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Harish Kumar Sharma
Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Shabnam Thakur
Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Kiran Rana
Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Meena Thakur
Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Correspondence
Harish Kumar Sharma
Department of Entomology, College of Horticulture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan- 173230 (Himachal Pradesh), India

Small scale rearing of *Bombus haemorrhoidalis* Smith

Harish Kumar Sharma, Shabnam Thakur, Kiran Rana and Meena Thakur

Abstract
The *B. haemorrhoidalis* queens were collected while foraging on *Adhatoda vasica, Brassica juncea, Hypericum oblongifolium, Papaver rhoeas, Scutellaria linearis, Cydonia oblonga* and *Antirrhinum majus* from February to April. Bumble bee colonies were reared under laboratory condition by maintaining 27±1°C temperature and 65-70% relative humidity and fed with 50% sucrose solution and fresh/stored pollen collected from honeybee colonies. Success rate of colony development under laboratory was more in queens collected during April (60%) as compared to queens collected during March (31.25%) and February (16.67%). Similarly, the per cent successful establishment in the field was recorded more in queens collected during April (40%) in comparison to queens collected during March (18.75%).

Keywords: *B. haemorrhoidalis*, reared, honeybee colonies, colony development

Introduction
Bumble bees are important pollinators belonging to insect order Hymenoptera. High speed of pollination, vibration to burst the pollen sacs and efficiency to forage at low temperature and light makes them the most reliable and efficient pollinators (Heinrich, 1979; Abrol, 2012) [8, 2]. Bumble bee pollination helps in improving fruit production, weight, size and other chemical characters to get cost effective production (Klein *et al.*, 2007; Aizen *et al.*, 2008) [11, 3]. Crops like tomato, pepper, cucumber, strawberries etc. grown under plastic tunnels, polyhouses or cages need such pollinators to get low cost constituents (Abak *et al.*, 1997; Kwon and Saeed, 2003) [1, 12]. The genus *Bombus* comprising 250 known species the world over (Williams *et al.*, 2008). India is home of 48 species of bumble bees found at an altitude of 2,000-15,000 feet along the entire Himalayas from Jammu & Kashmir to Nagaland. Out of these 48 species, 37 species are reported from North West Himalayas (Saini *et al.*, 2011) [14]. Different *Bombus* species like *B. terrestris, B. impatiens, B. occidentalis* and some others have been utilized for pollination worldwide (Kwon and Saeed, 2003; Velthuis and van Doorn, 2006; Klein *et al.*, 2007) [12, 20, 11]. Rearing of bumble bees and utilization for pollination in crops grown in polyhouses has taken the shape of industry in western world. In India, little work has been done in respect of biology, nest architecture, nesting habitat, domestication of different bumble bee species and utilization of laboratory reared bumble bees in pollination of crops (Sowmya *et al.*, 2015) [15].

Bombus haemorrhoidalis Smith is the only bumble bee species reared successfully on smaller scale and experimented for its usefulness in pollination of crops at Solan in India (Dayal and Rana, 2004; Thakur *et al.*, 2005) [7, 19]. *B. haemorrhoidalis* starts its life cycle with the onset of spring when queens come out of hibernation and start nesting sites in abandoned nests of rodents and small mammals. The queens start building nests with the secretion of wax after locating nesting sites. The egg, larval and pupal stages are covered with wax and can be seen only when wax coverings opened daily for feeding by queen or workers. Many workers (Thakur, 2002 and 2006; Dayal and Rana, 2004; Thakur and Kashyap, 2008; Chauhan, 2011; Chauhan *et al.*, 2013 and 2014 and Yankit, 2016) [16, 19, 25, 13, 25, 18] had made attempts for rearing and to study biology and life cycle of *B. haemorrhoidalis.*

B. haemorrhoidalis queens were reared successfully under laboratory conditions in two chambered wooden boxes at Nauni (Dayal and Rana, 2004; Chauhan, 2011) [4, 4. Two chambered wooden boxes of 15 x 8 x 6.5 cm (Dayal and Rana, 2004) and 15 x 12 x 8 cm and 16 x 12 x 10 cm (Chauhan, 2011) were found suitable for the rearing of bumble bee queens. They collected bumble bee queens during spring season and kept them in wooden cages and fed with 50% sucrose solution and fresh pollen collected from honey bee colonies. Chauhan (2011) further concluded that brood developed normally when temperature kept between 30-

36°C and 50- 60% relative humidity and queens fed with sugar solution (50%) and grinded pollen pellets. Chauhan *et al.* (2014) reared *B. haemo rrhoidalis* queen successfully for more than fifteen months without undergoing hibernation. Their studies concluded that 83.33 per cent queens started rearing brood out of total experimental queens and population was raised upto 150-180 workers.

Materials and Methods

The bumble bee (*Bombus haemorrhoidalis*) queens were collected from the field at Nauni during onset of spring in the early morning and evening. The mated queens were collected while foraging for pollen and nectar on different flowering plants. Queens were trapped with the help of insect collecting nylon net and brought to the laboratory in plastic vials having perforated lids. The captured queens were placed in wooden domiciles with proper feeding provision and ventilation. The collected queens of bumble bees during spring season were numbered according to date of collection and placed in wooden domiciles having dimensions 16×11×12 cm kept in the BOD incubator at 27±1℃ temprature and 65-70% relative humidity (Chauhan, 2011). Special care was taken for maintaining hygiene in domiciles. Wooden domiciles were cleaned daily under dark conditions using red light.

The bumble bee queens were fed daily on freshly prepared 50% sucrose solution and fresh/stored corbicular pollen collected from *A. mellifera* colonies. The quantity of sucrose solution (2-4ml) was given to queens and was increased with development in colony (4-10ml), as per colony requirement. Initially 1-3g of pollen was given to single queen, which was increased subsequently (4-12 g), as per colony requirement. The sucrose solution was replaced every day while the pollen was replaced at two days interval. Feeding was given in plastic (2.85-3.14 cm dia) and aluminium (2.89 cm dia) screw caps of bottles which were kept in either of the chambers of domiciles. The data on time taken by the bumble bee queens for wax secretion after collection (colony initiation), emergence of first brood and second brood of workers after start of wax secretion was recorded along with the number of workers emerged in first brood and second brood in the bumble bee colonies.

Seven laboratory bumble bee colonies were shifted to field conditions. Out of seven, three colonies were shifted for pollination in bell pepper under protected cultivation and four colonies were established in earlier prepared wooden boxes (*A. mellifera* Langstroth hives) and kept on iron stand inside a iron net cage. The bee hive was conditioned by putting dry grass to create natural environment for bumble bee colonies and wooden domiciles with bumble bee colonies were kept inside such hives. The number of workers was also counted at 9a.m. and the attempt was made to ascertain reasons for queen mortality and loss of colony.

Results and Discussion

The *B. haemorrhoidalis* queen's collection started with the appearance of overwintered queens in the month of February and continued till April, 2017. The fecundated queens of previous season coming out of hibernation were collected while foraging for pollen and nectar on their preferred flowering plants. In total 32 queens were collected from seven different flowering plants from February to April. *Adhatoda vasica* was one of the important flora which blooms from February to April and is visited by large number of *B. haemorrhoidalis*, consequently 22 queens were collected from this flora during February (3), March (11) and April (8).

The *B. haemorrhoidalis* was also collected while foraging on *Brassica juncea*, *Hypericum oblongifolium* during February, *Papaver rhoeas*, *Scutellaria linearis*, *Cydonia oblonga* during March and *Antirrhinum majus* during April. It was also observed that maximum bumble bee queens were collected during evening time from February to April.

Rearing of *B. haemorrhoidalis* under laboratory conditions

A perusal of data presented in Table 1 pertaining to colony development from bumble bee queens collected during February, 2017 revealed that out of six bumble bee queens, five queens started wax secretion 20.60±6.44 average days after putting them in artificial nest provided with food for rearing. Thereafter, queen 1 collected on February 11 started the brood rearing and developed upto 2nd batch of brood. This queen initiated wax secretion nine days after putting in hive, earlier than the other queens. The queen 1 successfully started brooding and the 1st worker emerged 33 days after wax secretion. The data further indicated emergence of six workers from 1st batch of brood. The emergence of 2nd batch of brood (12 workers) took forty eight days after wax secretion and this colony lived for sixty seven days after emergence of 1st worker, having total strength of eighteen workers.

Table 1: Colony development from bumble bee queens collected during February, 2017

Queen No.	Date of queen collection	Initiation of wax secretion (days after collection)	Emergence of 1st worker of 1st batch of brood (days after wax secretion)	Total workers emerged in 1st batch (number)	Emergence of 1st worker of 2nd batch of brood (days after wax secretion)	Total workers emerged in 2nd batch (number)	Queen loss (days after collection)
1.	Feb 11	9	33	6	48	12	100
2.	Feb 11	47	-	-	-	-	57
3.	Feb 18	25	-	-	-	-	56
4.	Feb 18	12	-	-	-	-	34
5.	Feb 24	10	-	-	-	-	24
6.	Feb 25	-	-	-	-	-	23
Mean±S.E.		20.60±6.44	33	6	48	12	49.00±10.85

The colony development of bumble bee queens collected during March, 2017 is presented in Table 2. Data revealed that out of sixteen bumble bee queens, nine queens started wax secretion 7.44±1.86 days after putting in artificial hive. Thereafter, only six queens started the brood rearing and developed upto 1st batch of brood. Irrespective of queens, the first worker emerged 24.00±1.23 days after wax secretion in 1st batch of brood. The average number of workers emerged in 1st brood was 5.00±0.91. While the average emergence of 1st worker from 2nd batch of brood was 47.20±1.25 days after wax secretion. The average number of workers emerged in 2nd brood was higher (10.40±0.78) than 1st brood. The successful

bumble bee queens developed colonies upto 2nd brood level and survived for 67.50±12.37 days after emergence of 1st worker of 2nd batch of brood. Three successfully laboratory reared colonies were established in the field.

Table 2: Colony development from bumble bee queens collected during March, 2017

Queen No.	Date of queen collection	Initiation of wax secretion (days after collection)	Emergence of 1st worker of 1st batch of brood (days after wax secretion)	Total workers emerged in 1st batch (number)	Emergence of 1st worker of 2nd batch of brood (days after wax secretion)	Total workers emerged in 2nd batch (number)	Queen loss (days after collection)	Queen loss (days after emergence of 1st worker from 2nd batch)
7.	March 02	21	20	3	45	7	151	85
8.	March 17	-	-	-	-	-	4	-
9.	March 19	5	26	7	44	11	Colony shifted to field	-
10.	March 27	-	-	-	-	-	29	-
11.	March 28	7	-	-	-	-	101	-
12.	March 28	13	-	-	-	-	108	-
13.	March 28	-	-	-	-	-	8	-
14.	March 29	-	-	-	-	-	3	-
15.	March 29	3	24	6	48	11	Colony shifted to field	-
16.	March 29	-	-	-	-	-	10	-
17.	March 29	5	-	-	-	-	22	-
18.	March 29	4	24	1	-	-	42	-
19.	March 29	3	29	7	52	12	Colony shifted to field	-
20.	March 30	6	21	6	47	11	103	50
21.	March 30	-	-	-	-	-	9	-
22.	March 30	-	-	-	-	-	1	-
Mean±S.E.		7.44±1.86	24.00±1.23	5.00±0.91	47.20±1.25	10.40±0.78	45.46±13.71	67.50±12.37

The colony development of bumble bee queens collected during April, 2017 is presented in Table 3. Data revealed that out of ten bumble bee queens, seven queens started wax secretion 7.43±1.18 days after collection. Thereafter, only six queens started the brood rearing and developed upto 2nd batch of brood. The average emergence of first worker from 1st batch of brood was recorded after 28.83±1.80 days, while the first worker of 2nd batch of brood was after 50.33±1.48 days after wax secretion. The 1st batch consists of average 4.67±0.45 workers while 2nd batch was having 12.83±1.88 workers. The successfully developed colonies of bumble bee queen's upto 2nd batch of brood survived for 37.00±24.75 days after emergence of first worker of 2nd batch of brood. Four successfully reared colonies were established in the field.

Table 3: Colony development from bumble bee queens collected during April, 2017

Queen No.	Date of queen collection	Initiation of wax secretion (days after collection)	Emergence of 1st worker of 1st batch of brood (days after wax secretion)	Total workers emerged in 1st batch (number)	Emergence of 1st worker of 2nd batch of brood (days after wax secretion)	Total workers emerged in 2nd batch (number)	Queen loss (days after collection)	Queen loss (days after emergence of 1st worker from 2nd batch)
23.	April 01	6	28	4	48	18	Colony shifted to field	-
24.	April 01	6	30	5	49	11	Colony shifted to field	-
25.	April 21	10	20	3	47	5	59	2
26.	April 21	-	-	-	-	-	1	-
27.	April 25	9	32	4	58	16	Colony shifted to field	-
28.	April 25	10	29	6	49	10	131	72
29.	April 25	-	-	-	-	-	3	-
30.	April 25	1	-	-	-	-	22	-
31.	April 25	10	34	6	51	17	Colony shifted to field	-
32.	April 26	-	-	-	-	-	5	-
Mean±S.E.		7.43±1.18	28.83±1.80	4.67±0.45	50.33±1.48	12.83±1.88	36.83±19.02	37.00±24.75

The observations on colony development are in close proximity to the observations of earlier workers. The emergence of worker bees of *B. haemorrhoidalis* queens after wax secretion took 28.00±1.00 days (Dayal and Rana, 2004), 23.7 to 30 days (Kashyap, 2007), 36.44 days (Chauhan et al., 2014) and 18-31 days (Yankit, 2016).

Success rate of colony development stages of bumble bee queens reared under laboratory and field conditions is presented in Table 4. Data revealed that percentage of queens starting wax secretion was more in queens collected during February (83.33%) as compared to April (70%) and March (56.25%).

Higher percentage of queens collected during April (60%) were found to produce 1st batch of brood in comparison to March (37.5%) and February (16.67%). Similarly higher percentage of queens collected during April (60%) were found to produce 2nd batch of brood as compared to during March (31.25%) and February (16.67%). The per cent colony development under laboratory was more in queens collected during April (60%) as compared to queens collected during March (31.25%) and February (16.67%). The per cent successful establishment in the field was recorded more in

queens collected during April (40%) in comparison to March (18.75%).

Table 4: Success rate of colony development stages of bumble bee queens reared under laboratory and field conditions

Month of queen collection	Total queens captured	Queens started wax secretion (%)	Colonies produced 1st batch of workers (%)	Colonies produced 2nd batch of workers (%)	Per cent colony development under laboratory condition	Successful establishment in the field (%)
February	6	83.33	16.67	16.67	16.67	0
March	16	56.25	37.5	31.25	31.25	18.75
April	10	70	60	60	60	40
Total	32	65.63	40.63	37.5	37.5	3.13

Out of total thirty two laboratory reared bumble bee colonies, seven colonies were shifted to field conditions during May (3) and June (4), 2017. The observations on the performance of laboratory reared bumble bee colonies under field conditions is presented in Table 5. Out of seven colonies, queen 31 and 19 had highest number of workers viz. 26.3±3.3 and 23.7±4.7, respectively. While queen 23 had the lowest number of workers (7). However, queen 31 with average strength of 26.6±3.3 workers developed fully and survived till December 16, 2017 in the field. The colony was again shifted to laboratory condition for further rearing.

No loss of colonies occurred during May and June. Three colonies collapsed due to infestation of conopid fly larvae and queen loss in July. Further loss of three colonies occurred due to absconding and loss of queen bees during August to December. These results suggested that success rate can be increased by managing the infestation of diseases or enemies of *B. haemorrhoidalis* mainly during rainy season.

Table 5: Performance of laboratory reared bumble bee colonies under field conditions

Date of colony shifting	Queen No.	Bumble bee population in colonies established in field								Mean ± S.E.	Queen loss (days after shifting)
		May	June	July	August	September	October	November	December		
May 19	9	25	15	Colony collapsed due to infestation of conopid fly larvae in queen						20±3.5	31
May 19	27	16	8	4	Colony collapsed due to absconding					9.3±2.9	49
May 25	19	23	34	14	Colony collapsed due to queen loss					23.7±4.7	57
June 09	24	-	11	9	Colony collapsed due to queen loss					10.00±0.7	36
June 16	15	-	9	Colony collapsed due to queen loss						9	12
June 19	23	-	7	Colony collapsed due to queen loss						7	11
June 24	31	-	14	20	25	39	33	29	Shifted to BOD	26.6±3.3	Present in laboratory

The investigations on success rate of colony development of *B. haemorrhoidalis* queens by earlier workers are in line with the present findings. Bumble bee rearing studies conducted by Kashyap (2007) revealed that out of fifteen queens, nine (60%) raised their colonies successfully, whereas according to Chauhan (2011), 30.56% colonies were successfully established from queens collected during February-April. The success rate of colony establishment from the queens reared under laboratory of *B. terrestris* also supports the present findings. 17.78% colonies produced successfully in China (Jie *et al.*, 2005) and 25% colonies in Korea (Kwon *et al.*, 2006).

Conclusion

Adhatoda vasica, *Brassica juncea*, *Hypericum oblongifolium*, *Papaver rhoeas*, *Scutellaria linearis*, *Cydonia oblonga* and *Antirrhinum majus* L. were the main flowering plants from which *B. haemorrhoidalis* queens could be collected from February to April and *A. vasica* was the important flowering plant from which maximum bumble bee queens were collected during evening time. Success rate of colony development under laboratory was more in queens collected during April (60%) as compared to queens collected during March (31.25%) and February (16.67%). Similarly, the per cent successful establishment in the field was recorded more in queens collected during April (40%) in comparison to queens collected during March (18.75%).

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