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Different castes in bumble bee, *Bombus haemorrhoidalis* Smith

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ABSTRACT

Life cycle of different castes (queen, workers and drones) of bumble bee, *Bombus haemorrhoidalis* was studied along with their morphological characters. Bumble bee queens were collected and reared under laboratory conditions for one cycle. These were fed with sucrose (50%) and corbicular pollen. Different development stages were recorded. Eggs were white in colour and rice shaped. The larvae were creamish white and earlier C-shaped and later on became swollen with increase in diet. Adults had yellow bands on the abdomen with black body. Different developmental periods were observed from egg till emergence of adults. Longevity of all castes was also recorded along with the identification characters of different castes.

Key words : *Bombus haemorrhoidalis, Different castes, Biology, Morphology, Longevity*

Introduction

Bumble bees are also known as buzz bees (produce vibrations of high frequency by beating of wings) considered to be very suitable pollinators of cucurbits and solanaceous crops under open as well as protected cultivation (Paydas *et al*., 2000; Thakur *et al.*, 2010). These bees pollinate tomatoes, egg plants, peppers, melons, raspberries, blackberries, strawberries, blueberries and cranberries (Smith, 1998). Generally, they are more efficient and reliable pollinators especially under protected conditions over honey bees as they carry a considerable amount of loose pollen grains, have short flight range and less population (Mackenzie, 2009).

The life cycle of *B. terrestris* is annual with one reproductive period. In spring, the hibernated and fertilized queens emerge from their winter quarters to start a colony on their own. It is a below-ground nester that preferentially uses abandoned rodent burrows as their nesting sites (Alford, 1975). As the season progresses, the workers take over the tasks of collecting resources and raising brood. Finally, around July to August, reproduction occurs after the production of males (the drones) and sexual females (the young queens or gynes). The queen of *B. terrestris* lays 8-16 eggs in a pollen lump with a wax canopy. The larvae emerge from the eggs in 5 days and feed on pollen and nectar for 14 days. The larvae then spin a silken cocoon and pupate for an additional 14 days. The development time from egg to adult is approximately four to five weeks (Free and Butler, 1959; Alford, 1975). Whereas, Bowers (1986) recorded 2-3 weeks developing time of larval into adult stages in *Bombus* spp.

Some researchers (Horbers, 1961; Plowright and Jay, 1966) reared the colonies of *B. nevedonesis, B. rufocnictus, B. borealis, B. fervidis, B. terricola* and *B. vagans* under controlled conditions. Bilinski (2000) observed that the queens of *B. ardens ardens*, *B. hypocrite* and *B. sappronenis* laid eggs within 5 days of field collection while a queen of *B. ignitus* did so in 9

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days. The first brood emerged in 28, 27 and 28 days in *B. ardens ardens*, *B. hypocrita* and *B. ignites*, respectively. The colony reached to peak in June and then rapidly decreased in late August. Female emergence took place after 65 days. In *B. haemorrhoidalis*, Dayal and Rana (2004) found that the queens deposited wax after 8.33 days of confinement and laid 6-9 eggs. First batch of workers emerged after 28.33 days of after oviposition. However, Thakur (2006) found that the wax secretion in same species started in 12 days and mound building started after 18 days of confinement. One or two workers emerged daily and 10 individuals emerged after 60 days of confining the queens. The time taken for development of worker from egg to adult was found 28.40 days in *B. haemorrhoidalis* by Chauhan *et al*. (2013). Asada and Ono (2000) found 29 days for queen development and 26-28 days for drones in *B. hypocrita* and *B. ignites*. According to Bowers (1986), male bumble bees took 2-4 weeks for development of larva into adult stages. As not much literature is available on this important bumble bee species, *B. haemorrhoidalis*, present studies were conducted to know different aspects of biology and life cycle.

Material and Methods

The present investigations entitled "Different castes in bumble bee, *Bombus haemorrhoidalis* Smith" were carried out during 2011-2014 in the laboratory, department of Entomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India at an altitude (1250m amsl), longitude of $77^0\,11'\,30''$ E and latitude $30^0\,52^2\,30^3$ N subtropical areas. The developmental biology of bumble bee, *B. haemorrhoidalis* was studied under artificial conditions. The studies conducted are as under:

Duration of egg stage and hatchability

The queens after capturing were put in rearing cages (150 x 80 x 65mm) fed with pollen and fifty per cent sucrose solution under the incubator conditions. The queens were observed daily. After the secretion of wax, eggs were laid by queens. Then the eggs were taken out from the colony and kept as such inside the incubator to work out the duration of egg stage and hatchability in days.

Duration of larval period

On hatching, the neonate larvae were put in the lids containing pollen ad labitum and the lids were put inside the petriplates. The Petri plates were kept inside incubator at the same temperature and humidity conditions. Food was given daily along with the observations on duration of different instars. Experiments were replicated five times with 5 larvae / replication. The moisture content of the food was properly maintained to ensure normal development.

Duration of pupal period

As the pre-pupae formed, these were shifted to the mother colony for pupation as wax is essential for pupation. The number of days for which the bee remained in the pupal stage was counted with the emergence of adults.

Identification of castes

The different castes viz., queen, drone and worker were identified on the basis of their body size, length of antenna, shape of abdomen, presence or absence of sting apparatus and presence of hairs on the body of the emerged adult bees.

Adult longevity

On emergence, the adults were kept separately in the wooden boxes in the incubator. These were provided with pollen and 50 per cent sucrose solution The longevity of male and female was recorded separately in each replication in the incubator (26.9±1°C and 65-70% RH).

Results

Developmental biology of different castes of bumble bee, *B. haemorrhoidalis*

Brood of different castes (queen, drone and worker bees) of *B. haemorrhoidalis* was differentiated on the basis of size and shape of brood, and size and colour of bands of adults. Data were recorded on the developmental biology of different castes like queen, drone and worker under artificial conditions at Nauni which have been described below:

Queen

Morphology

Queen started laying queen brood either in the late summer or in the autumn. The respective length and width of the queen cell were 21.97mm±1.04 and

12.90mm±0.99. The brood cells were found to be oval in shape. Adult queens at the time of emergence were having white and orange sclerite bands on body which later turns to yellow and orange bands. The posterior end of abdomen is blunt and bears sting.

Developmental biology

The developmental instars were differentiated on the basis of length. With each moult, the larval body length and width increases till pupation. Data presented in Table 1 reveal that the incubation period of egg ranged from 2-3 days with an average of 2.10 ± 0.05 days. The duration of the first, second, third and the fourth larval instars were varied from 3-4, 8-9, 4-5 and 4-6 days, respectively, with an average durations of 3.41± 0.08, 8.36± 0.19, 4.31± 0.09 and 5.05± 0.05 days.

Table 1. Developmental biology of queen of *B. haemorrhoidalis* under laboratory conditions

Biological parameter	Duration (days)	
	Mean± SE	Range (days)
Egg	2.10 ± 0.05	2-3
Larval instars I	3.41±0.08	3-4
II	8.36 ± 0.19	8-9
III	4.31 ± 0.09	4-5
IV	5.05 ± 0.05	4-6
Total larval period	21.13 ± 0.16	19-24
Pupal period	9.74 ± 0.11	9-10
Total developmental period	32.96 ± 0.10	30-37

The total larval period varied from 19-24 days with an average duration of 21.13 ± 0.16 days whereas, pupal period ranged from 9-10 days with average duration of 9.74 ± 0.11 days. Total developmental period for queen was found to be 32.96 ± 0.10 days with a range of 30-37 days.

Drone bee

Morphology

Drones are morphologically different from queen and workers as they are smaller in size, bear yellow or white pubescence on their head (vertex), thorax (lateral sides) and sometimes on legs also. They have third antennal segment longer than workers and queen. The posterior end of abdomen is round. Drones do not sting as these do not bear sting apparatus. Drones tended to left the nest permanently after 2-3 days of emergence.

Developmental biology

The data presented in Table 2 reveal that the average duration of drone egg incubation was 2.35 ± 0.04 days which ranged between 2 and 3 days .The durations of the I, II, III and IV larval instar were 2.11 ± 0.06, 8.16 ± 0.08, 3.01 ± 0.08 and 3.04 ± 0.07 days, respectively. The duration of pupal period ranged from 7-9 days with an average period of 7.74 ± 0.11 days. The total larval period was 16.32 ± 0.29 days with a range of 16-20 days whereas, the total developmental period of drone bee ranged from 25-31 days with an average duration of 26.41 ± 1.10 days.

Table 2. Developmental biology of drone of *B. haemorrhoidalis* under laboratory conditions

Biological parameter		Duration (days)	
		Mean± SE	Range (days)
Incubation period		2.35 ± 0.04	2-3
Larval instars	I	2.11±0.06	2-3
	II	8.16 ± 0.08	8-9
	III	3.01 ± 0.08	3-4
	IV	3.04 ± 0.07	3-4
Total larval period		16.32 ± 0.29	16-20
Pupal period		7.74 ± 0.11	7-9
Total developmental period		26.41 ± 1.10	25-31

Worker bumble bee

Morphology

Workers of bumble bee, *B. haemorrhoidalis* were similar in appearance to queens except their smaller size than queens. It was observed that workers perform all the duties of the nest except laying of eggs in the presence of mother queen. When the queen dies or failed to reproduce, workers also started egg laying. The posterior end of abdomen is blunt and bears sting.

Developmental biology

The incubation period of worker bee egg ranged from 2-3 days with an average duration of 2.90 ± 0.04 days. The durations of I, II, III and IV larval instars were 3.01± 0.06, 7.00 ± 0.18, 4.01± 0.08 and 4.94± 0.07 days, respectively (Table 3). The pupal development was completed in 8.74± 0.11 days (7-9 days).

The bumble bee worker completed the larval period in 18.96± 0.29 days. Its total developmental pe-

Table 3. Developmental biology of worker of *B. haemorrhoidalis* under laboratory conditions

Biological parameter		Duration (days)	
		Mean± SE	Range
Incubation period (Egg)		2.90 ± 0.04	2-3
Larval instars	I	3.01± 0.06	2-4
	II	7.00 ± 0.18	6-8
	III	4.01 ± 0.08	3-4
	IV	4.94 ± 0.07	4-5
Total larval period		18.96 ± 0.29	15-21
Pupal period		8.74 ± 0.11	7-9
Total developmental period		30.60 ± 0.10	24-33

riod from egg to the adult stage was ranged from 25 to 33 days (average 30.70 ±0.10 days).

Comparative duration of development stages in different castes

The average egg incubation period of different castes varied between 2.10 and 2.90 days. The development periods of larval stage of drone, queen and worker bees were 16.32, 21.13 and 18.96 days, respectively. Similarly, respective pupal stages were completed in 7.74, 9.74 and 8.74 days. In this way, respective castes took 26.41, 32.96 and 30.60 days to complete the development cycle (Table 4).

Table 4. Duration of developmental stages of different castes of *B. haemorrhoidalis* under laboratory conditions

Caste	Duration of development of different stages (days)			
	Egg	Larval	Pupal	Total period
Drone	2.35	16.32	7.74	26.41
Queen	2.10	21.13	9.74	32.96
Worker	2.90	18.96	8.74	30.60

Longevity of different castes

Data on longevity under laboratory conditions of different castes queen, worker and drone have been presented in Table 5 which reveal that under laboratory conditions, bumble bee queen had an average longevity of 294 ± 39.10 days, while the workers and drones lived for 54 days and 39 days, respectively.

Discussions

Present observations showed that bumble bee queen, drone and worker took about 32.96, 26.41 and 30.60 days, respectively for the development from egg to adult stage. Asada and Ono (2000) recorded 29 days for queen development and 26-28 days for drones in *B. hypocrita* and *B. ignites*. Bowers (1986) reported about 24 days for development of males of bumble bee larvae into adults (excluding eggs) in *Bombus* spp. Similarly, other investigators (Free and Butler, 1959; Alford, 1975; Katayama, 1973; 1975; Chauhan, 2011) have observed that the workers of *B. terrestris*, *B. ignites* and *B. haemorrhoidalis* took about 33, 29.10 and 30 days respectively, for their development from egg to adult which is in conformity with the results of present studies. The variation may be due to the different species of *Bombus* and climatic conditions. Data on longevity of bumble bees revealed that under laboratory conditions, *B. haemorrhoidalis* queen had an average longevity of 294 days, while its workers and drones lived for 54 and 39 days, respectively. According to Smeets and Duchateau (2003), *B. terrestris* workers lived for an average age of 61 days under controlled conditions. The life span of queen, worker and drone was observed to be 268, 56 and 42-49 days in *B. fervidus* (Anonymous, 2002) and 33 days for field worker in *B. pennysylvanicus*, respectively (Goldblatt and Fell, 1987). These variations possibly may be due to the different species of *Bombus* and geographical locations.

Table 5. Longevity of different castes of bumble bee, *B. haemorrhoidalis* under laboratory conditions

Caste of bumble bee	Number of days (Mean* ± S.E.)
Queen	294 ± 39.10
Worker	54 ± 6.07
Drone	39 ± 4.66

* n=20

Conclusions

Bumble bees have different castes (queen, drone and worker) with different development periods. The queen, drone and worker took about 32.96, 26.41 and 30.60 days, respectively for the development from egg to adult stage. Under laboratory conditions, queen, worker and drone had an average longevity of 294, 54 and 39 days, respectively. This study would help in sorting out the problems in caste differentiation and their rearing. Thus, provides a platform for further successful bumble bee rearing for the commercialization of this pollinator in the country.

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