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Rearing of Indian native bumble bee (*Bombus haemorrhoidalis* Smith) in mid hill conditions of Himalaya

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Abstract
During early spring, the hibernated queens were trapped from *Papaver rhoea, Caryopteris bicolor, Delphinium ajacis, Adhatoda vasica, Brassica juncea* and *Lupinus mutabilis* for initiating rearing of bumble bee, *Bombus haemorrhoidalis* Smith. Bumble bee colonies were reared under laboratory condition by maintaining 27±1°C temperature and 65-70 percent relative humidity and by continuously feeding the sucrose solution (50%) and fresh pollen pellets collected by honey bees. The average time for wax secretion was 9.33±1.45, 6.50±1.55 and 6.00±1.01 days during February, March and April, respectively whereas development time from egg to adult was ranged between 17 to 33 days. The developmental period of bumble bee colonies was found to be less in queens trapped during March and April.

Keywords: *Bombus haemorrhoidalis,* fresh pollen, hibernated, development period

Introduction
Bumble bees belongs to insect order Hymenoptera and tribe Bombini are efficient and natural pollinator of many crops (Parkar and Torchio, 2007) [11]. Bumble bees are more reliable pollinators of crops like tomato, vaccinium crops, eggplant, cucumber, blueberry, cranberry, etc., grown under protected conditions (Mackenzie, 2009) [7]. Bumble bees are mainly a temperate group and some species are also found in the tropics. Bumble bees prefer either underground small mammal nests or above ground nest in dry vegetation comprising of different nesting materials such as grass, thick dry leaves and wooden twigs with one or more entrances (Hines *et al*., 2007) [6]. Successful rearing of bumble bees is being done in some countries like Japan, China, Israel, Turkey etc. Worldwide only five species of bumble bees are commercially reared (Velthuis and Doorn, 2006) [16]. Several native bumble bee species are present in India, viz., *Bombus waltoni* (C.), *B. haemorrhoidalis* (S.), *B. kereinsis, B. himalayanus* (S.), *B. asiaticus* (M.), *B. personatus* (S.), *B. rufofaciatus* (S.), *B. trifaciatus* (S.) and *B. tumicatus*. Among these, *B. haemorrhoidalis* is widely available species spread from low lands to high altitude regions of Himalayas (Saini and Ghattor, 2007) [12]. In India, domestication of bumble bee (*B. haemorrhoidalis*), native bee species under laboratory conditions was started in 1997-98 (Thakur, 2002) [13] However, successful domestication of bumble bee (*B. haemorrhoidalis*) under captivity was first done by Dayal and Rana (2004) [4]. They reared spring collected overwintered queens in two chambered wooden boxes under controlled conditions of temperature and humidity by providing them pollen and sucrose solution as per earlier practices (Ono *et al.* 1994) [10]. Many workers (Thakur and Kashyap, 2008; Chauhan, 2011 and Yankit, 2016) [14, 1, 17] had made attempts for refinement of nesting material, rearing and to study biology and life cycle of *B. haemorrhoidalis*. Chauhan (2011) [1] reported that brood developed normally when queens fed with 50% sugar solution and grinded pollen pellets and kept at 30-36 ºC temperature and 50-60% relative humidity. Chauhan *et al*. (2015) [3] carried out studies on diapause and concluded that *B. haemorrhoidalis* undergoes facultative diapause which can be overcome by providing the required conditions of temperature and humidity for brooding.
Bombus haemorrhoidalis Smith is the only bumble bee species reared successfully on small scale and utilized for pollination of fruit and vegetable crops at Solan in India (Dayal and Rana, 2004; Thakur *et al*., 2005; Yankit *et al.*, 2018; Nayak *et al*., 2019) [4, 15, 18, 9].

B. haemorrhoidalis has a yearly life cycle. The queens starts new colony by herself with the onset of spring after emergence from hibernation. It starts searching nesting sites which are mostly abandoned small rodent nests, dry loosen grass, and the base of untidy hedges. The queens start building nests with the secretion of wax after locating proper nesting sites. Workers (females) are produced and start to forage. The colony develops and grows. Unfertilized eggs (males) are laid and worker larva develop into new queens. Males and new queens mate, the colony disintegrates, the old queen, workers and males die, and new queens hibernate.

Materials and Methods

Foraging bumble bee (*Bombus haemorrhoidalis*) queens were collected from the field at Nauni with the onset of spring in the early morning and evening, while the queens were foraging for pollen and nectar from various medicinal, vegetable and ornamental plants. Queens were collected with the help of insect collecting nylon net. The queens were brought to the laboratory in plastic vials having perforated lids. The captured queens were placed in domiciles with proper feeding provision. Spring collected queens of bumble bees were reared in wooden cages having dimensions 150 x 80 x 65 mm kept in the BOD incubator at 27±1ºC temperature and 65-70 percent relative humidity. Queens were fed with freshly prepared 50 percent sucrose solution and fresh honey bee collected pollen. The colonies/queens were fed daily. Artificial domiciles were also cleaned daily under dark conditions using red light. Feeding was given in lids of bottle/ plastic lids of glass which was kept in either of the chambers. The quantity of pollen and sucrose was increased with the increasing food demand in growing colony. Data on time taken by the bumble bee queens for wax secretion from the date of capturing was recorded along with the time required for the emergence of workers from the date of wax secretion in the bumble bee colony. The number of workers also counted in the bumble bee colony. Laboratory reared bumble bee colonies were shifted to the field conditions (Entomology Experimental Farm) and data on further development of colonies were recorded. Bumble bee rearing boxes with colony were placed in standard B type wooden beehives used for *A. cerana*. Loose cotton and dry grass placed inside the honey bee hive. These hives put on the iron made stands. Workers become acclimatized to the field conditions in 3 to 4 days and started foraging for nectar and pollen. Colonies were fed with pollen and 50 percent sucrose solution for daily consumption. After ten days, pollen feeding was stopped while the sucrose feeding was continued till nectar secreting flora was not in bloom. Data were recorded on activity of bumble bee at nest entrance, numbers of emerging workers, daughter queens and drones. Measurements of different types of cells of *B. haemorrhoidalis* colony were also recorded.

Results and Discussion

The collection of hibernated queens of *B. haemorrhoidalis* were started with the onset of spring in the early morning and evening and continued till April, 2017. The mated queens of previous season were trapped while the queens were foraging for pollen and nectar from diverse bee flora. The observations revealed that Basuti (*Adhatoda vasica* L.) was major bee flora for *B. haemorrhoidalis* and highest (21 queens) number of queens was collected from *Adhatoda vasica* (L.) as compared to *Delphinium ajacis* (L.) (4 queens), *Papaver rhoeas* (L.) (3 queens), *Caryopteris bicolor* (Mabb.) (2 queens), *Lupinus mutabilis* (Sweet) (1 queen) and *Brassica juncea* (L.) (1 queen) during February, March and April months of the 2017. In our experiment, ornamentals Rocket larkspur (*Delphinium ajacis* L.) and Golden poppy (*Papaver rhoeas* L.) were recorded as new bee forage plants in the month of March.

Rearing of *Bombus haemorrhoidalis* Smith queens under laboratory conditions: After collection, the bumble bee queens were brought to the laboratory and placed in two chambered wooden boxes (150 x 80 x 65 mm). The development period of the bumble bee was divided into two stages under laboratory conditions. At colony initiation stage, start of wax secretion (Days), emergence of workers of 1st brood after wax secretion (Days), number of workers in 1st brood and of workers of 1st brood after trapping of queen (Days) parameters were observed. At colony foundation stage, we observed the emergence of workers of 2nd brood after emergence of 1st brood (Days), number of workers in 2nd brood and average development time in *B. haemorrhoidalis* from egg (wax secretion) to adult.

At colony initiation stage: Twenty one out of thirty two queens started building wax mounds, in which thirteen queens develop 1st batch of workers but only nine queens successfully established their colony and raised their progeny. The average period for the start of wax secretion from the day of trapping queens during February, March and April were 9.33±1.45, 6.50±1.55 and 6.00±1.01 days, respectively (Table 1). Similarly, the average duration of emergence of workers of 1st brood after wax secretion were found to be 28.33±2.61, 24.00±1.29 and 21.00±4.01 days in the colonies headed by queens collected during February, March and April, respectively. The average number in first batch of workers during February, March and April months were recorded to be 3.33±1.45, 5.50±0.65 and 4.50±0.50 workers, respectively. The results are in conformity with Yankit (2016) [17] who have done the laboratory rearing and studied the food consumption of spring bumble bee (*Bombus haemorrhoidalis* Smith) queens. They reported that the queens trapped during February and March took on an average 14.12±1.54 days and 11.00±2.66 days for wax secretion and about 23.37±1.54 days and 25.66±3.64 days for the emergence of workers after wax secretion during the month of February and March, respectively.

At colony foundation stage: The average duration of emergence of workers of 2nd brood after emergence of workers of 1st brood were found to be 16.33±1.45**,** 13.50±0.96 and 12.00±1.00 days in the colonies headed by queens collected during February, March and April, respectively. The data recorded on the average number in second batch of workers during February, March and April months were 8.00±1.45, 9.25±0.48 and 11.00±1.00 workers, respectively. The queens trapped during March took fewer days for wax secretion as well as development of workers as compared to queens trapped in February month (Fig. 1). The average developmental time in *B. haemorrhoidalis* from egg (wax secretion) to adult (first emergence of workers) was found in the range of 17 to 33 days with an average of 24.00 days in the month of February-April, in the present experiment. The average developmental time of *B. haemorrhoidalis* from egg (wax secretion) to adult was in consonance with Yankit (2018) [18] who found in the range of 18 to 31 days with an average of 25.66 days in the month of March. Similar results

were reported by Mah and Bilinski (2001) [8] who found the average developmental time in *B. ardens*, *B. hypocrita sapporoensis* and *B. ignitus* from egg to adult as 28, 27 and 28 days, respectively. Similar study was conducted by Gonzalez *et al.* (2004) [5], who reported 29.6 days to be the average developmental time in *B. atratus*.

Table 1: Development of *Bombus haemorrhoidalis* colony from queens collected in different months

Month	Date of trapping queen	Start of wax secretion (Days)	Emergence of workers of 1st brood after wax secretion (Days)	No. of workers in 1st brood	Emergence of workers of 1st brood after trapping of queen (Days)	Emergence of workers of 2nd brood after emergence of 1st brood (Days)	No. of workers in 2nd brood
February	18/2/2017	7	28	4	35	13	6
	24/2/2017	9	24	3	33	19	8
	25/2/2017	12	33	3	45	17	10
	Mean±S.E	9.33±1.45	28.33±2.61	3.33±1.45	37.67±1.45	16.33±1.45	8.00±1.45
March	17/3/2017	8	21	4	29	11	9
	28/3/2017	5	25	6	30	15	10
	29/3/2017	3	23	7	26	13	8
	29/3/2017	10	27	5	37	15	10
	Mean±S.E.	6.50±1.55	24.00±1.29	5.50±0.65	30.50±2.33	13.50±0.96	9.25±0.48
April	1/4/2017	7	25	5	32	13	12
	21/4/2007	5	17	4	22	11	10
	Mean±S.E.	6.00±1.01	21.00±4.01	4.50±0.50	27.00±5.01	12.00±1.00	11.00±1.00

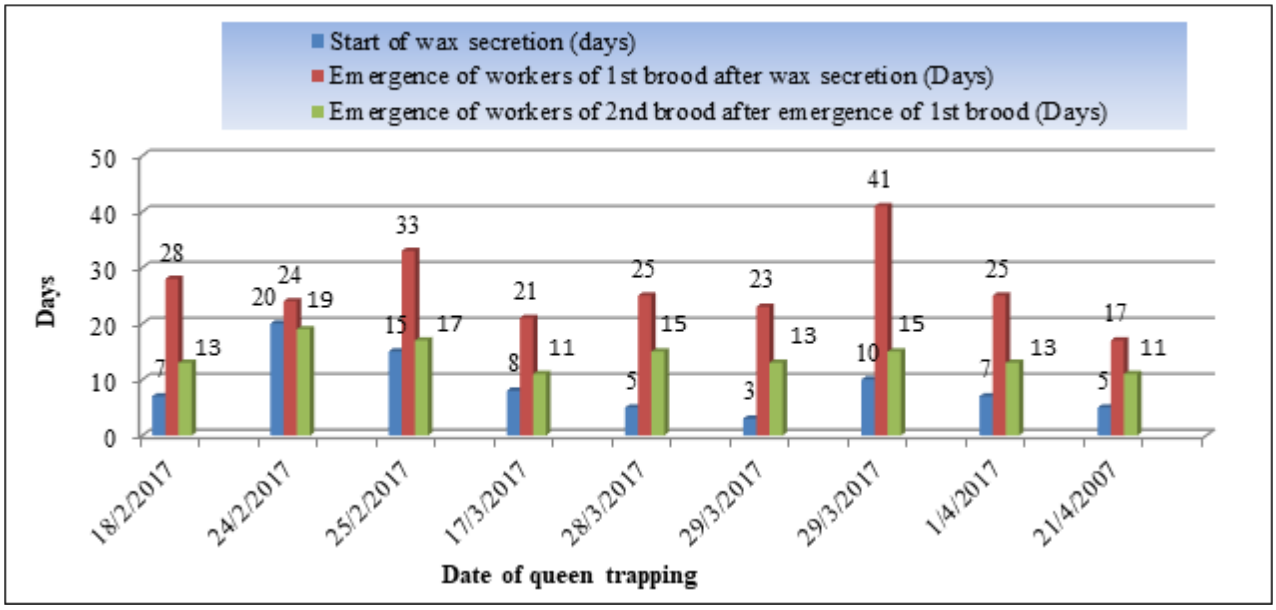

Fig 1: *Bombus haemorrhoidalis* colony development during 2017

Maintenance of laboratory reared bumble bee colonies under field conditions: In 2017, four colonies were shifted to the Entomology Experimental Farm in May (3 in no.) and June (1) when the strength of the colonies varied from 15 to 25 workers per colony (Table 2). Out of four shifted colonies, two colonies which were shifted during May developed well up to July and number of foragers range between 11 to 29 workers. Rearing of brood or emergence of foragers were not observed in these colonies August onward. It was observed that queen and forager bees went for foraging didn't return back to the colonies. Other two colonies developed well under field condition up to October. During July to August, 9 daughter queens and 16 drones were developed in these colonies (No. 3 and 4). These were again shifted to the laboratory during November and further maintained in BOD incubator. The mean numbers of population were ranged from 14.20 to 21.67 workers /colony.

Table 2: Colony development of laboratory reared bumble bee colonies under field conditions in different months

Colony No.	Date of colony shifted to field	Bumble bee population in colonies established in field during May-Oct							
		May	June	July	Aug	Sept	Oct	Nov	Mean±S.E
1	19/05/2017	25	29	11	Queen and forager bees went for foraging didn't return back to the colonies				21.67±5.46
2	19/05/2017	20	29	12					20.33±4.92
3	19/05/2017	15	29	15	27	23	20	Shifted to BOD	21.50±2.43
4	07/06/2017	-	22	14	16	11	8	Shifted to BOD	14.20±2.38

Activity of laboratory reared bumble bee (*B. haemorrhoidalis)* colonies in field condition: Data recorded on foraging activity of laboratory reared bumble bee colonies at nest entrance under field conditions **(**Entomological Experimental Farm) during May-Oct 2017 (Table 3). Observations recorded on activity of colony no. 1 revealed that maximum (2.96 bumble bees/5min) activity was during morning hours (1000-1100hr) which was statistically at par during evening hours (1600-1700hr, 2.93 bumble bees/5min). Minimum (1.26 bumble bees/5min) activity was recorded during afternoon (1300-1400hr). Similarly, mean activity of colony no. 2 and 4 were maximum during morning (1000-1100hr) i.e. 3.63 bumble bees/5min and 2.96 bumble bees/5min, respectively whereas minimum during afternoon (1300-1400hr) i.e. 1.93 bumble bees/5min and 1.44 bumble bees/5min. However, in colony no. 3 maximum (5.60 bumble bees/5min) activity was recorded during evening (1600-1700hr) and minimum (2.43 bumble bees/5min) activity during afternoon (1300-1400hr). It was observed that under field condition, activity of laboratory reared bumble bee colonies were found maximum during morning time (1000-1100hr) and evening time (1600-1700hr) while minimum in afternoon (1300-1400hr). The results of activity of different laboratory reared bumble bee (*B. haemorrhoidalis)* colonies at field condition in agreement with Chauhan (2013) [2] who found that maximum activity of bumble bee colonies were found during morning (0900-1100hr) and evening time (1600-1800hr) and minimum was during afternoon (1300-1500hr) in natural nest under field conditions.

Table 3: Activity of different laboratory reared bumble bee (*B. haemorrhoidalis)* colonies at field condition during May-Oct 2017

Day hours	Activity of different laboratory reared colonies at field condition (Number of bumble bees/5min at nest entrance)											Mean
	Colony no. 1		Mean	Colony no. 2		Mean	Colony no. 3		Mean	Colony no. 4		
	Incoming	Outgoing		Incoming	Outgoing		Incoming	Outgoing		Incoming	Outgoing	
1000-1100	1.72	4.19	2.96	2.39	4.86	3.63	2.39	5.86	4.13	1.72	4.19	2.96
1300-1400	1.03	1.50	1.26	1.69	2.17	1.93	1.69	3.17	2.43	1.39	1.50	1.44
1600-1700	3.83	2.03	2.93	4.50	2.69	3.60	6.50	4.69	5.60	3.50	2.06	2.78
Mean	2.19	2.57		2.86	3.24		3.53	4.57		2.20	2.58	
CD (0.05)												
Activities	0.23			0.29			0.23			0.27		
Day hours	0.29			0.25			0.29			0.33		
Activities ×Day hours	0.40			0.49			0.40			0.46		

Dimensions of different types of cells of *B. haemorrhoidalis* nest reared under laboratory and nest collected from field condition: The average length and width of queen cells, pollen pots, honey pots and worker cells of *B. haemorrhoidalis* in nest collected from field condition were found to be 20.50±0.14 mm and 14.10±0.04 mm; 18.50±0.02 mm and 16.50±0.02 mm; 18.00±0.01 mm and 14.60±0.03 mm and 14.00±0.03 mm and 10.10±0.03 mm, respectively (Table 4) whereas in laboratory reared bumble bee colonies, the average length and width of queen cells, pollen pots, honey pots and worker cells were found to be 17.40±0.03 mm and 13.30±0.07 mm; 17.70±0.02 mm and 15.40±0.02 mm; 16.00±0.02 mm and 14.00±0.05 mm and 13.40±0.04 mm and 9.10±0.02 mm, respectively. The results are in conformity with Chauhan (2011) [1] who found that the size of cells of bumble bee nest developed at the natural conditions was larger as compared to laboratory reared colony. He reported the average length and width of queen cells, honey pots and worker cells were 20.57±0.75 mm and 15.20±0.97 mm; 20.35±0.68 mm and 16.32±0.83 mm and 14.24±0.86 mm and 10.01±1.03 mm, respectively. It was observed that the dimensions of different cells of bumble bee colony in nest collected from field were greater than the dimensions of cells of laboratory reared colonies.

Table 4: Dimensions of different types of cells of *B. haemorrhoidalis* nest reared under laboratory and nest collected from field condition

Types of cells	Nest collected from field condition		Nest reared under laboratory condition	
	Length±S.E.(mm)	Width±S.E.(mm)	Length±S.E.(mm)	Width±S.E.(mm)
Queen cells	20.50±0.14	14.10±0.04	17.40±0.03	13.30±0.07
Worker cells	14.00±0.03	10.10±0.03	13.40±0.04	9.10±0.02
Honey pots	18.00±0.01	14.60±0.03	16.00±0.02	14.00±0.05
Pollen pots	18.50±0.02	16.50±0.02	17.70±0.02	15.40±0.02

Conclusion

Adhatoda vasica was major bee flora for Indian native bee, *B. haemorrhoidali* during February, March and April months. The *Delphinium ajacis* L. and *Papaver rhoeas* L. were new bee flora in the month of March. The queens trapped during March took fewer days for wax secretion as well as development of workers as compared to queens trapped in February month. The average developmental time in *B. haemorrhoidalis* from egg to adult was 24.00 days in the month of February-April. Hence, a healthy colony with many number of bumble bee workers can be useful in cross pollinated crops under protected condition for better quality fruit production.

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References

1. Chauhan A. Refinement of bumble bee rearing technology and its use in cucumber pollination. M.Sc. Thesis, Department of Entomology Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India, 2011, 152.
2. Chauhan A, Katna S, Rana BS, Miyan HV. Field establishment of artificially reared bumble bee (*Bombus haemorrhoidalis* Smith) colonies in Himachal Pradesh.

Insect Environment. 2013; 19:159-161.
3. Chauhan A, Rana BS, Katna S. Bumble bees in India: Rearing and Management. Edn. 1, Lambert Academic Publication, Omniscriptum Gmbh & Company, Eastern Europe, 2015; 1:148.
4. Dayal K, Rana BS. Record of domestication of *Bombus* species (Hymenoptera: Apidae) in India. Insect Environment. 2004; 10:64-65.
5. Gonzalez VH, Mejla A, Rasmussen K. Ecology of nesting behaviour of *B. atratus* Franklin in Andean Highlands (Hymenoptera: Apidae). Journal of Hymenoptera Research. 2004; 13:234-242.
6. Hines HM, Cameroon SA, Deans AR. Nest architecture and foraging behaviour in *B. pullatus* (Hymenoptera: Apidae), with comparisons to other tropical bumble bees. Journal of the Kansas Entomological Society. 2007; 80:1-15.
7. Mackenzie K. Pollination practices and the use of bees in the Vaccinium crops. Acta Horticulturae. 2009; 810:207-213.
8. Mah YI, Bilinski M. Some characteristics of Korean Indigenous bumblebee species (Hymenoptera: Apidae) under laboratory conditions. Acta Horticulturae. 2001; 561:287-291.
9. Nayak RK, Rana K, Sharma HK, Rana VS, Thakur M. Influence of bumble bee pollination on quantitative and qualitative parameters of kiwifruit (*Actinidia deliciosa* Chev.). Indian Journal of Horticulture. 2019; 76(2):294-299.
10. Ono M, Mitsuhata M, Sasaki M. Use of introduced *Bombus terrestris* workers helpers for rapid development of Japanese native *Bombus hypocrite* colonies (Hymenoptera: Apidae). Applied Entomological Zoology. 1994; 29:413-419.
11. Parker FD, Torchio PP. *Bombus terrestris* cutting a flower to rob its nectar. Beekeeping Information Index. 2007; 1:13-15.
12. Saini MS, Ghattor HS. Taxonomy and food plants of some bumble bee species of Lahaul and Spiti valley of Himachal Pradesh. Zoo's Printing Journal. 2007; 22:2648-2657.
13. Thakur RK. First attempt to study nest architecture and domicilation of bumble bee in India. In Proceedings of 6th Asian Apicultural Association International Conference and World Apiexpo, Banglore, India, 2002, 172.
14. Thakur RK, Kashyap L. Record of rearing bumble bee, *Bombus haemorrhoidalis* Smith in captivity and their utilization in polyhouse crop pollination. In Proceedings of 2nd International Beekeeping Congress, Thimpu, Bhutan, 2008, 31-33.
15. Thakur RK, Gupta JK, Gupta PR. Investigation on rearing of bumble bee (*Bombus* sp.) in captivity. In Proceedings of International Beekeeping Congress, Banglore, India. 2005, 18.
16. Velthuis HHW, Doorn VA. A century of advances in bumble bee domestication and the economic and environmental aspects of its commercialization for pollination. Apidologie. 2006; 37:421-451.
17. Yankit P. Studies on bumble bee pollination in tomato (*Solanum lycopericum* Mill.) under protected condition. M.Sc. Thesis, Department of Entomology, Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan, India. 2016, 72.
18. Yankit P, Rana K, Sharma HK, Thakur M, Thakur RK. Effect of bumble bee pollination on quality and yield of tomato (*Solanum lycopericum* Mill.) grown under protected conditions. International Journal of Current Microbiology and Applied Sciences. 2018; 7(1):257-263.