Research Article

FORAGING PREFERENCE OF GIANT HONEYBEE, *Apis dorsata* F., TO SELECTED HORTICULTURAL CROPS

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ABSTRACT

Foraging preference of giant honeybee, *Apis dorsata* Fab. to selected horticultural crops, litchi, *Litchi chinensis* Sonner, lemon, *Citrus limon* (Lin.) Burm. f., bottlebrush, *Callistemon citrinus* (Curtis) Skeels, cucumber, *Cucumis sativus* Lin., radish, *Raphanus sativus* Lin., and summer squash, *Cucurbita pepo* L., was studied during their blooming time at IAAS, Rampur, Chitwan, Nepal, 2001. The flowering of all six species of experimental plants started in the first week of March and lasted for two months with a peak flowering from 15 March to 5 April. Foraging preference of bees at 7.30, and 11.00 am and 3.00 pm and 5.30 pm during early, mid and late periods of flowering was assessed. Honeybees foraging at different times of day during early, mid and late flowering periods differed significantly. The highest mean number (8.04/min/m^2) of *A. dorsata* workers was recorded on bottle brush flowers at 7.30 am during early flowering period followed by litchi, summer squash and the lowest (0.25/min/m^2) on citrus at 5.30 pm during late flowering period. The bees never visited to the flowers of radish and cucumber. Pollen was preferentially collected from bottlebrush, summer squash and citrus in the morning and nectar from litchi and bottlebrush flowers throughout the day. Pollen foragers spent less time (2.9±1 sec/flower) and visited more flowers (17.9±6/min) when bees collected both pollen and nectar from the same plant. The number of outgoing and incoming foragers were the highest (59.0±14, 44.0±15/min/colony) at 7.30 am during mid flowering period and the lowest (17.6±7, 17.0±2/min/colony) at 5.30 pm during late flowering period, respectively.

Key words: Foraging preference, Apis dorsata, horticultural crops

INTRODUCTION

Nepal is a small mountainous agricultural country with highly diversified agro ecological zones and honeybee species. It is considered as a suitable place for the promotion of beekeeping with availability of diversified bee flora in abundance and suitable climatic conditions throughout the year. The giant honeybee (*Apis dorsata* Fab.), the rock bee (*Apis laboriosa* Smith), the Asiatic hivebee (*Apis cerana* Fab.) and the little bee (*Apis florea* Fab.) are the native honeybee species commonly found and distributed at different ecological regions of Nepal influencing both crops and bee hive production and productivity. The giant honeybee is distributed widely across the plains and foothills of Nepal. The colonies have the strong tendency of absconding, swarming and migration. The bees migrate several miles away in search of food and safe shelter. Colonies most often reoccupy the same nesting site of previous year in subsequent seasons (Paar *et al.*, 2000). The biology, foraging preference, and behavior of this giant honeybee is little known. Its great role as natural pollinator of several plants in its area of distribution is underestimated in many underdeveloped countries including Nepal. This is the most reliable natural pollinator of plants with large flowers and inflorescence secreting large amount of nectar and pollen. The bees forage for long distances by showing maximum foraging activity at a temperature between 25-35^{0}C, the distance and range being higher than the *Apis mellifera* (Sihag, 1998).

Out of the total honey and bee wax production of Nepal, large amount comes from the giant honeybee colonies (Wilde *et al.*, 2000). Professional honey hunters harvest the honey by cutting the whole comb after driving the bees off with a traditional fire smoke. Many people in the country consider this bee species as a furious enemy rather than the beneficial insect, which comes every year at the same time and location and serves the human beings freely by providing different bee products and pollination services.

Loss of natural nesting sites due to deforestation and fire in the forest, heavy use of pesticides, change in agricultural pattern, unscientific honey hunting etc. have threaten the existence of this bee species in many Asian countries including Nepal. The productivity of crops is in decreasing trend due to the lack of desired level of pollinators, while pollination services of honeybees has not been realized and under estimated by the

farmers and policymakers of Nepal (Partap and Partap, 2000). A number of factors such as species of bees, foraging preference, their population bee biology, types of bee flora available at the location etc. appear to influence crop pollination. Many species specialize on a limited flowering plant species for pollen and nectar collection sometime restricting their visits to a single plant causing pollination hindrance on some economically important plant species when they flower at the same time and foraging location (Sihag, 2000). A number of factors are involved to effect the preference of bees for floral rewards and has been found significantly different at different intervals of the day and stages of flowering (Aly and Hassan, 1999). Therefore, the knowledge on bee behavior and foraging preference and their interactions with different plant species are pre-requisite to frame on strategy for effective crop pollination and bee hive productions for different agro-ecological regions.

MATERIALS AND METHODS

A survey was done at the research site just prior the start of experiment to investigate the number of *A. dorsata* colonies and their estimated population. The study was carried out at IAAS, Rampur, Chitwan, Nepal during the months of February to May, 2002. The experiment consisted of six horticultural plant species recording bee visits on them during early flowering (20-25% initial flowering per plant), mid flowering (40-60% flowering per plant) and late flowering (25% remaining flowering per plant) periods four times a day, i.e. early and late morning, and early and later afternoon replicated six times.

Honeybee species used in the experiment

Species of honeybee used in this study was the giant honeybee *A. dorsata*. This is one of the important and widely distributed native wild bees of Nepal. Several sub-species and ecotypes have been reported widely distributed from Terai to an altitude of 1500 m asl. They are considered as an excellent source of honey, bee wax and bee-bread producer and good pollinators of many cultivated and wild plant species especially in plains and foothills of Nepal.

Plant species used in experiment

Six flowering plants of each litchi, *Litchi chinensis* Sonner; lemon, *Citrus limon* (Lin.) Burm. f.; and bottlebrush, *Callistemon citrinus* (Curtis) Skeels were selected randomly from the IAAS, Rampur Campus, Chitwan. Similarly, fields of cucumber, *Cucumis sativus* Lin; summer squash, *Cucurtita pepo* Lin.; and radish, *Raphanus sativus* Lin. were selected from the vegetable production block of IAAS, Rampur Campus to carry out this study. Each selected vegetable field was divided into fifty blocks measuring each $1m^2$. Twenty-four blocks from each experimental vegetable crops were selected randomly for the purpose of this study.

All six selected species of horticultural plants were well established at IAAS, Rampur within the close range (500 m radius from the *A. dorsata* bee colony) of bee foraging, which flowered almost at the same time and duration. A survey was also done to record the total number of experimental plants at flowering stage within 2 km radius from the experimental colonies of the giant honeybees (Table 1). The observations were recorded from the four different directions (east, west, north and south) of each selected tree species generally at the middle of the tree canopy. The numbers of bees visiting to the flowers were counted for one minute inside one square meter frame. In radish, cucumber and summer squash, the numbers of bees visiting to its flowers were counted inside $1m^2$ frame for one minute over the flowers of selected 24 plants for each crop. The observations and data recordings were performed in clear sunny days. Number of bees visiting to the flowers of different plant species were recorded during different times of the day as early morning (7.30-8.00 am), late morning (11.00-11.30 am), afternoon (3.00-3.50 pm) and late afternoon (5.30-6.00 pm) and different flowering periods of the plant as early flowering (20-25% initial flowering per plant), mid flowering (40-60% flowering per plant) and late flowering (25% remaining flowering per plant). The flowering periods of the experimental plants were determined by frequent visual observations. The percent of flowering was determined by sampling the inflorescence and counting the opened and unopened flowers per panicle or plant. The number of outgoing, incoming and pollen carrying bees were also counted at different flowering periods and times of the day in ten dorsata colonies. Also, the time spent per flower in seconds and number of flowers visited per minute was also assessed for all the experimental plants.

RESULTS

Flowering duration

Flowering of all six species of experimental plants started and ended almost at the same time (1 March to 30 April, 2001). The maximum coincidence of flowering of all six plant species occurred between 15 March to 5 April, 2001 under Chitwan condition providing diversified foraging choices for honeybees (Table 1).

Table 1. Selected horticultural plant species for study and their flowering duration at IAAS, Rampur

SN	Plant species	Number of plants grown	Beginning of flowering	End of flowering	Duration of flowering
1	Bottle brush	120	March 1	April 13	44 days
2	Citrus	50	March 8	April 5	29 days
3	Cucumber	250	March 15	Aril 30	45 days
4	Litchi	150	March 15	April 8	25 days
5	Summer squash	400	March 13	April 8	27 days
6	Radish	1000	March 3	April 8	36 days

Floral description

Litchi plants had the smallest bisexual and odorless flowers with green stigma and brownish pollen. The flowers remained opened from morning to evening. The flowers of citrus were medium in size with strong floral fragrance. It had bisexual flowers with green stigma and yellow pollen. Flowers remained opened from morning to evening. Bottlebrush produced small bisexual odorless flowers with red stigma and brownish pollen. Flowers remained opened from morning to evening. The flowers of radish were bisexual small in size and remained opened from morning to evening. The flowers had green stigma and yellow pollen with mild fragrance. Summer squash produced the largest, and unisexual flowers as compared to the flowers of other experimental plants. It had yellow stigma with yellow pollen and mild fragrance. The flowers remained open from morning to midday only. The flowers of cucumber were medium in size, unisexual with mild fragrance. It had red stigma and yellow pollen and remained open from morning to evening.

Number of *A. dorsata* colonies and estimated population within IAAS

A total number of 140 colonies (small and large) of *A. dorsata* were counted on water tanks, hostels, and apartments of the campus one week before blooming the experiment plants (1 March, 2001). The number of *A. dorsata* colonies declined to 95 at the end of the experiment as many of them absconded and migrated. The maximum number of bee population was estimated 10,000,000 at the start and 15,000,000 at the end of the study. This increment in the population was due to the increment in colony size and brood area during the later part of the experiment.

Foraging preference of *A. dorsata* bees

The foraging preference of *A. dorsata* worker bees differed significantly at different times of the day and flowering periods of the experimental plants (Table 2-4). Native hive bee *A. dorsata* preferentially concentrated their visits to litchi flowers in the early morning hours and then declined towards the later part of the day significantly during the entire periods of flowering. The highest mean number of bees was 6.83/min/m^2 at 7.30 am during mid flowering period and the lowest 0.25/min/m^2 at 5.30 pm during the late flowering period. The bees collected mostly nectar from litchi flowers. The mean highest number of *A. dorsata* bees on citrus was recorded (1.58/min/m^2) at 7.30 am during the mid flowering period and the lowest (0.25/min/m^2) at 5.30 during the late flowering period. The bees visited to the citrus flowers especially for pollen collection.

The foraging numbers of *A. dorsata* was the highest (8.04/min/m^2) in the early morning hours during early flowering period and then declined towards the later part of the day and flowering periods in bottlebrush flowers. The bees preferentially foraged first for pollen and then after for nectar in the flowers of bottlebrush. The worker bees of *A. dorsata* never visited to the flowers of radish and cucumber throughout the entire period of its blooming. The bees visited to the flowers of summer squash only in the early morning hours throughout its flowering duration and only for pollen collection. The highest number of bees on summer squash flowers was observed 1.38/min/m^2 during mid flowering period of summer squash.

Table 2. Foraging number of *A. dorsata* worker bees at different times of a day during early flowering periods of selected horticultural crops at IAAS

Plant species	Times of day			
	7:30 am	11:00 am	3:00pm	5:30pm
Bottle brush	8.04a	5.21a	5.45a	2.33a
Citrus	0.50c	0.29c	0.29bc	0.33b
Cucumber	0.00c	0.00c	0.00c	0.17b
Litchi	3.21 b	2.42 b	1.17 b	0.71 b
Squash	0.92 c	0.00 c	0.00 c	0.00 b
Radish	0.04 c	0.00 c	0.00 c	0.00 b

In each column, means followed by a common letter are not significantly different at 5% level by DMRT

Table 3. Foraging number of *A. dorsata* worker bees at different times of a day during mid flowering periods of selected horticultural crops at IAAS

Plant species	Times of day			
	7:30 am	11:0 am	3:00 pm	5:30 pm
Bottle brush	4.33 b	2.54 b	1.88 a	0.96 ab
Citrus	1.58 c	0.42 c	0.92 ab	0.83 ab
Cucumber	0.00 d	0.00 c	0.00 b	0.00 b
Litchi	6.83 a	4.00 a	0.96 ab	1.50 a
Squash	1.38 c	0.00 c	0.00 b	0.00 b
Radish	0.00 d	0.00 c	0.00 b	0.00 b

In each column, means followed by a common letter are not significantly different at 5% level by DMRT

Table 4. Foraging number of *A. dorsata* worker bees at different times of a day during late flowering periods of selected horticultural crops at IAAS

Plant species	Times of day			
	7:30 am	11:0 am	3:00 pm	5:30 pm
Bottle brush	1.79 a	1.13 ab	0.71 a	1.00 a
Citrus	0.42 bc	0.33 bc	0.58 a	0.25 ab
Cucumber	0.00 c	0.00 c	0.00 a	0.00 b
Litchi	2.21 a	1.50 a	0.67 a	0.25 ab
Squash	1.25 ab	0.00 c	0.00 a	0.00 b
Radish	0.00 c	0.00 c	0.00 a	0.00 b

In each column, means followed by a common letter are not significantly different at 5% level by DMRT

The bees spent 35.6±3.0 sec/flower on summer squash flower and 5.2±2.0 sec/flower on bottlebrush for pollen collection. Similarly, the bees spent 2.9±1.0 sec /litchi flower and 5.5±.3.0 sec/bottlebrush flower for nectar collection. Worker bees of *A. dorsata* spent 10.4±4.0 sec/citrus flower and visited 5.1±3.0 flowers/min for pollen collection.

The number of incoming foragers of *A. dorsata* bees was recorded the highest (59/colony/min) at 7.30 am during mid flowering period and the lowest (18.0±3.7/colony/min) at 3.50 pm during mid and late flowering period. The higher number of incoming worker bees (44±15.5/colony/min) were found at 7.30 am and the lowest (17±2.9/colony/min) at 5.30 am during late flowering periods of the experimental plants. The numbers of pollen foragers were recorded higher only in the morning hours during the entire period of the experiment.

DISCUSSIONS

The findings of the experiment showed that the giant honeybee, *A. dorsata* preferred more to forage on bottlebrush followed by litchi, citrus and summer squash flowers. The bees never visited to the flowers of radish and cucumber throughout its entire period of flowering showing a distinct foraging preference. The foraging intensity of the bees was observed maximum in the early morning hours, which declined continuously

afterwards. The bees collected more preferentially nectar from bottlebrush, litchi flowers and pollen from bottlebrush, citrus and summer squash flowers showing a distinct resources partitioning. The pollen collectors of *A. dorsata* spent seven fold times more on summer squash than on bottlebrush flowers. The bees spent 50% less time per litchi flowers than that of bottlebrush for nectar collection and thus foraged 50% higher number of litchi flowers per minute. The activity of bees was more pronounced in all four plants during the morning hours when air temperature was comparatively lower (19.3^{0}C at 7.30 am) than that of afternoon hours (33.1^{0}C at 5.30 pm). The pronounced activity of the bees during morning hours was due to the early release of fresh pollen and nectar and suitable foraging temperature.

These findings indicated that the seed production of radish and seed and fruit production of cucumber would be in jeopardy especially in places like Rampur where the pollinators are only the giant honeybees. However, the flowers of radish were more preferentially foraged by the worker bees of *A. cerana* and *A. mellifera* for pollen collection showing a distinct foraging preference by different honeybee species. The flowers of cucumber were not visited by any of the honeybee species, although they were flowering within 500 m from the colonies of *A. dorsata*, *A. mellifera* and *A. cerana*. Although the preference of honeybee species to a particular plant species is determined by several factors, like volume and sugar concentration and flavor of nectar, fragrance and color of the flowers, amount and quality of pollen etc, the actual reason(s) for more attractiveness towards bottle brush, litchi and less attractiveness towards summer squash, citrus and no attractiveness at all towards radish and cucumber to *A. dorsata* bees is still unknown and is a field of future study.

Several researchers have reported similar findings. Rao and Lazar (1983) in a study of bee behavior and pollination in onion revealed that *A. dorsata* never visited to the flowers of onion during the entire period of its blooming, while *A. cerana* and *A. florea* were observed collecting nectar. Partap *et al.* (2000) reported that cauliflowers were more attractive to *A. cerana* than radish. Similarly, the influence of mustard, radish, clover in detracting honeybee pollination of apples caused negative impact on apple pollination (Kakar, 1998). Verma (1995) also observed in his study that when alternate sources were available *A. mellifera* did not prefer to forage on the apple flowers. These investigations revealed that the bees prefer to forage on more attractive plants and neglect the others when they flower at the same time and location affecting the pollination requirements of the less attractive plant species to a greater extent.

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