



APIS MELLIFERA L. STOCK VARIED IN APPLE POLLEN FORAGING PREFERENCE

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ABSTRACT

Apis mellifera L. colonies were evaluated to explore the apple foraging preference for effective pollination. In 2017, colony G2 showed highest preference for apple pollen loads (18.78%), while L3 recorded lowest apple pollen load (9.89%). On the basis of preference, queens from H2, L3, and G2 were produced to raise progenies for further multiplication and evaluation in 2018 and similar selection experiment was conducted in 2019 and 2020. In 2020 significant number of foragers were conditioned to apple flowers from the colony selected during the year 2019, thus indicating that *A. mellifera* strains multiplied from the colony showing higher apple pollen foraging preference was carried over to next generation and can be exploited to produce progenies to improve pollen hoarding trait with the help of continuous selection and breeding process.

Key words: *Apis mellifera*, apple, cross-pollinated, pollen load, foraging preference, selection, multiplication, evaluation, recessive, tendency

Apple (*Malus domestica* Borkh, 1803) is the most important and highly cross-pollinated fruit crop grown in a temperate region of the world and India restricted to the hilly areas of Himachal Pradesh, Jammu and Kashmir and Uttarakhand (Rana et al., 1988). *Apis mellifera* L. is considered the most important pollinator of the apple crop and can be managed efficiently (Kumar et al., 1989) for commercial pollination in all apple-growing regions of the world (Brittain, 1933 and Gupta et al., 1993). The viability of pollen carried on the pollen collector's body is higher than nectar collectors, whereas pollen collectors have lower consistency to one cultivar of apple as compared to the nectar collector (Kendall, 1973; Robinson, 1979). Thus, the proportion of pollen collectors is important for improving the effectiveness of colonies for better pollination. In general, in apple pollination, the pollen collectors are considered to be more efficient than nectar collectors. However, Mayer et al. (1985) estimated that only 20% of the foragers in apple orchards are pollen collectors. Honey bees prefer branches located in the middle of trees rather than branches situated in higher and lower canopies (Mattu et al., 2012). The genotype of honey bee strains (i.e. high and low pollen-hoarding tendency) strongly affected foraging behaviour for nectar or for pollen (Pankiw et al., 2002). The inheritance of high pollen-hoarding behaviour is a recessive trait unlike the honey storing behaviour governed by the dominant character (Page

et al., 1995). Many environmental factors (Cooper and Schaffer, 1985; Tan et al., 2012; Joshi and Joshi, 2010) such as elevation (Mattu et al., 2012) and colony factors can impact foraging activity. Further, Fulop and Menzel (2000) observed that the reward volume in the form of nectar or sucrose solution impact foraging activity as the bees can perceive the calculative amount of reward from the feeding source. A strong genetic component is found to affect the efficiency of honey bee colonies to collect pollen (Page et al., 2000) and pollen hoarding by honey bees can be modified by the process of selection. Therefore, the selection is required to identify the honey bee colonies with the desirable traits and attributes. The present study was conducted to explore the possibility of breeding *A. mellifera* L. with a higher preference for apple pollen foraging.

MATERIALS AND METHODS

The study was conducted to select *A. mellifera* colonies with high apple pollen foraging preference at RHRS, Mashobra, Shimla in March-April during 2017 and in high-density apple plantation at Dr Yashwant Singh Parmar University of Horticulture & Forestry, Nauni, Solan in March-April during 2018, 2019 and 2020.

The goal of the study in the first year was to select the honey bee colonies with high and low apple pollen

foraging preferences. Twenty experimental colonies were assessed for their colony strength, brood area, pollen stores, honey stores, bee activity, hygienic behavior, temperament and disease incidence from August 2016 to February 2017 prior to selection of high and low pollen hoarding colonies. Thereafter, the performance of these colonies for pollen stores and incoming pollen foragers was recorded at 10 days interval and averaged separately. The performance of these colonies on all recorded parameters was ranked on a 5 scale basis and was averaged and considered as the criteria for their general and behavioral performance. On the basis of their performance three best performing colonies each from high pollen hoarding stock (H1, H2 and H3) and low pollen hoarding stock (L1, L2 and L3) were selected. It was also ensured that selected colonies were disease free and having gentle temperaments. Three colonies (more than 10 frames; 5- 6 brood frame) were randomly selected from the general stock of *A. mellifera* L. (G1, G2 and G3) maintained in the apiary of Dr. Yashwant Singh Parmar University of Horticulture & Forestry, Nauni (HP).

The selected stock of *A. mellifera* L. colonies were introduced into the high-density apple orchard of Fruit Science farm of the University when the trees were at 10% bloom for foraging preference study. Pollen loads of incoming bees were collected with the help of pollen trap. The collected pollen pellets were kept in the refrigerator at 4 °C. Fifty pollen pellets were randomly taken from each collected sample of the colonies and examined for the apple pellets (%). These were examined under microscope and verified with standard apple pollen slides for the presence of apple pollen grains. On the basis of these observations, the proportion of bees with apple pollen was worked out

in 2017 (Sharma et al., 2017). The queens were raised to develop colonies from those showing the highest preference for apple pollen and the evaluation was continued further during 2018, 2019 and 2020. Data recorded were analyzed in OPSTAT with suitable transformation in Randomized Block Design as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Nine colonies with high, low and general pollen hoarding tendencies were evaluated for their preference in apple flowering during March- April 2017. Out of nine, seven colonies collected a significantly the same apple pollen (%). These honey bees are from colony numbers G3, H2, G1, H3, L2, L1 and L3 with 13.44, 13.33, 12.89, 12.67, 12.00, 11.89 and 9.89% apple pollen (Table 1). Colony number G2 showed the highest preference for apple pollen foraging with 18.78% of apple pollen loads, while colony L3 was recorded with the lowest apple pollen load (9.89%). On the basis of preference, queens from H2 and L3 colonies were produced to raise progenies (H11, H12, H13) and (L11, L12, L13) for further multiplication and evaluation along with colonies from G2 general stock (G11, G12, G13) in high density apple plantation, Nauni during March and April 2018 (Table 1). Observations showed that progeny colonies number G11 have highest preference for apple pollen foraging with 77.55% of apple pollen loads followed by colony number G12 (74.18%), H11 (73.46%), L11 (72.64%) and H12 (68.82%), which were statistically at par with each other. Colony number H13 recorded the minimum apple pollen load (62.46%). On the basis of preference, queens from H11 and L13 colonies were produced to raise progeny colonies (H21, H22, H23) and (L21,

Table 1. Incoming bees (%) with apple pollen in high density apple plantation

Colony conditions	2017 (Mashobra)		2018 (Nauni)		2019 (Nauni)		2020 (Nauni)	
	Colony Number	Bees (%)	Colony Number	Bees (%)	Colony Number	Bees (%)	Colony Number	Bees (%)
High apple pollen foraging preference	H1	10.11	H11	73.46	H21	7.41	H31	41.49
	H2	13.33	H12	68.82	H22	12.04	H32	40.89
	H3	12.67	H13	62.46	H23	8.33	H33	48.14
General stock	G1	12.89	G11	77.55	G21	6.34	G31	31.86
	G2	18.78	G12	74.18	G22	5.35	G32	25.44
	G3	13.44	G13	65.18	G23	3.54	G33	33.79
Low apple pollen foraging preference	L1	11.89	L11	72.64	L21	8.33	L31	15.78
	L2	12.00	L12	64.27	L22	7.41	L32	30.75
	L3	9.89	L13	62.82	L23	3.70	L33	22.91
CD (0.05)		0.48		8.90		4.76		6.52

L22, L23) for further multiplication and evaluation along with colonies from G11 general stock (G21, G22, G23) during the year 2019 (Table 1) significant results found in colony H22 with 12.04% of apple pollen loads. However, colony G23 (3.54%) and L23 (3.70%) were recorded with minimum apple pollen load. Colony number H23 (8.33%) recorded with average number of apple pollens followed by colony number L21 (8.33%), L22 (7.41%), H21 (7.41%), G21 (6.34%) and G22 (5.35%). Multiplication from colonies, H22, L23 and G21 was done for further evaluation of their apple pollen foraging preference during the year 2020 (Table 1). The average highest apple pollen (%) in different categories was 48.14 (H31), 33.79 (G33) and 30.75 (L32). *A. mellifera* foragers multiplied from the colony showing the least preference for apple foraging were observed to collect the lowest apple pollen load i.e. 15.78% (L31), followed by 22.91% (L33) and 25.44% (G32) significantly at par with each other. In 2020 significant number of foragers was conditioned to apple flowers from the colony selected during the year 2019, thus indicating that *A. mellifera* strains multiplied from the colony showing higher apple pollen foraging preference was carried over to the next generation and can be exploited to produce progenies to improve pollen hoarding trait with the help of continuous selection and breeding process.

Earlier studies were conducted by Mackensen and Nye (1966) for the first-time selected honey bees for pollen preference. The present findings on variability in *A. mellifera* for apple pollen foraging support the earlier observations on preference of *A. mellifera* colonies for apple pollen (Anonymous, 2015). Observations were recorded at four different locations of Kullu valley, the preference of *A. mellifera* colonies for apple pollen varied from 4.30 to 97.62% in general stock of *A. mellifera*. Hellmich et al. (1985) observed that two lines (high and low) selected for pollen foraging in alfalfa crop were significantly different. A general trend of decline in apple pollen (%) was observed by Dag et al. (2005). The inheritance of high pollen-hoarding behavior is a recessive trait unlike the honey storing behavior, which is governed by dominant character (Page et al., 1995). As per the literature there are differences observed in the amount of apple pollen collected by the honey bee colonies. Many studies have reported variability among honey bee colonies in their tendencies for collecting pollen from specific species, which suggests that preference for pollen may be inherited and can be increased by the breeding and

selection procedures (Mackensen and Nye, 1966). In our study the observations recorded during 2020 revealed that selected colonies of *A. mellifera* had higher preference for apple foraging, indicating the possibility of selection of honey bees showing the particular trait.

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