Chapter 53

Foraging Behaviour of *Apis cerana himalaya* on Sunflower and Rape Seed

M.P. Singh, K.I. Singh and C.S. Devi
Department of Entomology, College of Agriculture, Central Agricultural University, Imphal, India

Previous biometric studies revealed the occurrence of a separate race of Asian hive bee named *Apis cerana himalaya* from the northeast Himalayan region (Singh and Verma, 1992; Singh *et al.*, 1990. As yet, no information is available on the foraging behaviour of this new race. There is potential for their use in the production of insect-pollinated seed crops. Rape seed and sunflower, the source of edible oil in northeast India, require pollinators, particularly honeybees, for increasing crop yield, improving seed quality and for exploitation of heterosis. Studies were, therefore, conducted on the foraging behaviour of *A. c. himalaya* on sunflower and rape seed under the agro-climatic conditions of the northeast Himalayan region.

Material and Methods

Foraging observations were made during winter 1992 and 1993 on sunflower var. Morden and rape seed var. M-27 at the Oilseed Research Farm of the College of Agriculture, Central Agricultural University, Imphal, India. The crops were raised in plots of 25 m × 12 m and replicated four times using the recommended local agronomic practices. However, no insecticidal application was made after the commencement of flowering.

Observations on the relative abundance of insect pollinators were recorded from 0600 to 1700 h at one-hour intervals on 10 plants over a 5-min period. Observations were recorded for daily time of initiation and cessation of foraging, duration of foraging activity, peak hours of foraging activity, duration of foraging trip, number of flowers visited by one bee per minute, time spent on flower, distance covered from flower to flower, individual bee's choice of forage (nectar or pollen), and weight of pollen load carried by bees at different hours of the day.

In order to differentiate between nectar and pollen collectors, returning foragers were collected with an aspirator at the hive entrance and frozen to prevent regurgitation of nectar. Frozen bees were sorted for type of forage, following the method of Erickson et al. (1973). The weight of pollen load was determined by anaesthetising samples of returning bees with carbon dioxide (Frisch, 1967), and then removing and weighing their pollen loads. Duration of foraging trip was determined by marking 10 bees with nail polish of different colours and noting the time of ingress and egress of the marked bees.

Table 1. Relative abundance of insect pollinators on sunflower at different hours of the day during winter seasons of 1992 and 1993.

Pollinators	Number of pollinators at different hours of the day													
	0600h	0700h	0800h	0900h	1000h	1100h	1200h	1300h	1400h	1500h	1600h	1700h	Mean	% of total
Apis cerana	4.35	6.60	4.35	4.50	2.35	1.70	1.05	1.35	1.55	1.00	1.90	2.25	2.75	46.37
himalaya	±0.39	±0.90	±0.55	±0.56	±0.37	±0.38	±0.36	±0.21	±0.25	±0.30	±0.45	±0.22	±0.41	
Apis dorsata	1.50	3.15	3.50	2.90	2.40	2.20	1.95	1.80	1.85	2.75	3.05	2.85	2.49	41.99
	±0.48	±0.97	±0.70	±0.40	±0.43	±0.25	±0.31	±0.28	±0.32	±0.39	±0.46	±0.50	±0.46	
Bombus	0.12	0.20	0.40	0.75	0.55	0.85	1.00	0.75	0.25	0.25	0.25	0.05	0.45	7.59
haemorrhoidalis	±0.09	±0.12	±0.22	±0.20	±0.15	±0.21	±0.28	±0.22	±0.13	±0.14	±0.20	±0.04	±0.17	
Nomia curvipes	0.0	0.10	0.10	0.30	0.35	0.65	0.60	0.35	0.15	0.20	0.05	0.0	0.24	4.05
	±0.0	±0.06	±0.09	±0.14	±0.17	±0.14	±0.20	±0.14	±0.7	±0.14	±0.04	±0.0	±0.10	

I: Mean ± standard error of 20 days observations: for population recorded in 10 plants per 5 min.

Table 2. Relative abundance of insect pollinators on rape flower at different hours of the day during winter seasons of 1992 and 1993

Pollinators	Number of pollinators at different hours of the day								
	0900h	1000h	1100h	1200h	1300h	1400h	1500h	Mean	% of Total Pollinators
Apis cerana himalaya	11.96	11.73	9.02	6.53	4.86	4.00	0.74	6.98	86.50
	±0.67	±0.67	±0.76	±0.66	±0.52	±0.45	±0.16	±0.56	
Episyrphus balteatus	0.19	0.31	0.59	0.74	0.92	0.73	0.25	0.53	6.57
	±0.11	±0.14	±0.14	±0.19	±0.28	±0.15	±0.13	±0.16	
Apis dorsata	0.20	0.32	0.30	0.30	0.42	0.35	0.15	0.29	3.59
	±0.14	±0.11	±0.13	±0.11	±0.18	±0.12	±0.06	±0.12	
Pieris brassicae	0.04	0.30	0.29	0.34	0.74	0.18	0.0	0.27	3.34
	±0.03	±0.14	±0.09	±0.19	±0.45	±0.08	±0.0		

1: Mean ± standard error of 23 days observations; for population recorded in 10 plants per 5 min.

Bees on the flowers were observed with a magnifying lens.

Results

Apis cerana himalaya was the main pollinator of sunflower constituting 46.37%, closely followed by *A. dorsata* (41.99%). Other visitors were *Bombus haemorrhoidalis* (7.59%) and *Nomia curvipes* (4.05%) (Table 1). Similarly, *A. c. himalaya* predominantly foraged on rape seed bloom and constituted 86.5% of the total pollinators population. Other visitors were *Episyrphus balteatus* (6.57%), *Apis dorsata* (3.59%) and *Pieris brassicae* (3.34%) (Table 2).

The foraging behaviour of *A. c. himalaya* on sunflower and rape seed is summarised in Table 3. Bees started foraging activity earlier (05.19 h) on sunflower than rape seed (08.04 h) and ceased later (18.08 h compared to 16.02 h). Thus, the average duration of foraging activity was longer on sunflower (12.49 h) than rape seed (07.58 h). Peak foraging activity was between 06.00 h and 09.00 h for sunflower, and between 09.00 h and 11.00 h for rape seed. The duration of individual foraging trips was longer on sunflower (8.60 min)

Table 3. Foraging behaviour of *Apis cerana himalaya* on sunflower and rape seed during winter seasons of 1992 and 1993

Parameter	Sunflower	Rape seed
Initiation of foraging (time of day)	05.19 ± 0.08h	08.04 ± 0.04h
Cessation of foraging (time of day)	18.08 ± 0.12h	16.02 ± 2.01h
Duration of foraging activity (h)	12.49 ± 0.18	07.58 ± 0.05
Peak foraging hours (time of day)	06.00–0900	09.00–11.00
Duration of foraging trip (min)	3.37 ± 0.19	8.60 ± 1.69
No. of flowers visited/min	1.70 ± 0.10	9.90 ± 0.42
Time spent on flower (sec)	52.98 ± 3.88	6.37 ± 0.73
Distance covered from flower to flower (cm)	74.63 ± 7.45	30.04 ±2.12
No. of stigmas touched/ visit	68.65 ± 6.71	–
Pollen load (mg) at:		
08.00h	2.35 ± 0.08	–
10.00h	3.27 ± 0.08	8.20 ± 0.45
12.00h	5.12 ± 0.07	9.60 ± 0.67
14.00 h	5.78 ± 0.10	7.50 ± 0.40
Ratio between pollen collectors and nectar collectors (P: N) at:		
08.00 h	1.0: 2.4	–
10.00 h	1.0: 4.2	1.0: 2.5
12.00 h	1.0: 17.9	1.0: 6.4
14.00 h	1.0: 16.5	1.0: 57.8

Values are mean ± standard error

than rape seed (3.37 min). *Apis cerana himalaya* visited a fewer sunflowers (1.7) per minute than rape flowers (9.9) spending more time on sunflower (52.98 sec) than on rape seed (6.37 sec). Bees covered longer distance from flower head to head of sunflower (74.63 cm) as compared to rape flower (30.04 cm). While foraging on sunflower, *A. c. himalaya* contacted 68.65 stigmas per flower visit. The average pollen load carried by an individual worker bee was maximum at 14.00 h for sunflower weighing 5.78 mg, whereas the maximum pollen load was carried at 1200 h for rape seed weighing 9.60 mg. In both crops, the ratio between pollen and nectar collectors increased from morning to evening, with greater amounts of pollen collected in the morning and greater amounts of nectar collected in the evening.

Discussion

Apis cerana himalaya was found to be the main pollinator of sunflower and rape seed under the agro-climatic conditions of the northeast Himalayan region. This is probably because other pollinators are little attracted to these crops and also because they are generally not present in sufficient numbers in nature during these cropping seasons.

Bees commenced foraging activity earlier and ceased later on sunflower than rape flowers, thus increased the duration of foraging activity. This is probably because observations were taken at different months during the peak flowering stage of sunflower (April) and rape seed (January) with different temperature regimes. Bisht (1966) also quoted difference in the mean time of initiation (5.00 to 10.30 h) and cessation (13.30 h to the end of the day) of pollen gathering activity of *A. cerana* during different seasons in Delhi.

In our study, foraging activity of *A. c. himalaya* peaked between 06.00 h and 09.00 h for sunflower, whereas it was 09.00 h and 11.00 h for rape seed. The duration of individual foraging trip was 3.37 min on sunflower and 8.60 min on rape seed. However, Benedek and Prenner (1972) reported duration of foraging trip of *A. cerana* on *Brassica campestris* as 35.5 min. Ribbands (1949) opined that the duration of foraging trip is influenced by the number of flowers available, their nectar and pollen content and the amount of competition. This investigation shows that bees visited 9.90 rape flowers spending 6.37 sec on each flower. However, Murell and Nash (1981) recorded that *A. cerana* spent 3.0 sec on *Brassica campestris* var. toria. Further it was observed that bees spent an average of 52.98 sec per sunflower head with foraging rate of 1.70 flower heads/min.

However, Panchabhavi *et al.* (1976) observed in Bangalore that *A. cerana* spent 130.4 to 154.3 sec per head of sunflower. The variation in the number of flowers visited and the time spent may be due to the amount of nectar available in the individual flower and also to the distances that the bees had to cover to find a suitable source. Pollen loads on *A. c. himalaya* foragers were heaviest at 14.00 h for sunflower and at 12.00 h for rape seed. This may be because the maximum amounts of pollen and nectar are presented by these plants during afternoon hours. In the present investigation, bees collected either pollen or nectar during a single foraging trip, but never both. This may be because the nectar and pollen of these crops are not equally attractive to the foragers at the same time. The number of nectar collectors increased from morning to evening, however a reverse trend was observed for pollen collectors. The present findings are corroborate by the results of Cherian *et al.* (1947).

References

Benedek, P. and Prenner, J. 1972. Effect of temperature on the behaviour and pollination efficiency of honeybees on winter rape flowers. *Z. Angew. Ent.* **71:** 120–124.

Bisht, D.S. 1966. *Studies on the behaviour of Apis indica F. under Delhi conditions with special reference to brood rearing and pollen gathering activities.* M.Sc. Thesis, Indian Agric. Res. Inst., New Delhi, India.

Cherian, M.C., Ramachandran, S. and Mahadevan, V. 1947. Studies on bee behaviour. *Indian Bee J.* **9:** 116–124.

Erickson, E.H., Whitefoot, L.O. and Kissinger, W.A. 1973. Honeybees: a method of delimiting the complete profile of foraging from colonies. *Environment Entomology,* **2:** 531–535.

Frisch, K.V. 1967. *The Dance Language and Orientation of Bees.* London: Oxford University Press.

Murrell, D.C. and Nash, W.T. 1981. Nectar secretion by toria (*Brassica campestris* var, Toria) and foraging behaviour of three *Apis* species on toria in Bangladesh. *Journal of Apicultural Research,* **20:** 34–38.

Panchabhavi, K.S., Devaiah, M.A. and Basavanna, G.P.C. 1976. The effect of keeping *Apis cerana indica* F. colonies on the seed set of sunflower, *Helianthus annuus* Linn. *Mysore Journal of Agricultural Science,* **10:** 631–636.

Ribbands, C.R. 1949. The foraging method of individual honeybees. *Journal of Animal Ecology,* **18:** 47–66.

Singh, M.P. and Verma, L.R. 1992. Morphometric comparison of three geographic populations of northeast Himalayan *Apis cerana. Proceedings of 1st International Conference on Asian Bees and Bee Mites.* Bangkok, Thailand. Pp 67–80.

Singh, M.P., Verma, L.R. and Daly, H.V. 1990. Morphometric analysis of Indian honeybee in the northeast Himalayan region. *Journal of Apiculrural Research,* **29:** 3–14.