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Diversity, Relative Abundance, and Diurnal Variation of Insect Visitors of Litchi (*Litchi chinensis* Sonn.) at Rampur, Chitwan, Nepal

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ABSTRACT

A study was conducted to record the diversity, relative abundance, and diurnal variation of insect visitors of litchi from March to April 2019 at the Horticulture Farm of Agriculture and Forestry University (AFU) Rampur (latitude 27°37' N and longitude 84°25' E). A total of twenty-seven species of insect flower visitors from six different orders and eighteen families was recorded. Hymenopterans were the most abundant insects (61.26%) in five different families, namely: Apidae, Megachilidae, Andrenidae, Vespidae and Braconidae followed by Diptera (26.13%), Coleoptera (4.50%), Hemiptera (4.50%), Lepidoptera (2.70%) and the lowest Orthoptera (0.90%), respectively. Honeybees were the abundant group of pollinators, *viz. Apis dorsata F.* (30.63%), *Apis mellifera L.* (9.46%), *Apis florea F.* (6.76%) and *Apis cerana F.*(3.60%) on litchi flowers. The foraging activity of *A. dorsata* was maximum in the morning at 09:00 am, followed by 12:00 noon, 06:00 am and 3:00 pm with 22.37, 14.07, 7.06, and 4.95 No/panicle/5 min respectively. Its foraging activity was the lowest (2.34 No/panicle/5 min) at 06:00 pm. Moreover, foraging activity of *A. mellifera*, *A. cerana*, were similar to *A. dorsata*, whereas the foraging activity of *A. florea* was maximum at 12:00 noon followed by 03:00 pm, 09:00 am and 06:00 pm with 12.04, 8.66, 3.24 and 3.17 No/panicle/5 min, respectively. Its foraging activity was the lowest at 06:00 am (0.88 No/panicle/5 min). Management and conservation of the pollinators in litchi orchard is essential to ensure pollination and production of litchi fruits.

Keywords: Litchi pollinators; *Apis dorsata*; *Apis mellifera*; *Apis cerana*; *Apis florea*

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is considered as one of the most important sub-tropical evergreen fruits which is believed to be originated from southern China. Litchi is nut type fruit with fleshy aril edible part belonging to Sapindaceae family. Litchi is the third most important fruit after mango and banana in terms of area and production in Nepal and Chitwan is major litchi growing area of the country covering an area of 302 ha with productive area 148 ha, production 1,228 mt of fruit annually and productivity 8.3 mt/ha [1].

Litchi is a cross pollinated plant and its flower requires sufficient pollinating agents for pollination and fruit set. Nectar and pollen presence in huge amount in the self-sterile flowers attracts various insects, such as honeybees, flies, ants and wasp leading to entomophilic cross pollination. It is estimated that one-third of the total human food supply relies on insect pollination [2,3]. Flowering in litchi occurs during the month of March-April, which attracts and invite a number of insects for pollination [4]. Pollination of entomophilous crops by honeybees is regarded as one of the effective and cheapest methods for improving the qualitative and quantitative yield of crops [5]. Litchi flowers are visited by varieties of insects including, Hymenopteran, Dipteran, Coleopteran, Hemipteran, Homopteran and Lepidopteran insect orders [6]. Most common insect pollinators are the honeybees, *Apis cerana F.*, *Apis dorsata F.*, *Apis mellifera L.* and *Apis florea F.*, and the syrphid flies *Melanostoma univittatum* De Geer. A total of 12 insect species, among which 6 species belonging to the order Hymenoptera, 5 species to Diptera and 1 species to Coleoptera were recorded visiting litchi flowers in India [4]. Minimum ecological conditions required for *Apis* species for commencement of flight activity is 15.5°C-18.5°C

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temperature, 600-1700 lx light intensity, and 9-20 mW/cm^2 solar radiation, respectively [7]. The foraging activity of *A. mellifera* at different hours of the day showed that maximum activity of bees was at 08:00 am followed by 10:00 am and 06:00 am with 128.83, 63.83 and 55.66 honeybees, respectively [8]. All farm inputs and varietal capacity goes in vain until an efficient and assured pollination guaranteed, which is major factor for quality and quantity production. Such study is scarce in Nepal. Therefore, a study was carried out to record the diversity, abundance and diurnal variation of pollinators of litchi.

MATERIALS AND METHODS

The study was conducted in horticulture farm (latitude 27°37' N and longitude 84° 25' E) at the Agriculture and Forestry University (AFU) Rampur, Chitwan during the flowering stage (March to April, 2019). The monitoring of pollinators was done using a pan trap, sweep net and visual observations during the flowering stage of litchi. Three different colored pan traps, namely: blue, yellow, and white traps were placed hanging on branches of litchi tree three meters apart to each other in alternate ways concerning to color of pan trap. After twenty-four hours of installation of traps, these pan traps were removed, and trapped insects were collected and kept in insect collection bottle with 10% formalin. Similarly, visual observations were carried out to study the diurnal variation of pollinators at different times of the day at 6:00 am, 9:00 am, 12:00 (noon), 3:00 pm and 6:00 pm during peak flowering stage of litchi using a hand tally counter and chronometer (stopwatch). Sweep net was used to collect flower-visiting insects, and representatives of the insect species sampled were sorted out, pinned in wooden insect box and preserved as dry specimen, observed under a microscope, and identified with the help of dichotomous key and matching museum specimens. The pollinator diversity of insect visitors to litchi during the flowering period was measured using the Shannon-Wiener Diversity Index [9] : $H=-\Sigma\ Pi(lnPi)$, where H represents the index of species diversity in a given locality, and Pi is the proportion of the total sample belonging to the i^{th} species.

RESULTS

Diversity of insect pollinators

The opening of flowers occurred during the first week of March, and 50% flowering was noticed in the mid-March, and flowering continued till the last week of March. The pollinator fauna of litchi included twenty-seven species from six different orders and nineteen families of class Insecta during the blooming period of litchi trees (Table 1). Among them, Hymenopteran was predominant comprising of twelve species from five different families, namely: Apidae, Megachilidae, Andrenidae, Vespidae, and Braconidae. Hymenopteran species were the most abundant insects (61.26%) visiting litchi flowers followed by Diptera (26.13%), Coleoptera (4.50%), Hemiptera (4.50%), Lepidoptera (2.70%) and the lowest Orthoptera (0.90%), respectively (Figure 1).

Table 1: Diversity and abundance of litchi flower insect visitors at Rampur, Chitwan, 2019.

SN	Insect visitors	Scientific name	Family	Order	No.	Abundance (%)
1	Rock bee	*Apis dorsata* Fabricius	Apidae	Hymenoptera	68	30.63
2	European honey bee	*Apis mellifera* Linnaeus	Apidae	Hymenoptera	21	9.46
3	Asiatic honey bee	*Apis cerana* Fabricius	Apidae	Hymenoptera	8	3.6
4	Red dwarf bee	*Apis florea* Fabricius	Apidae	Hymenoptera	15	6.76
5	Bumble bee	*Bombus pascuorum* Scopoli	Apidae	Hymenoptera	5	2.25
6	Carpenter bee	*Xylocopa tenuiscapa* Westwood	Apidae	Hymenoptera	4	1.8
7	Leaf cutter bee	*Megachile* sp.	Megachilidae	Hymenoptera	5	2.25
8	Andrena sp	*Andrena* sp.	Andrenidae	Hymenoptera	2	0.9
9	Golden wasp	*Vespa mangifica* Smith	Vespidae	Hymenoptera	3	1.35
10	Oriental wasp	*Vespa orientalis* Linnaeus	Vespidae	Hymenoptera	2	0.9
11	Paper wasp	*Polistes* sp.	Vespidae	Hymenoptera	1	0.45
12	Braconid wasp	*Apanteles glomeratus* Linnaeus	Braconidae	Hymenoptera	2	0.9
13	Blow fly	*Callipho* sp	Calliphoridae	Diptera	5	2.25

14	Green bottle fly	*Lucilia sericata* Meigen	Calliphoridae	Diptera	12	5.41
15	Flesh fly	*Sarcophaga peregrine* Robineau-Desvoidy	Sarcophagidae	Diptera	7	3.15
16	Syrphid fly	*Eristalis* sp	Syrphidae	Diptera	22	9.91
17	Horse fly/ Tabanus fly	*Tabanus* sp	Tabanidae	Diptera	4	1.8
18	House fly	*Musca domestica* Linnaeus	Muscidae	Diptera	8	3.6
19	Red Pumpkin beetle	*Aulacophora foveicollis* Lucas	Chrysomelidae	Coleoptera	1	0.45
20	Lady bird beetle	*Coccinella* sp	Coccinellidae	Coleoptera	5	2.25
21	Green June beetle	*Cotinis nitida* Linnaeus	Scarabaeidae	Coleoptera	4	1.8
22	Sandalwood defoilator	*Amata passalis* Fabricius	Erebidae	Lepidoptera	3	1.35
23	Cabbage butterfly	*Pieris brassicae nepalensis* Doubleday	Pieridae	Lepidoptera	2	0.9
24	Monarch butterfly	*Danaus plexippus* Linnaeus	Danaidae	Lepidoptera	1	0.45
25	Damsel fly	*Agriochemis* sp	Coenagrionidae	Odonata	2	0.9
26	Rice Gundhi bug	*Leptocorisa oratorius* Fabricius	Alydidae	Hemiptera	1	0.45
27	Litchi bug	*Tessaratoma papillosa* Drury	Pentatomidae	Hemiptera	9	4.05

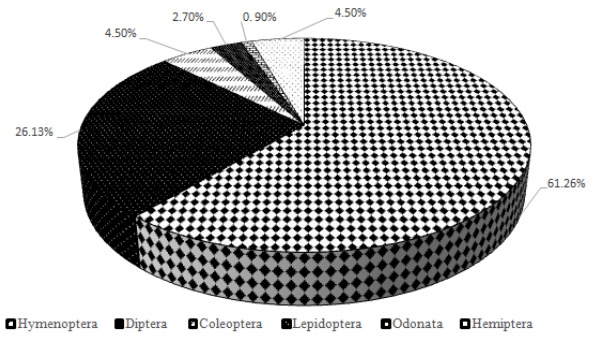

Figure 1: Abundance of different insect visitors/ pollinators during litchi flowering at Rampur, Chitwan, 2019.

Relative abundance of insect pollinators

Honeybees were the abundant group of pollinators, *viz. A.dorsata* (30.63%), *A. mellifera* (9.46%), *A. florea* (6.76%) and *A. cerana* (3.60%) on litchi flowers. The average population of *A. dorsata* was recorded 10.15 insects/panicle/5 min, which represented 30.63% of population of total insect pollinators visiting litchi flowers on visual observation. Syrphids in totality were the second dominant insect visitors with an average of 9.57 insects/ panicle/5 min constituting 9.91% of total insect fauna. Among the Dipterans, *Eristalis* sp. frequently visited litchi flowers followed by green bottle fly (5.41%). Of all the insect flower visitors, *A. dorsata* and *Eristalis* sp. were the most frequent visitors in litchi orchard. Higher number of *A.dorsata* was recorded on litchi flowers with an average (10.15 bees/m^2/5 min.) followed by *Eristalis* sp. (9.57 bees/m^2/5 min.), *A. florea* (5.59 bees/m^2/5 min.), *A. mellifera* (3.72 bees/m^2/5 min.) and A.cerana (2.33 bees/m^2/5 min), respectively.

Shannon-Wiener diversity index

The diversity index of insect visitors of litchi during the flowering was 1.07, less than 1.5 (Table 2), which revealed that there is low diversity of insect visitors. It may be due to the presence of some specific species in large numbers during the flowering stage of litchi at Rampur, Chitwan.

Table 2: Shannon-Wiener diversity index of insect visitors of litchi flowers at Rampur, Chitwan, 2019.

Insect order	Species (No.)	Total (No.)	Diversity index+
Hymenoptera	12	136	0.3
Diptera	6	58	0.35

Coleoptera	3	10	0.14
Lepidoptera	3	6	0.1
Odonata	1	2	0.04
Hemiptera	3	10	0.14
Total	28	222	1.07

[+]Low diversity =<1.5; medium diversity = >1.5 and <2.5; high diversity =>2.5

Diurnal variation of insect pollinators

Honey bees were the effective pollinators, whereas syrphid flies were frequent visitors on litchi flowers. The foraging activity of *A. dorsata* was maximum in the morning at 09:00 am, followed by 12:00 noon, 06:00 am and 3:00 pm with 22.37, 14.07, 7.06, and 4.95 bees/panicle/5 min, respectively (Figure 2). Its foraging activity was the lowest (2.34 bees/ panicle/5 min) at 06:00 pm. Similar foraging activity was performed by *A. mellifera*, *A. cerana*, whereas the foraging activity of *A. florea* was maximum at 12:00 (noon) followed by 03:00 pm, 09:00 am and 06:00 pm with 12.04, 8.66, 3.24, and 3.17 bees/panicle/5 min, respectively. Its lowest foraging activity was at 06:00 am (0.88 bees/panicle/5 min).

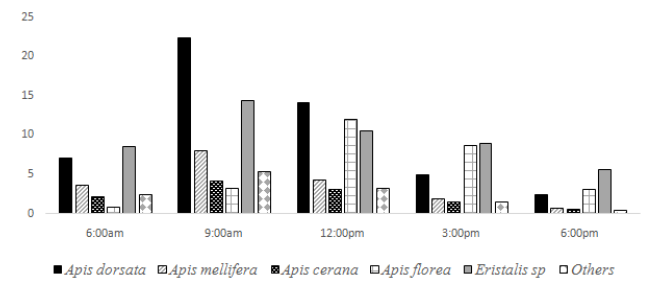

Figure 2: Diurnal variation of major pollinators on litchi flower (number/panicle/5 min) at Rampur, Chitwan, 2019.

DISCUSSION

Diversity of insect pollinators

In general, the diversity of pollinating insects varies from region to region and locality to locality. Insect fauna belonging to Hymenoptera, Diptera, Coleoptera, and Lepidoptera have been reported to visit and pollinate the litchi flowers, which are attractive to insects for both pollen and nectar. Twenty-one species of insects were recorded visiting litchi flowers at Rampur, Chitwan, which is slightly lower in species than present finding [10]. Similarly, twenty pollinator species under 23 genera from 8 families belonging to orders Diptera, Hymenoptera and Coleoptera were reported in Muzaffarpur, Bihar [11]. In another study, 20 species under 16 genera from 8 families belonging to orders Diptera and Hymenoptera were also reported from district Haripur, Pakistan [6]. Again, only total of thirteen insect pollinators belonging to order Hymenoptera, Diptera and Coleoptera were recorded in Nadia district of West Bengal [12]. Similarly, as low as twelve insect species was observed belonging to the order Hymenoptera, and Diptera visiting the flowers during the entire blossom period of litchi [13].

Relative abundance of insect pollinators

The Hymenopterans insects were the most dominant flower visitors constituting 74.69% of the insect visitors and 25.21% others [11]. In another study, they were observed as the most dominating pollinators, which represented 73.51%, among which *A. dorsata* (21.82%), *A.mellifera* (26.84%) and *A. cerana* indica (7.60%) were observed on litchi flowers [4]. Honeybees were the dominant flower visitors of litchi, and their abundance was in the order: *A. mellifera* (47.52%)>*A. cerana*(20.59%)>*A. dorsata*(5.38%) >*A. florea* (0.37%) and 25.21% others [11]. Diptera were observed as the second most abundant insect visitors constituting 26.47% of the total pollinators of litchi flowers, among which Syrphid flies were observed as the most frequent visitors on litchi flowers [4]. In a very recent study, *A. dorsata*, *A. mellifera*, *A. cerana* indica, *A. florea*, *Lassioglossum* sp., *Vespa tropicalis L.* and *Camponotus compressus F.* belonging to Hymenoptera, *Episyrphus balteatus* De Geer , *Eristalis* sp., *Syrphus* sp., *Sacrcophaga* sp. and *Lucilia sericat*a Meigen belonging to Diptera and *Coccinella septumpunctata L.* belonging Coleoptera were reported in litchi orchard [12].

A wild honeybee, *A. dorsata* immigrate towards southern areas of Chitwan valley from northern part during November-December and maximum colonies aggregate in March with maximum staying of eight months and return back to northern part during March-July [14] which support the dominance of A. dorsata at Rampur, Chitwan during flowering stage of litchi. The present finding reveals that *A. dorsata*, *A. mellifera*, *A. cerana* and *A. florea* were the most dominant and efficient pollinators of litchi flowers representing more than 65% of the total pollinating insects which are in line with the finding of other studies [7,15]. The honeybees, *A. dorsata*, *A. mellifera*, *A. cerana* and *A. florea* were the dominant flower visitors of litchi, of which *A. dorsata* (50.11%) was predominant visitor followed by *A. cerana* indica (11.80%), *A. florea* (8.68%) and *A. mellifera* (7.12%) [12,13]. Among *Apis* spp., the highest activities of *A. dorsata* (3.30 and 3.22 foragers/panicle/5 min), *A. mellifera* (2.92 and 2.98 foragers/panicle/5 min), *A. cerana indica* (1.24 and 1.38 foragers/panicle/5 min) has been reported [4]. The abundance of Hymenopterans (77.71% insect fauna/inflorescence/5 min.), among which *A. dorsata* was the predominant species ranking

first, which recorded 2.53 per inflorescence and represented 50.11% followed by Syrphids with an average of 1.00 insect per inflorescence constituting 22.27% of total insect fauna as the second dominant insect visitors to litchi flower [12], which support present finding at the Horticulture Farm of Agriculture and Forestry University in Rampur, Chitwan, Nepal.

Diurnal variation of insect pollinators

The foraging behavior of all honeybee species followed the same general pattern as temperature, solar radiation, light intensity, nectar sugar concentration and inversely with relative humidity between commencement and cessation [7]. The peak foraging behavior of honeybee species A. cerana, *A. mellifera* and *A. dorsata* were recorded around 12:00 noon to 2:00 pm, where the highest of all three bee species were recorded at 2:00 pm and the lowest at 10:00 am in rapeseed flower [16]. The foraging speed (time spent in second per flower per forager) of all the honeybees were observed the highest during 9-11 am, which gradually declined towards the succeeding time of the day [12]. Again, the foraging frequency of *A. dorsata* reached peak with speed of 5.38 second in the morning 9-11 am, which was minimum in late afternoon 3-5 pm for all the honeybees, which are similar to the present finding. The mean foraging speed was maximum in *A. dorsata* (4.64 second) and minimum in *A. florea* (3.32 second) [12]. On the contrary, the foraging rate (number of flowers visited per minute per forager) was the highest in afternoon 3-5 pm for all the honeybees and the maximum and minimum mean foraging rate was recorded in *A. florea* (12.29) and *A. dorsata* (10.54), respectively [12].

CONCLUSION

The monitoring of litchi pollinator recorded a total of twenty-seven species of insects from six different orders and nineteen families. Honeybees were the abundant group of pollinators, *viz. A.dorsata* (30.63%), *A. mellifera* (9.46%), *A. florea* (6.76%) and *A. cerana* (3.60%) on litchi flowers. It is concluded that litchi being an entomophilous fruit tree requires pollinating agents, so safe pesticides should be sprayed to control insect pests before and after the flowering stage, especially during the evening to protect pollinators' abundance in litchi orchard. Hence, pollinators' friendly proper bee management approach, like the timely establishment of colonies in sufficient numbers in litchi orchards and collaboration with beekeepers and growers, would lead to the enhancement of litchi fruit yields and conservation of insect pollinators.

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REFERENCES

1. Statistical information on Nepalese agriculture (2017/2018). Government of Nepal, Ministry of Agricultural Development, Agri-Business Promotion and Statistics Division, Agri statistics Section, Singha Durbar, Kathmandu Nepal; 2018.
2. Said F, Inayatullah M, Ahmad S, Iqbal T, Shah RA, Usman A, et al. Foraging behavior of the Himalayan Honeybee, Apis cerana (Hymenopteral: Apidae) associated with sunflower (Helianthus annuus L.) at Peshawar district of Khyber Pakhtunkhwa (KP). J Entomol Zool Stud. 2015;3(3):203-207.
3. Rişcu A, Bura M. The impact of pesticides on honey bees and hence on humans. Sci Pap Anim Sci Biotechnol. 2013;46(2): 272-277.
4. Rai VL, Srivastava P, Bisht K, Mishra VK. Diversity and relative abundance of pollinating insects visiting litchi (Litchi chinensis Sonn.) inflorescence under tarai agro-climatic condition. J Exp Zool India. 2017;20(1):221-227.
5. King J, Exley E, Vithanage V. Insect pollination for yield increases in lychee. In: Proceedings of the Fourth Australian Conference on Trees and Nut Crops. Exotic Fruit Growers' Association, Lismore, Australia. 1989;142-145.
6. Ali S, Shehzad A, Rafi MA, Zia A. Insects pollinators of litchi (Litchi chinensis Sonn.) from district Haripur, Pakistan. Pakistan J Agric Res. 2013;26(3):220-229.
7. Abrol DP. Diversity of pollinating insects visiting litchi flowers (Litchi chinensis Sonn.) and path analysis of environmental factors influencing foraging behaviour of four honeybee species. J Apic Res. 2006;45(4):180-187.
8. Kumar R. Planned honey bee pollination in litchi (Litchi chinensis Sonn.) - A new production strategy for enhancing fruit yield and quality in India. Acta Hortic. 2014;1029:281-286.
9. Shannon CE. A mathematical theory of communication. Bell Syst Tech J. 1948;27(3):379-423.
10. Thapa RB. Honeybees and other insect pollinators of cultivated plants: A review. J Inst Agric Anim Sci. 2006;27:1-23.
11. Srivastava K, Sharma D, Pandey SD, Anal AKD, Nath V. Dynamics of climate and pollinator species influencing litchi (Litchi chinensis Sonn.) in India. Indian J Agric Sci. 2017;87(2): 266-269.
12. Das R, Jha S, Halder A. Insect pollinators of litchi with special reference to foraging behaviour of honey bees. J Pharmacogn Phytochem. 2019;8(4):396-401.
13. Kumar Y, Sharma R, Khan M. Diversity and foraging behaviour of pollinator fauna on litchi (Litchi chinensis Sonn.). Bioinfolet. 2013;10(1A):78-81.
14. Pokhrel S. Climeto-cylic immigrations with declining population of wild honeybee, Apis dorsata F. in Chitwan valley, Nepal. J Agric Environ. 2010;11:51-58.
15. Kitroo, Abrol D. Studies on pollen carrying capacity and pollination efficiency of honey bee visiting litchi flowers. Indian Bee J. 1996;58:55-57.
16. Pudasaini R, Thapa RB. Foraging behavior of different honeybee species under natural condition in Chitwan, Nepal. Eur J Acad Essays. 2014;1(9):39-41.