

_Polygonum_ sp. was found as the secondary pollen source in Kumarsein (18.18%) and Rohru (11.04%) honeys of summer (Tables 3, 7), whereas, it was found as minor pollen source in Jubbal (1.47%) honey of autumn season (Tables 3, 10). In Shimla honey, it was found as secondary pollen source in rainy (20.17%) and as important minor pollen source in autumn.
(6.60%) honey. (Tables 4,11). Chanda and Ganguly (1981) observed it as a minor pollen source in honey samples from Baruipur (West Bengal, 1%). Sharma and Nair (1965) and Chaturvedi (1983) reported it as minor pollen source in Lucknow (0.6%) and Almora (0.1%) honeys respectively.

**Polygonum sp.** is a slender erect herb with tufted stem. It is a medium source of nectar to honeybees during summer and autumn seasons (Table 12). Some investigators have reported it as the major source of pollen and nectar to bees in Maharashtra (Chaubal and Deodikar, 1965); Kashmir (Deodikar, 1970) and Uttar Pradesh (Singh, 1983; Singh et al., 1983). Whereas, others have observed it as the minor honey source in Punjab (Chaudhari, 1977 a,b); Kashmir (Saraf, 1972) and Maharashtra (Chaubal and Kotmire, 1980).

**Polygonum sp.** yields surplus honey in some parts of United states and Canada, where it comes up freely in corn fields after cultivation has ceased (Robinson and Oertel, 1979). In Britain, this plant does not seem to be worked by bees very freely (Howes, 1979). The honey is very dark, spicy and granulates rapidly (Crane, 1975).

**Rumex sp. (Polygonaceae)**

**Rumex sp.** was present as the secondary pollen source in Kasauli (22.37%), Chamba (20.11%) and Bagi (19.83%) honeys of autumn season (Tables 3,8,10). In Shimla honey, it was a
secondary pollen source in summer (14.22%) and rainy (10.08%) honeys (Tables 4,11). Earlier melissopalynological studies revealed it as the important minor pollen source in Jeolikote (11%), Ranikhet (8.2%) and Almora (10.6%) honeys of Uttar Pradesh and important minor source in Kasauli (1.6%) and Indogangetic (less than 1%) honeys.

Rumex sp. is a minor source of pollen and nectar to honey bees in Himachal Pradesh (Table 12). Deodikar (1980) and Singh et al. (1983) also reported it as the minor honey source in Kashmir and Uttar Pradesh respectively.

Portulaca sp. (Portulacaceae)

Portulaca sp. was found as the secondary pollen source in Bilaspur (19.48%) honey of autumn season (Tables 3,6). Nair (1964) reported it as the minor pollen source in Himalayan (less than 1%) honey.

Portulaca sp. is an ornamental herb that acts as a medium source of nectar to honeybees (Table 12). Atwal et al. (1970) and Saraf (1972) also reported it as the major source of pollen and nectar in Punjab and Kashmir respectively. In Japan also, it is a good honey source (Suzuki et al., 1969).

Potentilla sp. (Rosaceae)

Pollen analysis revealed Potentilla sp. as the minor pollen source in Rampur (3.50%) honey of summer season (Tables 2,7), whereas, it was found as the important minor pollen source in Kullu (15%) honey of autumn season (Tables 3, 8; Fig. 27).
Potentilla sp. commonly called 'Silverweed' is a creeping plant with silvery leaves. It is a medium source of honey during summer and rainy seasons in Himachal Pradesh (Table 12). Saraf (1972) reported it as the major honey source in Kashmir, whereas, Chaudhari (1977 a,b) observed it as the minor source of pollen and nectar in Punjab.

There are more than a dozen species of Potentilla in Britain which are visited for nectar by bees (Howes, 1979). Prinsepia sp. (Rosaceae)

Prinsepia sp. was present as the predominant pollen source in Sabathu (46.03) honey and as secondary pollen source in Arki, Kumarsein and Janot (26.34, 21.36 and 16.78%) respectively) honey of autumn season (Tables 3,6,8; Fig. 28).

Prinsepia sp. is a major source of nectar to honeybees in Himachal Pradesh (Table 12). Shah and Shah (1979) also observed it as the major honey source in Kashmir.

Prunus sp. (Rosaceae)

Pollen analysis revealed Prunus sp. as the predominant pollen source in Rohru (47.23%) honey, secondary pollen source in Kumarsein (43.98%), Kalpa (27.26%), Chopal (27.19%), Chail (27.12%), Solan (24.09%), Jubbal (19.53%), Bagi (18.80%), Narkanda (18.75%), Kasauli (18.24%), Rajgarh (16.93%) and Banjar (16.60%), important minor pollen source in Kullu (13.40%) and as minor pollen source in Sabathu (3.22%) honeys of summer season (Tables 2,7,9; Fig. 29). Chaturvedi (1983) also reported
it as important minor pollen source in Jeolikote (11%), Ranikhet (8.2%) and Almora (10.6%) honeys but it was a minor pollen source in Kasauni (1.6%) honey of Uttar Pradesh.

Prunus spp. are the important temperate fruit crops of Himachal Pradesh which are major sources of pollen and nectar during the build up periods of bee colonies (Table 12). Other investigators have also reported them as the major honey sources in Punjab (Salvi, 1975); Kashmir (Saraf, 1972; Shah and Shah 1976) and Uttar Pradesh (Kohli, 1958, Singh, 1983; Verma, 1983). However, Chandran and Shah (1974) and Chaudhari (1977 a,b) reported them as the medium sources in Punjab and Tamilnadu respectively. These are also the good honey sources in Japan, Cyprus and Pakistan (Inoue, 1957; Church and White, 1980; Makhdoomi and Chohan, 1980).

These orchard trees are widespread in temperate regions of the world (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Battaglini and D'Albore, 1981). Honey is of light colour, granulates quickly and has excellent flavour (Crane, 1975).

Pyrus sp. (Rosaceae)

Pyrus sp. was found as the predominant pollen source in Jubbal (51.02%) and Narkanda (45.57%) honeys, secondary pollen source in Chopal (22.86%), Chail (22.82%), Solan (22.59%), Kalpa (20.50%), Bagi (16.89%) and as important minor pollen source in Hatkoti (11.28%) honeys of summer
season (Tables 2, 7, 9; Fig. 30).

**Pyrus** spp. are the important fruit trees restricted to the subtemperate and temperate zones of Himachal Pradesh. They are of great value to beekeepers as the early major sources of pollen and nectar for strengthening and building up bee stocks for the main honeyflows (Table 12). They are also the major source of pollen and nectar in Kashmir, Tamilnadu and Uttar Pradesh (Saraf, 1972; Chandran and Shah, 1974; Singh 1983). However, Chaudhari (1977 a,b) observed it as the medium honey source in Punjab.

**Pyrus** spp. have been reported as the major honey plants from Europe, United States and Canada (Howes, 1979; Robinson and Oertel, 1979; Crane, 1980; Battaglini and D'Albore, 1981). Honey is of light colour with a fragrant flavour (Crane, 1975).

**Rosa** sp. (Rosaceae)

Microscopical analysis of the summer honey samples revealed **Rosa** sp. as the important minor pollen source in Kullu (9.19%) and Janot (5.37%) honeys (Tables 2, 7), whereas, it was found as the secondary pollen source in Sundernagar (19.08%) honey of autumn season (Tables 3, 6, 10). Chanda and Ganguly (1981) observed it as the important minor and minor pollen source in honey samples from Narsipatham (Andhra Pradesh, 12%) and Palghat (Kerala, 1.5%) respectively.
Numerous beautiful roses are grown in different parts of Himachal Pradesh for their ornamental value. They are the medium sources of pollen and nectar to the honeybees (Table 12). Other investigators have also reported it as the good honey source in Maharashtra (Chaubal and Deodikar, 1965; Chaubal and Kotmire, 1980); Kashmir (Deodikar, 1970; Saraf, 1972) and Uttar Pradesh (Singh, 1983; Singh et al., 1983; Verma, 1983).

In Britain also, it is a good source of pollen and nectar to bees (Hodges, 1978).

_Rubus sp._ (Rosaceae)

_Rubus sp._ was found as the secondary pollen source in Chopal (20.47%) and Kullu (18%), important minor pollen source in Solan (14.5%), Janot (10.49%) and Bajnath (6.60%) honeys of summer season (Tables 7, 9). Microscopical analysis of honey samples from Bhimshankar (Maharashtra, 3.34%) and Tenali (Andhra Pradesh, 4.76%) also revealed it as the important minor pollen source (Seethalakshmi, 1980).

_Rubus sp._ is a white flowered shrub that acts as a medium source of pollen and nectar to honeybees in Himachal Pradesh (Table 12). It is a major source of pollen and nectar in Maharashtra (Chaubal and Deodikar, 1965); Kashmir (Deodikar, 1970; Saraf, 1972) and Uttar Pradesh (Singh, 1983, Singh et al.; 1983; Verma, 1983). In Bangladesh also, it is a major honey source for bees (Dewan, 1980).
In Britain, several species of Rubus are visited by bees for pollen and nectar (Hodges, 1978).

**Citrus** sp. (Rutaceae)

*Citrus* sp. was found as the predominant pollen source in Bilaspur (48.40%) and Mandi (45.65%), secondary pollen source in Baijnath (34%) and Kangra (20.63%) and as the important minor pollen source in Chamba (11.68%), Sundernagar (10.66%) and Arki (10.32%) honeys of summer season (Tables 2, 5, 7). Chanda and Ganguly (1981) reported it as secondary pollen source in Orissa (20%) honey, whereas, Suryanarayana et al. (1981) found it as important minor and minor pollen source in honey samples from Castlerock (Karnataka, 4.12%) and Sitakundu (West Bengal, 2.94%) respectively. Similarly, Nair (1964, 1985) observed *Citrus* as the important minor pollen source in Indogangetic (9.3%) and Peninsular (3.7%) and as minor pollen source in Himalayan (below 1%) honeys.

*Citrus* spp. are cultivated throughout Himachal Pradesh as the medium sources of pollen and nectar to honeybees (Table 12). Other investigators have reported them as the important honey sources from Punjab (Atwal et al., 1980; Salvi, 1975; Chaudhari, 1977 a,b); Maharashtra (Chaubal and Kotmire 1980); Kashmir (Deodikar, 1970; Saraf, 1972); Uttar Pradesh (Kohli, 1958; Singh, 1983; Verma, 1983) and Tamilnadu (Chandran and Shah, 1974). However, Naim and Fhadke (1976) observed it as the minor pollen and nectar source in Bihar.
It is also a medium honey source in Cyprus, Bangladesh and Sri Lanka (Church and White, 1980; Dewan, 1980; Baptist and Punchihewa, 1980).

Citrus trees are widely planted in United States, Canada, Italy, Britain, Brazil and Africa for their good honey potentiality (Robinson and Cortal, 1979; Crane 1980; Vorwohl, 1981, Battaglini and D'Albor, 1981; Crane and Walker, 1984; Imperatriz-Fonseca et al., 1985). Honey is of light colour with an acidic flavour (Crane, 1975).

Salix sp. (Salicaceae)

Pollen analysis revealed Salix sp. as the predominant pollen source in Nirmand (46.32%) and secondary pollen source in Chamba (37.72%), Rajgarh (21.50%) and Kasauli (17.51%) and as important minor pollen source in Hatkoti (13.98%) honeys of summer season (Tables 2, 7, 9). It was also present as secondary pollen source in Chamba (19.60%) honey of autumn season (Tables 3, 8, 10). In Shimla honey, it was present as secondary pollen source in spring (16.50%) honey (Tables 4, 11). Chaubal and Deodikar (1965) also observed it in the Western ghat honeys.

Salix spp. commonly called "Willows" are the important ornamental and timber trees of Himachal Pradesh. They are the medium sources of pollen and nectar to honeybees (Table 12). These are also the medium honey sources in Kashmir (Deodikar, 1970; Saraf, 1972; Shah and Shah, 1976) and Uttar Pradesh (Singh, 1983; Verma, 1983). It is a major honey plant in
Japan (Sakai and Matsuka, 1982).

These trees are widely distributed in Canada, Britain, United States (Hodges, 1972; Adams et al., 1979; Crane, 1980; Adams and Smith, 1981). Honey is of light amber colour with a mild flavour and fine aroma (Crane, 1975).

*Nephelium* sp. (Spindaceae)

Microscopical analysis of the summer honeys revealed *Nephelium* sp. as the secondary pollen source in Sundernagar (21.33%) and as important minor pollen source in Chamba (13.01%) honey (Tables 2, 5, 7). Sharma and Nair (1965) and Seethalakshmi (1980) reported it as the predominant pollen source in Dehradun (Uttar Pradesh, 52.2%) and Muzaffarpur (Bihar, 78.72%) honeys respectively. However, it was secondarily represented in eastern (25.7%) honeys and as an important minor pollen source in Indogangetic (12.1%) honeys (Nair, 1964, 1985).

*Nephelium* sp. is a large evergreen fruit tree which acts as a major source of honey in lowerhills of Himachal Pradesh. (Table 12). It is a major source of nectar to honeybees in Punjab (Salvi, 1975; Chaudhari, 1977 a,b); Karnataka (Divan and Rao, 1971); Bihar (Naim and Fhadke, 1976; Srivastva and Tripathi, 1980) and Uttar Pradesh (Kohli, 1958; Singh, 1983; Verma, 1983). This tree is native to China but is now widely grown in different parts of Asia like Malaysia, Bangladesh and Sri Lanka (Makhdzir and Osman, 1980; Dewan, 1980; Baptist and Punchinewa, 1980).
The honey is of light golden colour with very good flavour, taste and aroma (Crane, 1975).

**Sapindus** sp. (Sapindaceae)

*Sapindus* sp. was present as secondary pollen source in Rampur (36.41%), Hailpur (34.43%), Kangra (18.56%) and Hamirpur (17.11%) and as an important minor pollen source in Sabathu (11.90%) honey of summer season (Tables 2, 5, 7). Seethalakshmi (1980) observed *Sapindus* sp. as the predominant and important minor pollen source in honey samples from Puttur (Karnataka, 71.04%) and Surulipathy (Tamilnadu, 10.44%) respectively, whereas, Nair (1964, 1985) reported it as important minor pollen source in Western (9.8%) and Pennisular (13%) honeys.

*Sapindus* sp. commonly called 'Reetha' is a deciduous timber and avenue tree and is a major source of nectar to honeybees in Himachal Pradesh (Table 12). It is also a major honey source in Uttar Pradesh and Kashmir (Kohli, 1958; Deodikar, 1970). This tree is a major source of nectar in tropical Asia (Singh, 1962; Crane, 1980; Sharma, 1980; Suryanarayanan et al., 1981; Nair, 1985). Soapnut honey is waterywhite in colour with a mild flavour (Crane, 1975).

**Scrophularia** sp. (Scrophulariaceae)

Pollen analysis revealed *Scrophularia* sp. as the predominant pollen source in Rajgarh (47.12%) and as secondary pollen source in Chopal (18.33%), Kasauli (17.79%), Nirmand (17%) and Chail (16.26%) honeys of autumn season (Tables 3, 10).
Scrophularia sp. commonly called 'figwort is a coarse perennial plant that acts as a major source of nectar to honeybees in Himachal Pradesh (Table 12).

These perennials are widespread in Europe and Russia as the major honey plants with there flowers secreting nectar freely (Howes, 1979, Crane, 1980). The honey is light coloured with a little aroma of excellent quality (Crane, 1975).

Tilia sp. (Tiliaceae)

Tilia sp. was present as the predominant pollen source in Banjar (46.61%) honey and as important minor pollen source in Chopal (11.60%) and as the minor pollen source in Baijnath (4.40%) honeys of summer season (Tables 2, 7, 9). During autumn season, it was present as predominant pollen source in Mahan (45.27%) and as secondary pollen source in Janot, Chamba, Baijnath and Nirmand (42.57, 37.77, 20.09 and 19.51% respectively) honeys (Tables 3, 6, 8, 10).

Tilia sp. commonly called 'Lime' is a beautiful avenue tree that acts as the major source of nectar to honeybees in Himachal Pradesh (Table 12). Saraf (1972) also reported it as the prolific source of pollen and nectar to honeybees in Kashmir. It is also a major honey source in China, Japan and Korea (Focke, 1968; Sakai and Matsuka, 1982; Kim, 1985).

Lime is widespread in Europe, North America and Russia for its excellent honey potentiality (Hodges, 1978;
Howes, 1979; Adams et al., 1979; Robinson and Oertel, 1979; Crane, 1980; Adams and Smith, 1981; Villanueva, 1988). Honey from lime is watery white in colour with a distinct flavour (Crane, 1975).

Besides the above sporomorphs, members of the following families were represented in small proportions in the summer honey samples: Acanthaceae (1.89-5.42%); Aceraceae (0-2.45%); Amaranthaceae (2.08-2.98%); Asteraceae (1.76-12.24%); Berberidaceae (0-2.45%); Brassicaceae (1.69-8.27%); Chenopodiaceae (1.06-13.25%); Combretaceae (0-2.05%); Euphorbiaceae (0.98-1.59%); Lamiaceae (1.93-8.28%); Papilionaceae (2.76-11.11%); Poaceae (1.0-4.73%); Polygonaceae (0.931%); Ranunculaceae (2.50-2.81%); Rosaceae (1.65-19.04%); Rutaceae (2.52-7.31%); Salicaceae (2.52-20.77%); Arecaceae (1.52-2.38%); Asteraceae (1.63-10.28%); Balsaminaceae (1.46-1.76%); Brassicaceae (1.48-6.48%); Caesalpiniaceae (2.87-8.47%); Capparidaceae (1.04-4.43%); Chenopodiaceae (3.24-7.69%); Convolvulaceae (1.35-2.08%); Gentianaceae (8.37-8.67%); Geraniaceae (0-4.53%); Iridaceae (1.25-9.13%); Lamiaceae (1.51-19.48%); Malvaceae (1.45-4.58%); Cnaghceae (1.18-4.43%); Papilionaceae (1.51-8.40%); Planta ginaceae (0-1.15%); Poaceae (1.70-3.07%); Polygonaceae (1.42-2.02%); Ranunculaceae (1.01-3.14%); Rhamnaceae (1.15-14.66%); Rosaceae (1.62-21.64%); Salicaceae (2.42-3.12%); Scrophul ariaceae (1-3.45%) and
Tiliaceae (1.25-2.69%) were present in small percentages. (Tables 6,8,10; Figs. 31 to 37). Nair (1964), Seethalakshmi (1980) and Chaturvedi (1983) also reported the presence of members of above families in honey samples from various parts of the country.

Present millisopalyhological studies revealed that summer honeys of Bilaspur (Citrus sp.); Mandi (Citrus sp.); Hamirpur (Toona sp.); Nahan (Eucalyptus sp.); Arki (Trifolium sp.); Janot (Trifolium sp.); Kullu (Robina sp.); Hatkoti (Medicago sp.); Rohru (Prunus sp.); Banjar (Tilia sp.); Nirmand (Salix sp.); Kasauli (Nelilotus sp.); Jubbal (Pyrus sp.); Bagi (Trifolium sp.); Narkanda (Pyrus sp.) were unifloral, whereas, rest of honey samples were multifloral (Table 2). In autumn honeys, samples from Rairpur (Helianthus sp.); Hamirpur (Salvia sp.); Nahan (Tilia sp.); Arki (Fagopyrum sp.); Rampur (Plectranthus sp.); Kullu (Plectranthus sp.); Sabathu (Prinsepia sp.); Hatkoti (Plectranthus sp.); Banjar (Fagopyrum sp.); Reajgarh (Scrophularia sp.); Jubbal (Plectranthus sp.) and Chail (Impatiens sp.) were unifloral and all other samples were multifloral (Table 3). Thus out of sixty four honey samples twenty seven were unifloral and thirty seven were multifloral (Tables 2,3). Seethalakshmi (1980) and Chaturvedi (1983) also observed uniflorality and multiflorality in various honey samples.

In the present investigations, besides entomophilous, anemophilous pollen types were also observed. The anemophilous
types came from Amaranthus sp. in Jubbal (5.63%) and Shimla (0.94%); Plantago sp. in Raipur (2.58%); Nalagarh (8%) and Shimla (8.56%); Zea sp. in Sundernagar (2%); Rampur (6.16%) and Janot (10.24%); Polygonum sp. in Kumersein (18.16%) and Rohru (11.04%); Rumex sp. in Chamba (20.11%) and Shimla (14.22%); Amaranthaceous member in Bilaspur (2.65%); Nalagarh (2.98%); Narkanda (2.08%), and Shimla (8.60%); Chenopodiaceous member in Bilaspur (1.06%); Raipur (2.29%); Kangra (2.46%); Nalagarh (3.34%); Sundernagar (1.53%); Rampur (2.94%); Janot (2.56%); Kullu (2.89%); Kumersein (6.15%); Kasauli (13.25%); Narkanda (1.82%) and Kalpa (9.26%); and Poaceous members in Bilaspur (1.59%); Raipur (4.16%), Kangra (4.73%) and Solan (1%) honeys of summer season (Tables 5,7,9,11). In autumn honeys, following anemophilous types were present: Ainus in Baijnath (3.06%) and Kullu (2.75%); Artemisia in Jubbal (16.08%) and Chopal (22.72%); Plantago in Baijnath (36.76%); Polygonum in Jubbal (1.47%) and Shimla (6.60%); Chenopodium in Jubbal (1.22%), Shimla (2.28%) and Bagi (10.57%); Apiaceous member in Nalagarh (3.21%), Mandi (2.52%), Rajgarh (2.93%), Rampur (2.64%), Janot (5.12%), Hatkoti (5.91%), Kumersein (9.02%), Rohru (17.52%), Chopal (20.77%), Narkanda (7.03%) and Kalpa (9.65%); Amaranthaceous member in Kasauli (2.96%), Jubbal (1.34%), Chopal (1.66%), Chail (3.40%); Arecaceous member in Raipur (2.38%), Hamirpur (1.65%), Sundernagar (1.52%), and Baijnath (3.92%), Janot (2.43%) and Sabathu (2.42%); Chenopodiaceous in Kasauli (7.66%), Chopal (3.24%), Chail (7.69%); and Poaceous members in Bilaspur (2.99%), Raipur (1.85%).
Chambha (3.07%), Kullu (3.0%), Aiki (1.70%), and Kumarsein (2.30%) (Tables 6, 8, 10, 11). This anemophily may be due to atmospheric contamination of honeys in combs by the air borne dispersal or deliberate collection of pollen by honeybees from anemophilous plants (Adams et al., 1979; Chanda and Ganguly, 1981).

**Pollen load studies**

Pollen load studies provide useful information regarding the bee preferences and their pollen carrying capacity (Sharma, 1970 a,b; Deodikar and Suryanarayanan, 1977).

In the present investigations, pollen load analysis at Summer hill and Navbahar apiaries (Shimla) revealed that heavier pollen pellets were collected in March (13.72 mg ± 0.22 S.E.); April (13.07 mg ± 0.23 S.E.); May (14.42 mg ± 0.21 S.E.); June (14.72 mg ± 0.20 S.E.); September (13.29 mg ± 0.19 S.E.) and October (12.40 mg ± 0.20 S.E.), whereas, the pollen loads were lighter in weight during July (7.24 mg ± 0.16 S.E.); August (7.34 mg ± 0.21 S.E.); November (8.25 mg ± 0.14 S.E.); December (7.93 mg ± 0.11 S.E.); January (5.66 mg ± 0.09 S.E.) and February (7.17 mg ± 0.18 S.E.). Thus, A. cerana collected heavier pollen pellets in spring, summer and autumn as compared to rainy and winter seasons (Table 13, Fig. 2). This may be because of the multiplicity of bee floume and ideal weather conditions during spring, summer and autumn seasons that heavier pollen loads of higher weight were collected as compared
to other seasons. Matlu (1932) also observed similar trend in *A. cerana* with regards to pollen load collection.

Average weight of pollen load in relation to the body weight of the bee was maximum in summer (24.34%) and minimum in late winter (11.10%) season. In other seasons of the year, it varied (Table 13, Fig. 2). These variations may be due to more changes in the weight of pollen pellets as compared to the body weight of bee during different seasons. The percentage of pollen load to the body weight of *A. cerana* at Coimbatore (South India) was 27.7% in spring and 26% in early winter season, whereas, in Kashmir it was 29% in summer and 28% in autumn (Cherian et al., 1946; Punjabi et al., 1969). These variations in the pollen carrying capacity of Indian honeybee in different parts of the country may be due to certain factors such as weather, flowering stage of the bee plant, variations in the bee flora available and variations in bee size (Mattu and Verma, 1980, 1983, 1984 a,b). Moreover, above authors have collected this data for specific plants such as maize, apple, Cholam etc., whereas, the present results included data from general flora (wild and cultivated) of Shimla hills and was not of any specific crop. Different authors have also reported variations in the pollen carrying capacity of European bee, *A. mellifera*. For example, it was 13.6% (Gillete, 1897); 9.5 to 24% (Kellogg and Asquith, 1934) and 20% (Parker 1926). Thus present results suggest that *A. cerana* resembled *A. mellifera* in its pollen carrying capacity. Similar conclusion was also
made by Mattu (1982) for this species.

Although pollen pellets of different colours such as yellow, red, white, orange, green, grey, brown and mixed were collected by *A. cerana* in different seasons, yet, yellow coloured pellets were present predominantly throughout the year (Table 14; Figs 4, 5, 6). It may be because most of the bee plants such as *Brassica* sp., *Fagopyrum* sp., *Impatiens* sp., *Taraxacum* sp., *Malus* sp., *Berberis* sp. etc. of this region possess yellow coloured pollen. In the present investigations, mixed pollen pellets were observed (Tables 14, 17) as reported earlier by Chaudhari (1978) from Himachal Pradesh and Punjab. However, Jhajj and Goyal (1979 a,b) did not observe mixed coloured pollen pellets for this species at Ludhiana (Punjab). Contrary to the observations of Suryanaryanan (1978), no pink coloured pollen loads were found in the present studies (Tables 14, 17).

**ECO-PHYSIOLOGICAL STUDIES**

Eco-physiological studies are useful for evaluating the honey potentials of different bee plants (Maurizio, 1975; Howes, 1979).

**Floral ecology and biochemistry of the nectars**

Floral data on different phenotypic characteristics of *Plectranthus rugosus* revealed that 100 per cent germination of seeds of this species occurred at 25, 28, and 10°C after 168, 144 and 120 hours of incubation (Table 19). Mean size of bud and flowers of *Plectranthus rugosus* was $0.54 \text{ mm}^2 \pm 0.01 \text{ S.E}$
and 0.98 mm^2 ± 0.01 S.E. respectively. It took 78.45 hours ± 0.18 S.E. for the complete opening of flowers. Mean number of healthy flowers per plant was 38.2 ± 0.51 S.E. (Table 20; Figs. 7, c, 9).

Present biochemical studies on nectars of different plant species revealed fluctuations in the nectar sugar concentration during different hours of the day. All plant species showed an increase in their sugar content from morning to evening hours (Table 21; Figs. 38, 39, 40). This may be due to evaporation of nectar water as a result of changing weather conditions such as temperature, humidity, light intensity etc. While studying the sugar content of bee plants, similar conclusions were also drawn by Waller et al. (1981) for Gossypium sp. and Southwick (1983) for Asclepias syriaca.

In Asian continent also, similar trend in the nectar sugar concentration was observed by different investigators on various crops: Carvia callosa (Phadke, 1964); Thelepaepale ixiocephala (Phadke, 1965); Gossypium arboreum (Tanda and Goyal (1979 a,b); Elletaria sp. (Chandran et al; 1980); Brassica campestris (Murrell and Nash, 1981); Ipomoea kentrokaulos (Reddi and Reddi, 1982); Hevea brasiliensis (Shakuntala Nair and Wakhle, 1983); Nephelium litchi (Shakuntala Nair, 1983); Brassica campestris (Tanda, 1984).

Present biochemical results showed that sugar content was 0.132 mg ± 0.016 S.E. to 0.397 mg ± 0.026 S.E. in
**Plectranthus rugosus; 0.171 mg ± 0.026 S.E. to 0.298 mg ± 0.037 S.E. in Plectranthus gerardianus and 0.114 mg ± 0.052 S.E. to 0.277 mg ± 0.043 S.E. in Plectranthus cotatus of family Lamiaceae (Table 21, Fig. 3B). Different investigators have reported the sugar values in various plant species of family Lamiaceae as: Lamium album (0.12-0.14 mg); Lamium maculatum (0.32 mg); *Salvia officinalis* (0.37 to 1.56 mg); *Salvia pratensis* (0.60 mg); *Salvia verticillata* (0.06-0.58 mg); *Thymus vulgaris* (0.01-0.09 mg); *Lavandula spica* (0.09 mg) *Dracontophyllum moldaviicum* (0.1-0.75 mg) and *Glechoma sp.* (0.16 mg) (Demianowicz et al., 1960, 1963; Gulyas, 1967; Kropacova and Kropac, 1969; Jablonski, 1968; Maurizio, 1954; Southwick et al., 1981; Szklanowska, 1965).

Biochemical results on plants of family Rosaceae revealed sugar content as 0.132 mg ± 0.016 S.E. to 0.251 mg ± 0.033 S.E. in *Prunus cerasoides*; 0.059 mg ± 0.003 S.E. to 0.199 mg ± 0.014 S.E. in *Prunus utilis* and 0.002 S.E. to 0.197 mg ± 0.077 S.E. in *Rosa moschata* and 0.085 mg ± 0.003 S.E. to 0.159 mg ± 0.007 S.E. in *Rubus lasiocarpus* (Table 21, Fig. 39). Earlier investigators have reported sugar contents for different plant species of family Rosaceae as: *Malus sylvestris* (0.03-1.94 mg, Ewert, 1940; 3.26-7.09 mg, Sazykin, 1955, 0.23 mg; Southwick et al., 1981); *Prunus armeniaca* (0.31-0.84 mg, Ewert, 1940); *Prunus avium* (1.50 mg, Boetius, 1948; 0.81-2.30 mg, Sazykin, 1955); *Prunus domestica* (0.25 mg, Fahn, 1949; 0.96-1.74 mg, Sazykin, 1955);
Prunus persica (0.54-1.38 mg, Ewert, 1940; 0.19-2.38 mg; Mishra et al., 1985); Pyrus communis (0.69 mg, Boetius, 1948; 0.84 - 0.85 mg, Sazykin, 1955); Rubus idaeus (1.8 -8.1 mg and 1.41 mg, Demianowicz, et al., 1960; Senduleac and Baculinschi, 1959); Fragaria sp. (0.6-0.8 mg, Petkov, 1965) and Rosa spinosissima (0.17 mg, Southwick et al., 1981).

Present investigations showed that sugar content was 0.064 mg + 0.002 S.E. to 0.238 mg + 0.027 S.E. in Adhatoda zeylanica and 0.062 mg + 0.001 S.E. to 0.170 mg + 0.069 S.E. in Berberis lycium (Table 21, Fig. 40). A number of researchers have given sugar values for honey plants of different families; Acer sp. and Aesculus sp. (0.641-2.719 and 0.194-0.397 mg respectively, Haragsim, 1971); Asclepias syriaca (2.8 mg, Southwick, 1983); Brassica oleracea (0.747 mg, Gupta et al., 1984 a,b); Catalpa sp. (0.54 mg, Southwick et al., 1981); Echium vulgare (0.07 mg, Southwick et al., 1981); Faqopyrum sp. (0.046 - 0.14 mg, Girikh et al., 1971); Ibex glabra (0.17 - 0.68 mg, Krell and Dietz, 1985; Lotus corniculatus (0.03 -0.07 mg, Degrandi - Hoffman and Collison; Medicago sativa, Melilotus alba and Onobrychis vicifolia (0.04 -0.20, 0.001 -0.060 and 0.020, Demianowicz et al., 1963); Nephelium litchi (5.078 mg, Shakuntala Nair, 1983); Ricinus communis (0.60 mg, Mukhametzyanova and Kashmidov, 1977); Robinia pseudoacacia (1.082 mg, Haragsim, 1971; 0.76 - 4.0 mg, Cirnu et al., 1977; 13.4 mg, Howes, 1979); Taraxacum sp. (1.9 -5.2 mg, Szabo, 1984);
*Tilia europaea* (0.08 mg, Southwick et al., 1981); *Trifolium pratense*, (4.4-14.8 mg, Szabo and Najda, 1985). These variations in the sugar contents of different plants from various parts of the world (Table 22) may be due to different climatic and floral conditions in the various continents.

Comparative foraging behaviour of *A. cerana* and *A. mellifera* on *Plectranthus* bloom

Foraging studies on the hourly fluctuations in the population of honeybees on flowers of *Plectranthus rugosus* showed that hours of peak activity for *A. cerana* were between 0900 to 1100 hours, whereas, *A. mellifera* showed maximum activity between 1000 to 1200 hours. (Table 23, Fig. 41). These variations in the peak hours of foraging activities of these two species of honeybees may be attributed to the changes in temperature and other weather conditions during different hours of the day. A number of investigators have reported different periods of maximum foraging activity for *A. cerana* on different crops from various parts of India: 0600 to 1100 hours on *Helianthus annuus* (Tamilnadu); 0900 to 1400 hours on strawberries (Jeolikote, Uttar Pradesh); 1200 to 1400 hours on cauliflower (Solan, Himachal Pradesh); 0900 to 1100 hours on *Cardamom* (Kerala); 1500 to 1600 hours on peach and almond (Solan, H.P); 0900 to 1130 hours on apple and 1000 to 1100 hours on plum (Shimla hills, H.P) crop (Rangarajan et al., 1974; Singh, 1979; Dhaliwal and Bhalla, 1980; Chandran et al., 1980;
Mohana Rao and Lazar, 1980; Mohana Rao et al., 1981; Bhalla et al., 1983 b; Verma and Dutta, 1986; Rana, 1986). These variations in the results may be due to different climatic and floral conditions in the various parts of the country.

Similarly, many research workers have reported different peak periods of foraging activity for *A. mellifera* in different parts of the world. For example, it was from 0830 to 1030 hours in Brazil (Kerr et al., 1970); from 0800 to 1000 hours in Egypt (Ibrahim and Selim, 1972); from 1000 to 1200 hours in Romania (Ciurdarescu, 1972); from 1000 to 1100 hours in Venezuela (Nunez, 1977); 1100 to 1200 hours in USA (Collison and Martin, 1979); 1300 to 1600 hours in Canada (Szabo, 1980); 1100 to 1200 hours on peach at Ludhiana (Mann and Singh, 1980); 1100 to 1320 hours on apple crop in Shimla hills (Verma and Dulta, 1986) and 1100 to 1200 hours on plum crop in Shimla hills (Rana, 1986). These differences in the foraging activity patterns in the various parts of the world may be due to the existence of genotype-environment interactions (Kerr et al., 1970).

Present studies on the foraging behaviour of *A. cerana* and *A. mellifera* on *Plectranthus* bloom showed that peak period of foraging activity of *A. mellifera* (1000 to 1200 hours) was observed after that of *A. cerana* (0900 to 1100 hours) (Table 23, Fig. 41). These variations could be because of differences in their preferences for different temperatures and inherent rhythms of activity in two species.
of honeybees. Similar trend was also observed by Verma and Dulta (1986) and Rana (1986) for these two species of honeybees on apple and plum crop respectively.

Studies on the sequence of pollen, nectar and pollen plus nectar collection activity of *A. cerana* and *A. mellifera* revealed that, percentage of nectar collectors was significantly greater ($P < 0.01$) than those collecting pollen and pollen plus nectar during different hours of the day (Table 24, Fig. 42). Other investigators have also found similar pattern for *A. cerana* (Cherian et al., 1947; Mattu and Verma, 1985; Verma and Dulta, 1986) and *A. mellifera* (Erickson et al., 1973) except for the observations of Reddy (1980) who recorded pollen plus nectar collectors in greater number than other categories of bees.

Number of pollen plus nectar collectors varied from 3 to 9 per cent for *A. cerana* and 1.50 to 8 per cent for *A. mellifera* on Plectranthus bloom (Table 24, Fig. 42) Rana (1986) found percentage of pollen plus nectar collectors as 3.33 to 6.67 for *A. cerana* and 9.33 to 12 for *A. mellifera* on plum bloom. However, Verma and Dulta (1986) could not observe any forager of *A. cerana* collecting both pollen plus nectar, whereas, number of pollen plus nectar collectors for *A. mellifera* varied from 6 to 11 per cent on apple crop. In the present investigations, no significant differences ($P > 0.05$) were observed in the number of pollen plus nectar collectors of
A. cerana and A. mellifera except at 1300 hours. (Table 23). But, Rana (1986) reported significantly higher number of pollen plus nectar collectors for A. mellifera than A. cerana during different hours of day on plum crop.

The present foraging data suggested that number of bees collecting pollen was significantly more in the morning hours (40 per cent for A. cerana and 39 per cent for A. mellifera) than in the evening hours (21.50 per cent for A. cerana and 26.50 per cent for A. mellifera) on Plectranthus bloom. However, percentage of nectar collectors was significantly greater in the afternoon hours (69.50 per cent for A. cerana and 59.50 per cent for A. mellifera) than in the morning (57 per cent for A. cerana and 47.50 per cent for A. mellifera) hours (Table 23, Fig. 42). This may be because in many plants pollen dehisces in the morning, whereas, nectar continues to be available in the afternoon (Free, 1970; McGregor, 1976; Tanda and Goyal, 1979 a). Further nectar is dilute in the early morning and becomes more concentrated as the day advances (Tanda and Goyal, 1979 b). This shift from foraging for pollen in the morning to nectar in the afternoon increases the colony efficiency as well as gives the forager a chance to sample the crop for its suitability for further exploitation (Jhajj and Goyal, 1979 a,b). Similar trend of change from pollen foraging in the morning to nectar in the afternoon have also been reported by Free (1963), Tanda and Goyal (1979 a,b), Gupta et al. (1984 a) and Mattu and Verma (1985).
Studies on the foraging attributes of honeybees revealed no significant differences \((P > 0.05)\) in the time spent on each *Plectranthus rugosus* flower by *A. cerana* \((3.18\) seconds) and *A. mellifera* \((2.41\) seconds). Similarly, distance covered from one flower to another did not differ significantly \((P > 0.05)\) between these two species of honeybees, however, *A. cerana* \((2.14\) seconds) took significantly \((P < 0.01)\) more time to shift from one flower to another than *A. mellifera* \((1.50\) seconds) (Table 25). Rymashevskii (1956) reported that average time spent by *A. mellifera* in visiting flower of various plants varied widely; apple \((34\) seconds); apricot \((30.8\) seconds); strawberry \((38\) seconds); Cherry \((40.7\) seconds); raspberry \((58\) seconds) and blackcurrent \((67.3\) seconds). However, Weaver (1957) reported that time spent per flower by tripping nectar collectors, nectar plus pollen collectors, base workers and pollen gatherers of *A. mellifera* was 10.5, 10.2, 8.4 and 4.4 seconds respectively. Verma and Chauhan (1985) observed time spent per apple flower by *A. mellifera* as 6.63 seconds. Similarly, other investigators have also reported different timings for *A. cerana* on various crops; cucumber \((7.65\) seconds); cauliflower \((2.70\) seconds); soapnut \((7.7\) seconds); *Brassica campestris* \((3\) seconds); *Plectranthus rugosus* \((2.4\) seconds); apple \((6.4\) seconds) Verghese and Prasad, 1980; Dhaliwal and Bhalla, 1980; SubbaReddi et al., 1980; Gupta et al., 1984 a; Verma and Chauhan, 1985). These differences in the time spent per flower on different crops by
A. cerana and A. mellifera may be due to their preferences for pollen and/or nectar foraging.

Foraging data showed that A. mellifera (22.79) visited significantly ($P < 0.01$) more number of flowers per minute than A. cerana (18.38). However, there was no significant difference ($P > 0.05$) in the number of branches visited per minute (Table 25). These differences in the number of flowers visited per minute by two species of honeybees may be due to easy access of A. mellifera to available nectar than A. cerana which has to spend comparatively more time for its collection. Gupta et al. (1984) also found that A. mellifera visited more Plectranthus flowers than A. cerana, whereas, Bhalla et al. (1983, a, b) reported that A. cerana visited 10 mustard, 6.9 plum, 6.4 peach and 4.9 almond flowers per minute in Solan hills of Himachal Pradesh. Dhaliwal and Bhalla (1980) reported 14.33 as the mean number of cauliflower flowers visited per minute by Indian honeybee, whereas, A. cerana and A. mellifera visited 10, 25 and 8 flowers of apple per minute (Verma and Chauhan, 1985). These variations in the number of flowers visited per minute of different crops by A. cerana and A. mellifera may be probably due to different amounts of nectar and/or pollen present in different flowers as time spent per flower depends upon amount of nectar present and morphology of flower Pyke et al., 1977).

Worker bees of A. mellifera (Mean weight, 11.67 mg ± 0.37 S.E. to 12.82 mg. ± 0.37 S.E) carried significantly ($P < 0.01$) heavier pollen loads than A. cerana (Mean weight ,
9.85 mg ± 0.26 S.E. to 10.60 mg ± 0.34 S.E. (Table 25, Fig.43). Similar results have also been reported by Verma and Dulta (1986) and Rana (1986). Several other investigators have also noted differences in the weight of pollen pellets collected by A. mellifera and A. cerana. For example, A. mellifera carried pollen loads weighing 11.2 mg (Gillette, 1897); 12.4 to 13.4 mg (Kellogg and Asquith, 1934) and 15.0 to 19.7 mg (Parker, 1926), whereas, plain and hill variety of A. cerana carried 10.6 and 14 mg respectively (Cherian et al., 1946; Punjabi et al., 1969). This difference in the pollen loads of the worker bees of these two species may be due to the differences in their pollen carrying capacities on the basis of the body size. Morphometric studies conducted by Mattu and Verma (1980, 1983, 1984a,b,c) have already suggested that morphological characters related to foraging and pollination efficiency are significantly bigger in A. mellifera than in A. cerana. Further it is established that small insects with smaller bodies carry little pollen, whereas, large hairy insects bear considerable amount of pollen on their bodies (Karmo and Vickery, 1954; Free, 1970; Kendall and Solomon, 1973).

Present foraging results showed that duration of a foraging trip was significantly longer (P < 0.01) for A. mellifera (16.88 minutes ± 0.39 S.E.) than A. cerana (16.63 minutes ± 0.34 S.E) (Table 25). This difference may be
because of different foraging efficiencies, differences in the time spent per flower and availability of fuel contents (Carbohydrates plus respiratory enzymes) for flight in flight muscles. It has already been suggested by Verma and Dulta (1986) that *A. mellifera* has more fuel in terms of glycogen than *A. cerana* in thoracic flight muscles. Different investigators have reported different durations of foraging trip for *A. mellifera* in various parts of the world. For example, mean duration of foraging trip for *A. mellifera* was reported as 30 to 120 minutes by Lunden (1914), 34 to 49 minutes by Park (1928); 80 minutes by Singh (1950); 17.02 minutes by Verma and Dulta (1986) and 11.85 minutes by Rana (1986), whereas, for *A. cerana* this duration was observed as 45 to 83 minutes by Mattu (1982); 11.85 minutes by Verma and Dulta (1986) and 9.26 minutes by Rana (1986). These variations in the results may be because of different foraging efficiencies of these two species of honeybees.