MATERIAL AND METHODS

The present investigations were carried out to study the pollinator diversity and the foraging behaviour of insect visitors of some important oil seed, vegetable, fruit and forest plants. Studies were directed towards determining the most efficient pollinator and contribution of insect visitors to the health of the crop ecosystem by pollinating activity.

STUDY AREA

Investigations for oil seed, vegetable, fruit and forest plants were conducted in farmers’ field and forest areas. Oil seed, vegetable and litchi crops were studied in field/grooves in and around Chandigarh. This highly commercial and technologically advanced crop area has undergone drastic changes due to rapid and extensive urbanization in what is now called the tricity. Further, being agriculturally and technologically rich, this ecosystem has been subject to the effect of practices like monoculture, fragmentation and pesticide applications. Part of the investigations pertaining to forest trees were conducted near Madhuban in Karnal. Kinnaur in the remote high altitude region of Himachal Pradesh where the process of modernization has not yet interfered with the cultivation of the major fruit crop of apple was selected for studies on this crop.

STUDY MATERIAL

This comprised the plant component and the insect component. The plant component comprised the crops selected for the study and included:
Material and methods

Oil seed crops represented by Sunflower and Brassica.

Vegetable crops represented by Brassica and Okra.

Fruit crops represented by Apple and Litchi.

Forest plants represented by Eucalyptus.

The insect material included the flower visitors of the selected plants in bloom.

The plant material and its important characteristics

1. Helianthus annuus L. (Sunflower)

Sunflower is a sub-tropical to temperate region crop. It was traditionally grown for its ornamental value. However, presently sunflower is mainly grown for its oil. Many sunflower varieties exhibit a degree of self-incompatibility and pollen movement by insects is important. Its flowering period in this region is from July-September. Observations were taken three times in a week for a period of five weeks.

2. Brassica campestris L. var. sarson

The Brassica campestris L. var. sarson is a winter season oil seed and vegetable crop cultivated in subtropical to temperate agro climates in India. It has a long blossoming period lasting for about four months i.e. from December to March. The crop produces large qualities of nectar and pollen and is visited by a variety of insects. The plant is benefited by cross pollination.

Studies were conducted during the full blooming period of crop i.e. in the months of February-March, 2004, at village Togan near Chandigarh. Observations were taken three times in a week for a period of five weeks.
3. **Abelmoschus esculentus** (L.) Moench (Okra)

It is a common kitchen garden vegetable crop grown throughout the Northern plains of India. It is very popular with the Indian palate and is therefore economically important. Its blossoming period is from June to September. The flowers are large, yellowish, present in the leaf axil. The large corolla attracts several insect pollinators.

Okra was studied in fields at village Tasoli near Chandigarh in the months of June-July, 2004. Observations were taken three times in a week for a period of five weeks.

4. **Malus domestica** Borkh. var. royal delicious (Apple)

This is a highly commercial fruit crop of Himachal Pradesh. Flowers are self incompatible and require the services of insects for transfer of pollen from the pollinizer variety. Flowering period is short, lasting about 15 days.

The study on apple was performed during its full bloom in the months of April-May, 2003 at village Pooh, District Kinnaur in Himachal Pradesh. Data were recorded everyday for a period of two weeks.

5. **Litchi chinensis** Sonn. (Litchi)

This is a popular edible fruit tree introduced in India from China. The litchi inflorescence is a branched panicle with large number of small, greenish-yellow flowers in terminal clusters about a foot long. *L. chinensis* is an excellent honey plant and depends on insects for cross pollination.

Studies were conducted in the months of March-April, 2004, at Pinjore Garden, Chandigarh and data were collected three times in a week for a period of five weeks.

6. **Eucalyptus tereticornis** Sm.

This is a forest tree native to Australia that has now been introduced to
almost all parts of the world. It yields a valuable oil used by cosmetic and pharmaceutical industries. The bark is used for manufacturing paper pulp. The tree acts as a wind break and is also good for conservation of soil. It is the source of quality nectar collected by honey bees. Beekeepers migrate honeybees to *Eucalyptus* plantations for harvesting *Eucalyptus* honey.

Observations were taken during February-March (2005) three times a week for a period of five weeks.

### The insect material and its method of study

The insects visiting the flowers of the crop under study were collected by sweeping a hand net. Collections were made during the blossoming period of crop/trees every two hours between 0900 to 1700 hrs. A few visitors observed on the bloom at any other time of the day were also captured. Collected insects were killed in a glass bottle fumigated with ethyl acetate. These were stretched on a thermocol sheet, dried and preserved in insect cabinets. The preserved insects were identified by comparison with reference collection in the entomology laboratory of the Department of Zoology, Panjab University, Chandigarh, with the help of taxonomic keys and were also got identified by taxonomists in the parent department and in the Zoology Department of Punjabi University, Patiala.

The following parameters were considered for making observations on the insect material:

1. **Pollinator diversity**: Diversity was observed as the number of different species of insects visiting the crop. The insects on a particular crop were caught with a sweep net as described above.

2. **Relative abundance**: Five randomly selected areas of 1m × 1m size were taken in case of field crops and 5 equal sized branches in case of fruit crops. The visits of each insect were recorded for 5 minutes in the selected areas. Observations were taken three times in a day between 0900-1100 hrs, 1200-1400 hrs and 1500 to 1700 hrs during the full bloom of the crop.
3. **Foraging behaviour:** This was studied with respect to the following two attributes:

i. **Foraging rate:** Rate was determined by recording the number of flowers visited per minute by each type of insect. Observations were recorded between 0900-1100 hrs, 1200-1400 hrs, 1500-1700 hrs and were repeated five times during each interval.

ii. **Foraging duration:** The time spent by each insect species on one flower (in seconds) was recorded with the help of a stopwatch. Observations were recorded three times in a day viz., 0900-1100 hrs, 1200-1400 hrs, 1500-1700 hrs and repeated five times during each period.

4. **Pollen Counting:** Three individuals of each species were captured on the flowers and immediately killed separately in vials containing 70% alcohol. The pollen grains adhered to the body of each insect were washed in alcohol and a constant volume of 1 ml each was prepared. The hind legs in case of *Apis* visitors were amputated before killing them and then the rinsate was made.

The number of loose pollen grains adhered to the body of pollinators were counted with the help of haemocytometer as suggested by Kumar *et al.* (1985).

On the basis of the data obtained for the pollination attributes studied viz., relative abundance of flower visitors, their foraging rate, foraging duration, number of loose pollen grains attached to their body each insect species was assigned performance scores (PSs) as per the formula of Sihag and Rathi (1994) given below:

\[ P_{ij} = \frac{N_{ij}}{N_j} \times S \]

where,

\[ i = 1 \text{ to } x \text{ and } j = 1 \text{ to } r, \text{ both taking positive, whole number and finite values.} \]

\( P_{ij} = \text{performance scores of } i^{\text{th}} \text{ species for } j^{\text{th}} \text{ attribute.} \)
Material and methods

\[ N_{ij} = \text{Importance value of } i^{th} \text{ species for } j^{th} \text{ attribute} \]

\[ N_j = \text{Total importance value of all the species for } j^{th} \text{ attribute.} \]

\[ S = \text{Total number of species} \]

Since foraging duration per flower is inversely related to pollinating efficiency the formula was modified by taking the reciprocal of the values for that attribute.

Pollination Index (PI) was then calculated by multiplying all the PSs of that species. A pollinating efficiency ranking was done according to pollination indices (PI) of different species and conclusions were drawn as to which insect species was the most efficient pollinator of the specific crop contributing the highest degree to the pollination of that crop.

CROP HEALTH VIS-À-VIS POLLINATORS

Experiment was conducted to assess the effect of presence or absence of insect pollinators on the health/yield of a crop. Litchi trees were taken for this study and the following method was employed.

Five trees were marked in different parts of the litchi groove. Two branches of equal health and flower intensity were selected on each tree. One branch was enclosed in nylon net just prior to the opening of flowers while the other was left uncovered (Plate 1). The following observations were taken at the end of the experiment:

i. Number of fruits/branch
ii. Size of fruits (length).

STATISTICAL ANALYSIS

Data pertaining to relative abundance, foraging rate and foraging duration were analysed using factorial randomized block design. The data on loose pollen grains were subjected to simple randomized block design analysis.
Plate 1. A-B: Experimental trees of *Litchi chinensis* Sonn. showing branches bagged to exclude pollinators.