

## Foraging behaviour of different major pollinators during blooming period in high altitude apple (*Malus × domestica*) orchards\*

BISWAJIT DAS<sup>1</sup>, HARE KRISHNA<sup>2</sup>, N AHMAD<sup>3</sup>, J K RANJAN<sup>4</sup> and PRAGYA<sup>5</sup>

Regional Station, Central Institute of Temperate Horticulture, Mukteshwar, Uttarakhand 263 138

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Apple (*Malus × domestica* Borkh) occupies a major share both in terms of area (274 thousand ha) as well as production (1.985 million metric tonnes) among different fruit crops grown in Uttarakhand (NHB 2009). The inter relationship of main apple cultivars with pollinizers is dependent upon various factors like bloom synchronization, foraging behaviour of pollinators, prevailing weather during the bloom period apart from many other orchard health factors. Many new spur type as well as other superior apple cultivars have been introduced in the farmer's orchards by distributing quality planting material over the years. Moreover, Majority of old orchards are confronted with declining trend in fruit set and production due to lack of abundance of natural population of pollinators, insufficient proportion of pollinizers and inclement weather conditions prevailing during the bloom period which has become an annual feature in Uttarakhand.

Reports indicated that number of orchards as much as around 42% have only less than 10% pollinizers with production potential of only 1.3 boxes of fruits (18 kg/boxes) per tree in Uttarakhand (Gautam *et al.* 2005). Amongst various pollinator groups in apple orchards most economically important pollinating agents are bees. The present study was carried out to examine the inter-varietal bloom synchronization trends among the recommended apple cultivars with their suitable pollinizers, and also to study the foraging behaviour of some major pollinators during the bloom period in relation to the prevailing weather conditions in the high altitude apple orchards.

The study was undertaken during 2007 and 2008 at experimental apple orchard, Regional Station, Central Institute of Temperate Horticulture, Mukteshwar.

\*Short note

<sup>1</sup>Senior Scientist (Horticulture) (e mail: biswajitsom\_dr@yahoo.co.in), <sup>2</sup>Scientist (Horticulture) (e mail: kishun@rediffmail.com),

<sup>3</sup>Director (e mail: dnak59@rediffmail.com), <sup>4</sup>Scientist (e mail: jkranjan2001@yahoo.co.in),

<sup>5</sup>Scientist (e mail: ruchi\_105@rediffmail.com)

Geographically the orchard is located at 29° N latitude and 79° E longitude at an altitude of 2 200 m above mean sea

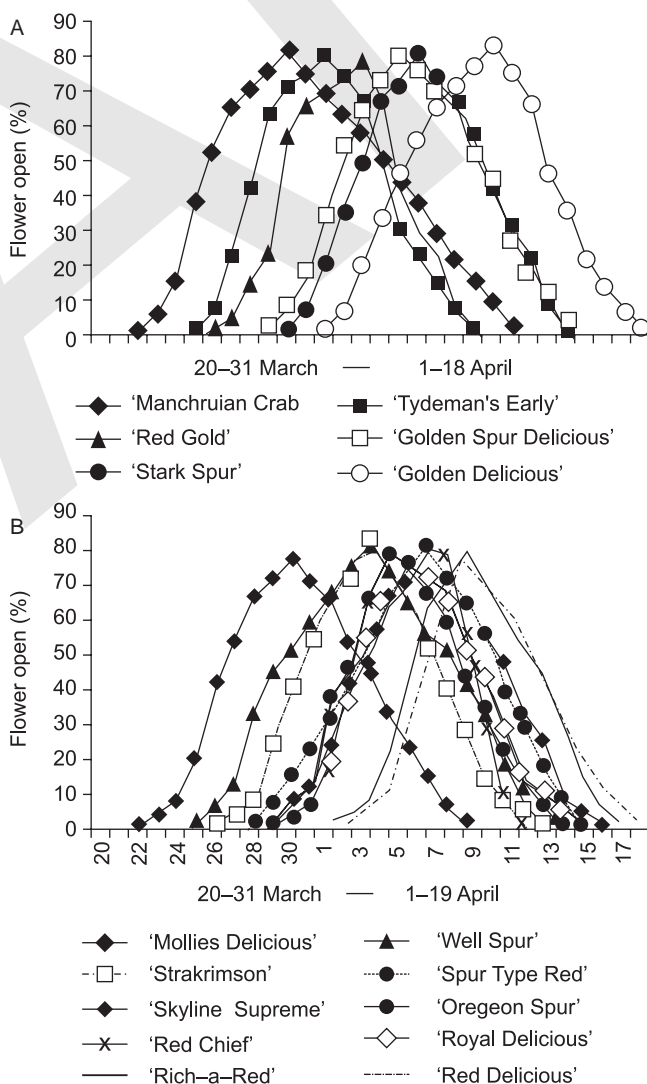


Fig 1 Blooming duration and bloom synchronization of apple, A. pollinizers, B. apple cultivars

Table 1 Foraging behaviour of different pollinators during apple flowering.

Date		Foraging time																		Avg. bee mortality**	
		6 to 8 AM						8 AM to 2 PM						2 to 5 PM							
		<i>A. mellifera</i>		<i>A. cerana</i>		Syrphids		<i>A. mellifera</i>		<i>A. cerana</i>		Syrphids		<i>A. mellifera</i>		<i>A. cerana</i>		Syrphids			
2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	Am	Ac
6/4	26/3	4.3	1.7	8.0	6.7	6.3	3.3	15.0	13.0	18.3	16.0	20.0	18.3	11.0	5.0	14.0	10.6	3.6	3.7	22.8	2.6
7/4	27/3	3.0	2.3	9.3	10.6	6.3	4.7	14.0	13.0	16.0	16.3	20.0	18.6	8.6	5.3	12.3	10.3	3.0	4.0	47.0	3.7
8/4	28/3*	2.7	1.3	6.7	11.0	6.6	2.3	14.0	0.7	18.6	3.0	20.6	0.0	4.3	0.0	9.3	2.0	3.0	0.0	76.2	2.7
9/4	29/3	2.3	3.0	9.7	7.7	5.3	2.3	13.0	13.3	16.0	18.0	19.3	21.0	6.3	8.0	10.0	12.0	0.7	4.3	43.6	2.6
10/4	30/3	3.0	4.0	11.0	12.0	5.6	12.0	15.0	13.0	17.0	17.0	20.6	18.7	8.6	10.7	12.0	14.3	4.3	4.0	13.4	3.0
11/4	31/3	4.0	4.3	9.6	10.7	6.3	12.0	12.6	14.0	17.0	16.0	18.0	21.7	9.0	8.6	11.6	13.6	3.0	4.3	28.0	3.1
12/4*	1/4	0.0	4.7	0.0	11.3	0.0	12.0	3.6	14.0	5.0	16.7	0.0	20.3	0.3	11.7	2.3	15.3	0.0	3.0	20.2	5.6
3/4	2/4	5.7	3.0	10.6	9.7	6.6	12.7	10.6	13.0	17.0	18.3	18.3	18.3	4.3	11.3	9.3	15.6	4.0	4.6	19.0	3.2
14/4*	3/4*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	5.0	0.0	0.0	0.0	0.3	0.0	11.6	0.0	1.7	95.6	4.6
15/4	4/4	4.0	4.3	11.6	12.3	8.0	5.3	13.3	3.0	17.0	16.7	18.3	18.7	7.3	9.3	11.0	13.0	1.6	4.0	14.2	3.2
16/4*	5/4*	0.0	1.7	0.0	9.6	0.0	2.3	0.0	1.6	0.0	3.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	75.7	5.6
17/4*	6/4*	2.3	0.0	8.6	0.7	3.7	0.0	1.6	12.0	4.0	15.0	0.0	16.3	0.3	9.3	6.0	14.0	2.0	1.7	69.5	3.2
18/4*	7/4	0.0	1.7	0.0	10.0	0.0	7.0	5.0	4.0	11.3	11.0	9.3	15.3	0.0	0.0	2.7	0.0	0.0	0.0	57.2	4.2
19/4*	8/4*	0.0	0.0	0.0	1.6	0.0	0.0	4.0	12.0	7.6	15.3	7.0	19.3	0.3	12.0	1.0	14.3	0.0	4.3	59.3	6.1
20/4*	9/4	0.0	7.6	0.0	13.6	0.0	14.0	0.0	13.6	2.3	16.3	0.0	21.3	0.0	13.0	0.0	15.0	0.0	3.0	58.0	3.0
21/4	10/4	4.0	4.3	10.0	10.0	8.0	11.6	11.6	14.0	15.0	18.3	18.0	19.3	11.0	10.3	14.6	15.6	14.6	3.6	12.8	3.2
22/4	11/4	4.0	3.3	11.0	7.6	8.3	9.6	14.3	14.0	18.6	17.3	20.3	22.0	13.0	5.3	15.3	11.7	8.3	4.3	13.3	2.5
23/4	12/4	3.6	3.0	9.3	10.0	8.6	6.0	15.3	11.0	16.0	15.7	22.0	18.3	12.0	5.6	16.6	12.3	9.0	3.6	32.7	3.1
24/4	13/4	3.0	3.6	8.3	10.3	4.0	3.6	11.0	14.3	16.6	16.6	16.0	20.7	3.6	7.6	9.6	12.0	7.3	3.0	37.5	2.1
25/4*	14/4	0.3	5.3	8.7	8.6	4.6	6.6	5.7	11.6	11.6	17.0	9.0	20.6	3.0	10.0	9.0	14.3	1.6	10.3	33.8	3.5
26/4	15/4	0.6	4.3	6.0	7.6	3.3	3.6	5.6	12.0	11.7	15.0	9.3	19.3	3.3	9.0	8.3	13.3	4.3	4.0	16.6	2.5
	16/4		2.3		5.3		3.3		7.0		11.0		14.3		7.0		8.0		5.3		
Mean		2.23	2.99	6.59	8.5	4.36	6.1	8.82	10.2	12.22	14.32	12.67	16.47	5.06	7.24	8.34	10.83	3.35	3.49	40.3	3.5

\*Rainy days with medium to heavy hail storm, \*\*Am, *Apis mellifera*, Ac, *Apis cerana*

level. A total of 10 commercially important apple cultivars and six pollinizers were included to study the blooming behaviour (Fig 1). On an average 1–3% flowers opened on marked trees were considered as bloom initiation and end of the effective bloom period, whereas 50–85% flowers opened were considered as peak bloom period. Healthy bee hives with strength of 25 000–30 000 of *Apis mellifera* L. and *A. cerana indica* Fabr. working bees were centrally placed in the orchards @ 4 hives/ha keeping in view the higher bloom density of spur type cultivars. Beehives were placed at the time of 5–10% flower open stage (Delaney and Tarpy 2008). Daily foraging behaviour of pollinators in the orchards were recorded in terms of number of bees and syrphids visiting/m flowering branch/5 min. Bee mortality were also recorded in terms of number of bees died daily around the hives. Foraging activities of different pollinators were recorded in three time intervals, viz 6–8AM, 8AM–2PM and 2–5PM everyday during the bloom period. Temperature (°C), rainfall (mm) and hail storm intensity (light, medium and heavy) were also recorded during the

three time intervals.

Amongst different pollinizers (Fig 1) ‘Malus manchurica’ (maxim.) Kom was very early to flower (22 March) and continued till 11 April, followed by ‘Tydeman’s Early Worcester’ (25 March–9 April) and ‘Red Gold’ (26 March–9 April). ‘Golden Spur Delicious’ (29 March–14 April) and ‘Stark Spur Delicious’ (30 March–14 April) were mid bloomer, whereas ‘Golden Delicious’ (1–18 April) was found to be mid to late bloomer. Cultivar ‘Mollies Delicious’ was very early to bloom (22 March–8 April), whereas ‘Starkrimson’, ‘Well Spur’, ‘Skyline Supreme’, ‘Red Chief’, ‘Oregon Spur’ and ‘Royal Delicious’ were mid bloomer (25 March–14 April). ‘Rich-a-Red’ and ‘Red Delicious’ were mid to late bloomer (1–17 April). The observations revealed that there is a complete synchronization in blooming of commercial apple cultivars with at least one or more than one pollinizers. Apart from several factors, winter and pre-bloom temperature and precipitation are the main determining factors for time and intensity of bud break (Jindal and Mankotia 2004).

Observations (Table 1) on foraging of bees and syrphids on apple flowers at the time of bloom period showed that during the morning hours (6–8 AM) comparative foraging of *A. cerana indica* Fabr. was higher than *A. mellifera* L. Peak foraging duration was observed to be from 8 AM to 2 PM for these two types of bees, *A. cerana indica* Fabr. and *A. mellifera* L., with average number of bees visiting the flowers/5 min, 12.22 and 8.82 in 2007 and 14.32 and 10.20 in 2008, respectively. Such trend in foraging behaviour has also been reported by Verma and Daulta (1986) and Dashad (1989) where they observed that though honeybees start foraging in the morning hours, however, as day progresses till early afternoon they become more active. In the evening hours, number of pollinators foraging declined gradually but *A. cerana indica* Fabr. worker bees continued foraging effectively in both the years with number of bees 8.34 and 10.83 visiting the flowers/5 min in 2007 and 2008, respectively. Similarly foraging of syrphids was in abundance during 8 AM–2 PM, however during morning and evening hours it was also observed to be lesser. In the morning hour (6–8 PM) temperature ranged from 4.2 to 9.4 and 4.5 to 11.5°C with an average of 6.85 and 7.93 °C in 2007 and 2008, respectively. In the second time interval, ie 8 AM–2 PM, the temperature ranges were 4.6–20.4 and 6.6–21.0°C with an average of 13.92 and 17.45°C and in the evening hour (2–5 PM) the ranges were 5.5–17.5 and 5.4–15.6°C with an average of 9.9 and 12.13°C in 2007 and 2008, respectively. The foraging behaviour of bees and syrphids if examined in light of the prevailing weather conditions during the bloom period at Mukteshwar hill, it is evident that low temperature accompanied by rainy days and hailstorm were the main causes of preventing effective foraging, irrespective of type of pollinators. Temperature in 2008 was relatively higher during the bloom period which was found to be congenial for better foraging of bees and thereby numbers of effective foraging days were more during the total span of apple bloom period. Verma and Daulta (1986) also observed that *A. cerana* Fabr. started foraging more actively early in the morning than *A. mellifera* L. This is due to the fact that *A. mellifera* L. foraging activity is significantly dependent on temperature (Vicens and Bosch 2000) and become less active below 12 °C. Higher mortality of *A. mellifera* L. worker bees (40.3/day) in comparison to *A. cerana indica* Fabr. (3.5/day) was

recorded during bloom period which was found to be mainly due to inclement weather conditions (Table 1).

#### SUMMARY

An experiment was carried out during 2007–08 at high altitude apple orchards in Uttarakhand to study the foraging behaviour of honeybees and syrphids during the bloom period of different apple cultivars in relation to prevailing weather conditions. Observations revealed a complete synchronization of blooming among different apple cultivars and their suitable pollinizers which ranged from 25 March to 17 April. Honeybee (*Apis cerana indica* Fabr.) was very efficient in foraging in terms of higher numbers of working bees visiting/m flowering branch/5 min. (12.22 and 14.32 in 2007 and 2008, respectively) during the peak foraging hours (8 AM–2 PM). Moreover, during morning (6–8 AM) and evening (2–5 PM) hours at very low temperature, *A. cerana indica* Fabr. showed a better foraging efficiency than *A. mellifera* L.

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