Chapter 55

Foraging Competition between *Apis cerana* and *Apis mellifera* and its Impact on Crop Pollination

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Apis mellifera is thought to displace the native pollinators from both floral resources and the geographic areas (Schwarz, 1948; Sakagami, 1959, Prance, 1976, Roubik, 1978). When two species compete for limited amount of food resources, an increase in resource harvest by one species corresponds to the diminished harvest by other (Roubik, 1978). Andrewartha and Birch (1954) made some field studies to demonstrate the importance of the interspecies competition for food.

Since its introduction in 1990, *A. mellifera* has replaced the traditional beekeeping in *terai* and mid-hill areas of Nepal. The possible reasons for this being the higher productivity of *A. mellifera,* transfer of diseases and parasites and competition for food etc. Thus, the information on such aspects as transfer of bee diseases and foraging competition between the two species is important for developing appropriate management practices for both the species. In this paper, therefore, the investigations have been made to study the foraging competition between *A. mellifera* and *A. cerana,* and its impact on crop pollination.

Material and Methods

Experiments were conducted on 5 × 5 sq m plots of four crops viz mustard (*Brassica campestris*), broadleaf mustard (*Brassica juncea*), cauliflower (*Brassica oleracea botrytis*), and radish (*Raphanus sativus*) on HMG's Vegetable Seed Production Farm, Khumaltar in the Kathmandu valley, Nepal. For each crop, three such plots were sampled. Each plot of mustard had about 50–60 plants whereas those of broadleaf mustard, cauliflower, and radish had 25–30 plants in each plot. Total number of flowers/plant were about 207 in mustard, 5636 in broadleaf mustard, 4200 in cauliflower and 1248 in radish.

Foraging competition between the species was studied by counting the number of foragers of *Apis cerana* and their foraging behaviour during the presence of and after the removal of *Apis mellifera* from the plots of the crops under investigation. For this, one colony each of *A. cerana* and *A. mellifera* was introduced near the plots and an hourly count of number of foragers of *A. cerana* per five minutes was made throughout the day (from 0800 h to 1600 h). Hourly observations on the foraging behaviour of *A. cerana* were recorded for the time spent per flower by a forager, number of flowers visited per minute, weight of pollen load carried by an individual bee, per centage of pollen collectors and other sources of pollen visited (i.e. per centage of foragers collecting pollen from other crops). Such observations were recorded for one

week. After one week, *A. mellifera* colony was removed from the plots and similar observations on the number and foraging behaviour of *A. cerana* were recorded for another week in the absence of *A. mellifera.*

Results and Discussion

A. cerana foragers were less abundant when *A. mellifera* bees were present in the plots on all crops. Removal of *A. mellifera* colony from the plots led to reversal in the abundance trends among both the species. After removal of *A. mellifera,* the number of *A. cerana* foragers increased significantly from 12.6 to 20.8 in mustard, 12.3 to 18.3 in broadleaf mustard, 18.4 to 28.3 in cauliflower and from 9.7 to 16.2 in radish (Table 1). These results revealed that *A. cerana* responded to the increased number of available flowers by recruiting more foragers and the extent of this response varied depending upon the crop. Since the foraging was more profitable in terms of the amount of nectar produced and sugar concentration in the nectar of mustard, there was more increase in the number of foragers in this crop followed by cauliflower, broadleaf mustard and radish.

The results showed that the presence of *A. mellifera* in the field reduces the number of *A. cerana* bees in the field. It was also observed that the two species try to displace each other rather than visiting / pollinating the flowers. It can, therefore, be inferred that the presence of both *A. cerana* and *A. mellifera* in the same field may not be complementary for the pollination of vegetables and other crops. It may rather adversely affect the pollinating efficiency of both the species. For beekeeping, it has implications in planning and development.

Observations on the foraging behaviour of *A. cerana* (Table 2) showed that the removal of *A. mellifera* significantly increased the time spent per flower by a foraging bee from 3.3 to 4.9 seconds on mustard, 2.8 to 3.2 on broadleaf mustard, 5.8 to 6.7 on cauliflower, and 4.3 to 5.3 seconds on radish. Removal of *A. mellifera* also decreased the

Table 1. Number of *A. cerana* foragers during the presence and after removal of *Apis mellifera*

Crop	Number of *A. cerana* foragers/5 min in 5 x 5 sq.m plots		Values of '*t*' and degrees of freedom (*df*)
	During the presence of *A. mellifera*	After removal of *A. mellifera*	
Mustard	12.6 ± 1.2	20.8 ± 1.3	*t*= 12.2; *df*=8; (*p*=0.01)
Broadleaf mustard	12.3 ± 1.3	18.3 ± 2.1	*t*= 5.4; *df*=8; (*p*=0.01)
Cauliflower	18.4 ± 1.1	28.3 ±0.8	*t*= 16.6; *df*=8; (*p*=0.01)
Radish	11.7 ± 0.9	16.2 ±1.4	*t*= 8.7; *df*=8; (*p*=0.01)

number of flowers visited per minute of each crop by foraging bees of *A. cerana,* for example, the number of *A. cerana* foragers decreased from 13.9 to 11.5, 13.8 to 11.9, 8.0 to 7.3, and from 9.0 to 8 in mustard, broadleaf mustard, cauliflower and radish respectively after removal of *A. mellifera.*

Weight of pollen load carried by an individual foraging bee of *A. cerana* increased from 6.9 to 9.8, 12.1 to 13.6, 7.1 to 9.3, and 7.0 to 10.0 mg on mustard, broadleaf mustard, cauliflower, and radish respectively after removal of *A. mellifera.* Similarly, the percentage of pollen collectors was also increased. Percentage of pollen loads from crops other than experimental crops significantly decreased from 19.7 to 3.6 after *A. mellifera* was removed.

Since a decrease in *A. mellifera* bees corresponds to the increased visitation time per flower and increased weight of pollen loads by the foragers of *A. cerana,* it appears that the bees responded to the increased pollen availability by spending more time on the flower for the collection of more available pollen by recruiting more pollen collectors. During the presence of *A. mellifera* in the experimental plots, more foragers of *A. cerana* visited other crops in the vicinity for pollen and nectar, but after its removal these switched back to the crops under investigation. This was evident by the fact that more bees of *A. cerana* brought pollen loads from

Table 2. Foraging behaviour of *A. cerana* during the presence and after the removal of *A. mellifera*

Parameter		Floral Resource (Crop under investigation)			
		Mustard	Broadleaf mustard	Cauliflower	Radish
Time on flower (s)	During *A. mellifera*	3.3 ± 0.7	2.8 ± 0.2	5.8 ± 0.2	4.3 ± 0.1
	After *A. mellifera*	4.9 ± 0.8	3.2 ± 0.2	6.7 ± 0.3	5.3 ± 0.3
		t = 10.7; df = 98	t = 10.1; df = 98	t = 18.0; df = 98	t = 22.7; df = 98
		P=0.01	*P=0.01*	*P=0.01*	*P=0.01*
Number of flowers visited/min	During *A. mellifera*	13.9 ± 1.3	13.8 ± 0.5	8.0 ± 0.5	9.0 ± 0.4
	After *A. mellifera*	11.5 ± 1.5	11.9 ± 0.6	7.3 ± 0.5	8.0 ± 0.5
		t = 8.6; df = 98	t = 17.3; df = 98	t =7.; df = 98	t = 11.1; df = 98
		P=0.01	*P=0.01*	*P=0.01*	*P=0.01*
Weight of pollen load (mg)	During *A. mellifera*	6.9 ± 0.5	12.1 ± 0.6	7.1 ± 1.2	7.2 ± 0.5
	After *A. mellifera*	9.8 ± 0.3	13.6 ± 0.5	9.3 ± 0.3	10.2 ± 0.5
		t = 15.8; df = 18	t = 8.6; df = 18	t = 5.7; df = 18	t = 13.4; df = 18
		P=0.01	*P=0.01*	*P=0.01*	*P=0.01*
Number of pollen collectors (%)	During *A. mellifera*	44.6 ± 4.6	45.7 ± 3.9	46.1 ± 3.7	39.5 ± 2.7
	After *A. mellifera*	56.7 ± 3.5	52.3 ± 4.7	59.3 ± 3.7	49.4 ± 3.4
		t = 4.8; df = 8	t = 2.4; df = 8	t = 5.6; df = 8	t = 5.1; df = 8
		P=0.01	*P=0.05*	*P=0.01*	*P=0.01*
Other pollen sources visited (% pollen loads of other crops)	During *A. mellifera*	19.7 ± 1.1	16.1 ± 2.1	12.7 ± 1.9	13.3 ± 1.9
	After *A. mellifera*	7.7 ± 1.2	9.6 ± 1.9	3.6 ± 0.3	5.7 ± 0.6
		t = 15.5; df = 8	t = 5.1; df = 8	t = 10.6; df = 8	t = 8.5; df = 8
		P=0.01	*P = 0.01*	*P=0.01*	*P=0.01*

other crops during the presence of *A. mellifera* but after its removal, the number of pollen loads from other crops decreased significantly (Table 2).

Receprocal shifts in the resource use pattern do not always imply competition, but when induced experimentally, these prove that resources are limiting and hence competition occurs (Roubik, 1978). Competitive superiority is necessary attribute of a species able to establish in a saturated community (McArthur and Wilson, 1967) and at floral resources is likely to be of major importance (Roubik, 1978). The present study revealed that *A. mellifera* being stronger and competitively superior, it can outcompete *A. cerana* in areas where it is introduced and this has been true in many areas. The introduction of *A. mellifera* in to the Hindu Kush-Himalayan region has led to the decline in *A. cerana* populations in their native habitat to the level that has threatened its extinction and traditional beekeeping.

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