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Ethological studies on bumble bees under subtropical conditions in India

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Abstract

Native pollinators play an important role in the sustenance of plant diversity which further supports the existing fauna. Among the different pollinators in the temperate regions of the globe, bumble bees have a very important place. Bumble bees are wild pollinators and belong to order Hymenoptera, family Apidae and genus Bombus. Ethological studies were made to know the behaviour of these important pollinators so that the observations could be put in practical application to mould this pollinator as a commercial pollinator in Asia. Different behavioural aspects related to nesting, foraging, pollination, flora, mating and hibernation were studied under natural conditions in sub-temperate and sub-tropical regions in India.

Keywords: Bumble bees, behaviour, flora, foraging, nests, mating, hibernation.

Nesting Behaviour

Nesting sites

Bumble bees nests below the ground in the forests, fields and barren lands. The nesting of bumble bees started with the onset of spring season when the hibernated queens of bumble bees come out and starts searching for the nesting places. The nesting sites are mostly the abandoned nests or cavities underground. Bumble bee queens when found a suitable place for nesting starts building up of the nest. The nests are located mostly in North-West direction and found supported by attachment to the roots of nearby vegetation (trees or shrubs). The nesting place may be a piece of barren land, uncultivated fields or bunds along the fields which is a good sunny site and in front of the nest the land is evenly leveled with small grasses at the entry point. The nest entry is hidden (concealed).

Nests of bumble bees

The nests of bumble bees are oval to circular in shape and found in undisturbed areas nearby a tree or near bush (Fig 1a and Fig 1b). These are covered by involucrum (dry grass (Fig 2), small twigs, leaves, small wooden pieces, pine needles etc.) from outside (Gonzalez *et al.*, 2004). Queens of bumble bees after locating a suitable nesting place initiates building of nest by secreting wax from the ventral side of the abdomen and priming a small area with it. It then lays 2-6 eggs either on the floor or makes egg cups. Bumble bee queen incubate the eggs by covering them with their abdomen (Fig 3). After 2-5 days, the eggs hatches into off-white coloured larvae. Queen opens the brood cells for feeding the larvae and then after feeding again closes it with the wax. The size of the nest increases with the brooding activity and finally reaches to its maximum population (120 – 350 individuals in *B. haemorrhoidalis*). Size of the nest depends on the geographical conditions and species of bumble bee.



Fig. 1a Bumble bee natural nest



Fig. 1b Nest concealed with grass



Fig 2 Involucrum (grass) of nest



Fig 3 Queen incubating the brood

Castes of bumble bees

With the initiation of the nest, bumble bee starts raising the brood cells. The larvae grow and in 23-30 days adults are emerged. After the emergence of the workers, the queen performs only the work of egg laying and occasionally leaves the nest. The workers took all the duties (pollen, nectar gathering, feeding of young brood and building and maintenance of nest etc.). The colony grows gradually with time and till autumn season gets fully developed. The numbers of bumble bee workers in the nest are at its full strength during this time of the year. With the onset of autumn, the queen starts laying eggs which matures to form new daughter queens and drones that can be found mating in the day time. The queens are larger in size while the drones are smaller than queens and workers.

Types of cells in the nest

The cells of bumble bee are circular to oval in shape and arranged in circular or conical manner in the nest. The worker cells are smaller in size as compared to the queen cells. Some cells (honey pots) are filled with honey and are bigger than the worker cells. The cells in the nest are slightly brownish to yellowish brown in colour. The size of different types of cells (queen, worker and honey pots) are 16.56-20.57mm in length and 12.55-15.20mm diameter, 13.16-14.24 in length and 10.01-10.95mm in width . Honey pots are 15.31-20.35mm in length and 12.91-16.32mm in width (Kashyap, 2008; Hoffmann *et al.*, 2004) (Table 1). Drones cells are similar to worker cells and are formed in the late summer and early autumn. All the cells have a common building material of wax and pollen.

Table 1. Dimensions of the natural nests of bumble bees at two different altitudes

Types of cells	Altitude, 2300m		Altitude, 1250m	
	Length±S.E.(mm)	Width±S.E.(mm)	Length±S.E.(mm)	Width±S.E.(mm)
Queen cells	16.56±2.1	12.55±0.27	20.57±0.75	15.20±0.97
Worker cells	13.16±0.79	10.15±1.07	14.24±0.86	10.01±1.03
Honey pots	15.31±0.25	12.91±0.23	20.35±0.68	16.32±0.83

Foraging Behaviour

With the onset of spring (February-March), hibernated queens come out and search for nesting places. Till the time they found suitable nesting place, they could be seen resting on the plants in the hidden area or foraging on flowers. After finding a suitable habitat, queens start foraging on blooming flora for the collection of pollen and nectar. Queens generally forages during early morning (0530-0800h) and evening (1700-1900h) time (Table 2). The queen forages till the first batch of workers emerged and then occasionally leaves the nest. Workers share all the duties of the nest except egg-laying. The workers forage (over a distance of about half a mile) for nectar and gather pollen. Different species of bumble bees have different flower preferences, but all bumble bees need to visit a variety of different plant species, as they are active from early spring through to late summer. On a daily basis, they can be seen searching for nectar and pollen from early morning right through to the evening. They are active on days when it is too cold or rainy for other insects to fly.

Table: 2. Foraging activity of bumble bee at the natural nest entrance

Day hours (h)	Incoming workers/5min	Outgoing workers/5min	Mean
0530	21.50	26.67	24.08
0630	15.33	19.17	17.25
0830	20.17	21.83	21.00
1000	18.67	22.50	20.58
1200	13.00	16.00	14.00
1400	9.83	11.83	10.83
1600	18.17	19.50	18.83
1800	22.00	20.50	21.25
Mean	17.33	19.75	

CD_{0.05}

Time : 2.62

Incoming/Outgoing workers : 1.31

Insect x Time : 3.70

Components of foraging behaviour of bumble bees

Foraging rate: Bumble bee forages on mostly all kinds of flowers and covers about 8-12 flowers in one minute. The foraging rate depends upon the floral morphology of plants.

Foraging speed: The time spent by a bumble bee forager on a single flower for the collection of pollen and nectar is 4-8sec/flower. In the plants of family *Papilionaceae*, *Labiatae* etc., bumble bee foragers spends as long as 20-30 sec/ flower.

Loose pollen grains: Bumble bee carries more loose pollen grains on their robust hairy bodies which were found to be 2150-2800. Loose pollen grain carrying capacity is one of the most important factors for the contribution of an insect in pollination of plants.

Relative abundance: Bumble bees forages on almost all the blooming crops (floriculture, vegetable, medicinal, wild flowers) but are found in large number of crops belongs to families *Labiatae*, *Papilionaceae*, *Solanaceae*, *Verbenaceae* and *Scrophulariaceae*.

Flora of bumble bees

Bumble bee depends on large number of floral sources for their survival and sustenance in nature. Floral cycle (Fig 4) depicts that during spring, under subtropical regions of India, the flora available comprises of many wild and cultivated plants. *Caryopteris bicolor*, *Scutellaria linearis*, *Jasminum* sp., *Nicotianum* sp., *Rosmarinus officinalis*, *Salvia moorcroftiana*, *Chrysanthemum* sp., *Antirrhinum* sp., *Delphinium* sp., *Lupinus mutabilis*, *Callundula* sp., *Papaver sominiferum*, *Raphanus sativus*, *Brassica* sp., *Pisum sativum*, *Prunus persica*, *Prunus pashia*, *Malus domestica*, *Pyrus communis*, *Wisteria sinensis*, *Olea europea* and some wild bushes belong to *Astracae* family . Summer flora includes *Jakaranda mimmosaefolia*, *Punica granatum*, *Rubus elliptica*, *Trifolium* sp., *Acacia catechu* and plants belongs to *Cucurbitaceae*. While *Alpinia calcarata*, *Hypericum perforatum*, *Plantago lanceolata*, *Solanum lacinatum*, *Solanum indicum*, *Chichorium intybus*, *Digitalis purpurae*, *Oenothera biennis*, *Clitoria ternatea*, *Solanum sissymbriifolium*, *Duranta* sp., *Gladiolus* sp., constitutes the rainy and autumn season flora for the bumble bees (Chauhan, 2011).



Fig.4 Bumble bees foraging on different flora (Wild, medicinal, floriculture etc.).

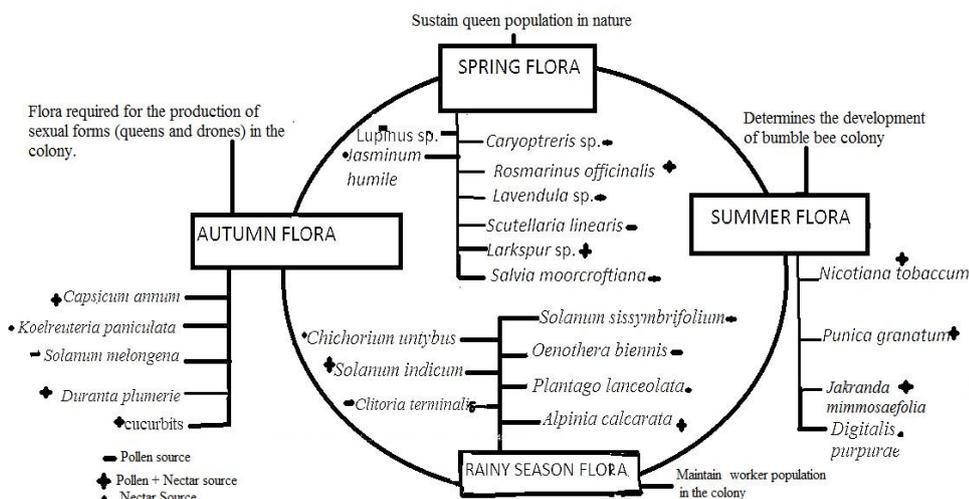


Figure 5. Bumble bee floral cycle during a year under sub-tropical regions

Mating behaviour of bumble bees

In the late summer or on the onset of autumn, mother queen starts laying eggs which later on is moulded into queen (fertilized eggs) and drone cells (unfertilized eggs). Drones leave the nests after some days of emergence. It forages on flowers and scouting on other nests of bumble bees in search of new unmated queens for mating (Duvosin *et al.*, 2002). Queens after emergence lives in the nest for about a week and then leaves the nest for mating. After mating, the mated queens come back to their nests while drones do not.



Fig 6. Bumble bee mating under natural habitat conditions

Bumble bees mate during the day time. When a drone locates an unmated queen, it starts flying around the queen and catches it from behind and the mating starts (Fig. 6). The mating lasts for 15-30 minutes (Brown and Baer, 2005; Delplane, 1996). Two or more drones can mate with a single queen. After mating, the drones flew away while the queen returns back in the nest and remains in the nest till onset of winters.

Hibernation/ Diapause

Before the winters, the queens feed on the food stores (nectar and pollen) in the nest and searches for the hibernating sites. After getting a suitable hibernating place, queens leave the nest and with the first showers of the winter, the queen undergoes hibernation and spends whole winters inactively. Diapausing bumble bee queens require large fat reserves, and these fat reserves are used during diapause; the amount of metabolic reserves remaining after completion of diapause depends on diapause length (Holm, 1972).

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