Influence of weather parameters on pollen and nectar foraging activity of *Apis* and non-*Apis* species of honey bees in wild and cultivated varieties of jamun (*Syzygiumcumuni* L. skeels)

ABSTRACT

The study oninfluence of weather parameters on pollen and nectar foraging activity of *Apis* and non-*Apis* species of honey bees in wild and cultivated varieties of jamun revealed that two peaks in nectar forager activity of *A. dorsata, A. florea* and *A. cerana* was recorded, the first peak during 0800-1200hr and second peak during 1400-1800hr, whereas in the case of *T. iridipennis,* one peak during 0800-0900hr was observed. Only one peak in the pollen forager of *A. dorsata, A. florea* and *A. cerana*was recorded during 0900-1200/1300hr, where as in case of *T. iridipennis*, two peaks were observed, the first peak during 1000-1200hr and the second peak during 1500-1800hr. The nectar foragers of *T. iridipennis*showed a significant negative, a significant positive and a significant negative correlation at five per cent level of significance with hourly temperature, relative humidity and wind speed. The nectar foragers of *A. cerana*had a significant positive correlation on wild *S. cumini* at GKVK at five per cent level of significance with hourly wind speed. A highly significant positive, a significant positive and a non-significant negative correlation at one and five per cent level of significance existed between the number of pollen foragers of *T. iridipennis*with hourly wind speed, temperature and relative humidity.Out of studied *Apis* and non-*Apis*bees, the relative humidity and wind speed affected the pollen and nectar foragers of *T. iridipennis* on wild and cultivated varieties of jamun.

Keywords: *Apis*, non-*Apis*, Nectar foragers, Pollen foragers, Weather parameters

1. INTRODUCTION

Syzygiumcumini L. Skeels belonging to family Myrtaceae is an important evergreen tropical fruit bearing plant. Jamun is native to Asia especially India. It is considered as medicinally important fruit tree but it's still an under explored indigenous fruit crop of India (Singh *et al.*, 2011). The species range across India, Bangladesh, Pakistan, Nepal,

Sri Lanka, Malaysia, the Philippines and Indonesia. In India, it is present in both moist and dry situations, seen in the tropical wet evergreen forests, tropical semi evergreen forests, tropical moist deciduous forests, littoral and swamp, tropical dry deciduous, tropical dry evergreen, subtropical broad-leaved hills and subtropical pine forests. It is also found growing in the lower ranges of the Himalayas up to an altitude of 1300 meters (Wrigley and Fagg, 2003).

S. cumini is considered as medicinally important fruit tree but it is still an under explored indigenous fruit crop of India. The species range across India, Bangladesh, Pakistan, Nepal, Sri Lanka, Malaysia, the Philippines and Indonesia. In India, it is present in both moist and dry situations, seen in the tropical wet evergreen forests, tropical semi evergreen forests, tropical moist deciduous forests, littoral and swamp, tropical dry deciduous, tropical dry evergreen, subtropical broad leaved hills and subtropical pine forests. It is also found growing in the lower ranges of the Himalayas uptoan altitude of 1300 meters (Saurabh Singh *et al.*, 2019; Patil*et al*., 2012).

S. cumini has gained worldwide attention for its medicinal properties. Its leaves are used as fodder, green manure and food for tassar silkworms in India. The leaf distillates yield an essential oil which is used as fragrance in soaps and is blended with other chemicals to make inexpensive perfumes (Patel *et al.,* 2010).

In recent years, jamun fruits are becoming popular due to their rich medicinal properties particularly for their antidiabetic properties. The medicinal value is due to the presence of malic acid, oxalic acid, gallic acid and tannins. The fruits are rich sources of anti-oxidant compounds, including flavonoids, phenolics, carotenoids and vitamins, which are all considered beneficial to human health, for decreasing the risk of degenerative diseases by reduction of oxidative stress and for the inhibition of macromolecular oxidation (Ayyanar and Subash-Babu, 2012).

The ant species, *Technomyrmexalbipes*S. and *Oecophyllasmaragdina*F. were found visiting the flowers of *Syzygiumoccidentale.* The *T. albipes*foraged only the floral nectar but*O. smaragdina*foraged both nectar and flower visitors. *T. albipes*was observed to be a dominant floral visitor and contributed 91 per cent of total visitation, with very high mean frequency (136.45 visits / h / flowers, N=198) as compared to visits (7.75

visits/ h/ flowers, N=77) made by *O. smaragdina*. The crawling behavior of ants on the outer surface of the stamens made the pollen grains stick to their body often comes in contact with the stigma (GibyKuriakose*et al*., 2018). Further they could observed that honey bees, *Apiscerana*and *T. iridipennis*regularly foraged for the pollen and occasionally for the nectar and often came in contact with stigma, but their frequency of visits to the flowers were very low and they consistently avoided those flowers in which *O. smaragdina*was present. The *Xylocopa*sp. (visitation rate=0.33 visits / flowers/h; N=35) foraged both the nectar and pollen, but did not come in contact with stigma. The bird species, *Leptocoma minima* Sykes (Nectariniidae) was the most frequent visitor followed by *Cinnyrisasiaticus* Latham (Nectariniidae). The *Arachnotheralongirostra* Latham (Nectariniidae) was the infrequent visitor, to the flowers during the late flowering period of *Syzygiumoccidentale.*

HaftomGebremedh, *et al*. (2014) stated that the number of bees that collected nectar had a positive association with air temperature (r=0.67; P=0.01) and negative relationship with relative humidity (r=-0.59; P=0.001). However, the number of bees that collected pollen had a positive correlation with relative humidity (r=0.62; P=0.001) and negative association with air temperature (r =-0.72; P=0.001).

Maximum temperature (>30^0C) had negatively affected bee activity with correlation coefficients of -0.72, -0.59 and -0.61 for outgoing bees, pollen and nectar collectors respectively. The number of worker bees going out to forage, came down significantly at temperature beyond 30^0C. Contrary to this, the minimum temperature showed a positive impact on outgoing bees (r = 0.66) and nectar collectors (r = 0.67) while pollen collectors showed no significant correlation. The relative humidity also showed positive impact on the frequency of worker bees moving out of hive (r = 0.69) and those coming in with nectar (r = 0.68) but negatively affected the number of pollen collectors. Diurnal variations showed peak activity of bee foragers between 06.00 and 10.00 a.m. Rainfall hampered foraging activity while wind speed was found to have no significant effect on bee activity (Rami Reddy *et. al.*2015).

In stingless bees, the number of pollen loads increased as relative humidity rose (r = 0.40), while high temperatures had negative influence on the number of pollen loads

collected (r = -0.23); and the number of nectar loads was also positively correlated with air temperature (r = 0.24) (Fidalgo and Kleinert 2010). In view of earlier works the study aims to evaluate pollen and nectar activity of *Apis* and non-*Apis* bees on the flowers of wild and cultivated varieties of Jamun with prevailing weather parameters.

2. MATERIALS AND METHODS

Study Area

The study was carried out at Regional Horticultural Research and Extension Centre, College of Horticulture (RHREC); UHS sub campus, GKVK, Bengaluru-560 065 during the flowering period of 2018-19 (fig1).

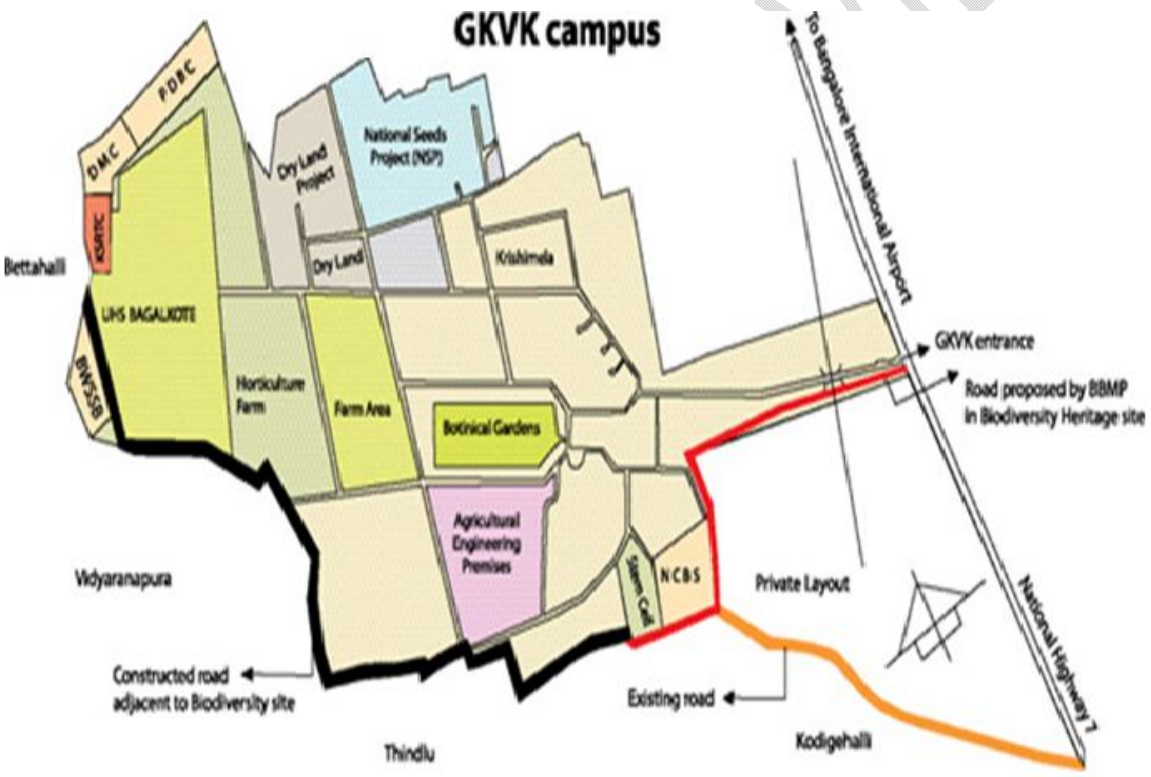


FIG 1: Map of the first study area at RHREC, UHS, GKVK, Bangalore during 2018

Wild and Cultivated Varieties of *S. cumini*

The observations on nectar and pollen foragers of *Apis* and non-*Apis* bees were made on four cultivated varieties of *S. cuminiviz*., GKVK-1, GKVK-2, K-45, N-20 in jamunorchard which were six years old planted at the spacing of 5m x 5m and also on naturally grown wild *S. cumini* trees of more than six-year-old at experimental site, RHREC, College of Horticulture; UHS sub-campus, GKVK, Bengaluru. Further nectar and pollen foraging behaviour *Apis* and non-*Apis*honey bees were correlated with prevailing environmental parameters of the said experimental site.

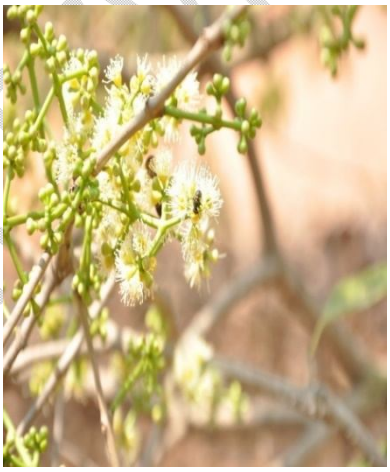
Nectar and Pollen foragers of *Apis* and non - *Apis* species of honey bees

The nectar and pollen foraging *Apis* and non - *Apis* species of honey bees was recorded during full bloom stage of crop. From the four directions of wild and cultivated varieties of *S. cumini,* four inflorescences were randomly selected and were tagged and labelled. Nectar and pollen collecting bees were observed for four days; from 10thto 14thMarch, 2018 for the varieties GKVK-1, GKVK-2, N-20, K-45 and wild *S.cumini*at GKVK. On each day, one inflorescence each from wild and cultivated varieties in one direction were observed for five minutes at hourly intervals from 0600-1900 hrs of the day and the honeybee species alighting were counted and similar observations were continued up to four days. The honey bee species collecting pollen from the flower along with pollen load in their hind legs was treated as a pollen forager and the honey bee species collecting the nectar from the flower without pollen load in their hind leg was treated as nectar forager. The observations on the pollen and nectar collecting bees were expressed as number of pollen or nectar collecting bees per 5 minutes per four inflorescences. The mean of weather parameters prevailed from 0600-1900 hrs at hourly interval during observation period of experimental site was utilized for correlation studies. . *Apisdorsata*F., *A. cerana* F. and *A. florea* F. were Apis Species of honey bees and *T. iridipennis*was non-*Apis* species of honey bee (fig 2).

*Apisdorsata*F.

*Apisceranа*F.

*Apisflorea*F.



*Tetragonulairidipennis*S.

FIG 2: *Apis* and non - *Apis* species of honey bees

Analyses of data

The data was analysed statistically and descriptive statistics were done using SPSS 12.0 (SPSS Inc., an IBM Company, Chicago, USA) and graphs were generated using Sigma Plot 7 (Systat Software Inc., Chicago, USA).

3. RESULTS AND DISCUSSION

Prevailing meteorological parameters of experimental site at GKVK during observation on pollen and nectar foraging activity of*Apis* and non- *Apis*species of honey bees in wild and cultivated varieties of *S. cumini*:

The pollen and nectar foraging activity of*Apis* and non- *Apis* species of honey bees in wild and cultivated varieties of *S. cumini* recorded during 2nd week of March, 2018 from 10th March, 2018 to 14th March, 2018 for the period of five days at GKVK. The prevailing hourly intervals meteorological data of experimental site during this period was collected from KSNMDC, Bangalore (Table 1).The hourly mean temperature of experimental site of GKVK ranged from 19.240 ^{0}C (0600 -0700hr) to 32.140 ^{0}C (1400-1500hr), hourly mean relative humidity was ranged from 31.70 (1400-1500hr) to 86.38 (0600-0700hr) per cent and hourly mean wind speed ranged from 0.30 (0600 -0700hr) to 1.88 (1200-1300hr) nautical miles per hour, respectively.

Table 1: Meteorological data of experimental site at GKVK, Bengaluruduring observation on pollen and nectar foraging activity of *Apis* and non- *Apis* species of honey bees in wild and cultivated varieties of *S. cumini*(2018)

Time (hr)	Weather parameters		
	At GKVK		
	Temp (°C)	RH (%)	Wind speed (nautical miles/hr)
0600-0700	19.24	86.38	0.30
0700-0800	21.10	75.64	0.56
0800-0900	23.10	64.97	1.00
0900-1000	25.98	55.96	1.30
1000-1100	27.96	45.48	1.72
1100-1200	29.82	38.36	1.72
1200-1300	31.02	34.46	1.88
1300-1400	32.08	33.42	1.84
1400-1500	32.14	31.70	1.54
1500-1600	31.58	32.52	1.76
1600-1700	30.12	34.42	1.6

1700-1800	28.76	36.80	1.28
1800-1900	27.28	43.40	1.16

Weather parameters (Temp=temperature, RH=relative humidity and wind speed) are the mean from 10-03-18 to 14-03-18

Nectar and pollen foraging activity of *Apis* and non -*Apis* species of honeybees on wild *S. cumini* at GKVK

Nectar forager activity of *A. dorsata, T. iridipennis, A. florea* and *A. cerana*were observed from 0600-1900hr, 0700-1400hr, 0800-1800hr and 0800-1900hr, respectively on the flowers of wild *S. cumini* at GKVK (Table 2). The first peak in the nectar foragers of *A. dorsata*(16/5min. /4infl.), *T. iridipennis* (6/5min. /4infl.) and *A. cerana*(7/5min. /4infl.) was observed during 0800-0900hr, whereas in case of nectar foragers of *A. florea*, the first peak was recorded during 1000-1100 hr (6/5min. /4infl.) of the day. The number of all the nectar foragers declined during afternoon hours of the day. The second peak in the nectar foragers of *A. dorsata* (15/5min. /4infl.) and *A. florea* (11/5min. /4infl.) was recorded during 1600-1700hr whereas, in case of nectar foragers of *A. cerana*, the second peak was recorded during1400-1500hr (10/5min. /4infl.) of the day. The mean number of nectar foragers of *A. dorsata*(8.00 ± 4.74/5min. /4infl.) were maximum, followed by *A. cerana* (4.15 ± 3.00/5min. /4infl.), *A. florea* (3.69 ± 3.54/5min. /4infl.) and lowest (2.00 ± 2.08/5min. /4infl.) was recorded in case of *T. iridipennis*.

Pollen forager activity of *A. cerana, A. florea, A. dorsata* and *T. iridipennis*were observed from 0800-1400hr, 0800-1500hr, 0900-1400hr and 0900-1900hr respectively on the flowers of wild *S. cumini* at GKVK (Table 2).The first peak in the pollen foragers of *A. cerana*((21/5min. /4infl.) and *A. florea* (26/5min. /4infl.) was observed during 1100-1200hr,whereas in case of pollen foragers of *A. dorsata*(23/5min. /4infl.) and *T. iridipennis (*19/5min. /4infl.), the first peak was recorded during 1200-1300 hr of the day. The second peak in the pollen foraging activity was observed only in case of *T. iridipennis*(13/5min. /4infl.) during 1600-1700hr of the day. The mean number of pollen foragers of *A. florea* (8.77 ± 9.41/5min. /4infl.) were maximum, followed by *T. iridipennis*(7.38 ± 6.02/5min. /4infl.), *A. dorsata* (7.08 ± 9.22/5min. /4infl.) and lowest (5.92 ± 7.92/5min. /4infl.) was recorded in the pollen foragers of *A. cerana.*

Correlation between the nectar and pollen foraging activity of *Apis* and non -*Apis* species of honeybees on wild *S. cumini*at GKVK with prevailing weather parameters

The number of nectar foragers of *A. dorsata* and *T. iridipennis*on the flowers of wild *S. cumini*at GKVK at hourly intervals had a non- significant negative correlation with hourly temperature (r=-0.29 and -0.39) and a non- significant positive correlation with hourly relative humidity (r=0.27 and 0.46).

A non- significant negative correlation existed between the number of nectar foragers of *A. dorsata*at hourly intervals with hourly wind speed (r= -0.08), whereas, a significant negative correlation existed between the number of nectar foragers of *T. iridipennis*at hourly intervals with hourly wind speed (r=-0.57*) at five per cent level. Similarly, a non-significant positive correlation existed between the number of nectar foragers of *A. florea* and *A. cerana*at hourly intervals with hourly temperature (r=0.37 and 0.50) and non-significant negative correlation with hourly relative humidity (r=-0.36 and -0.47). The number of nectar foragers of *A. florea* at hourly intervals had a non-significant positive correlation with hourly wind speed (r=0.39), whereas, the number of nectar foragers of *A. cerana* at hourly intervals had a significant positive correlation with hourly wind speed (r=0.67*) at five per cent level (Table 2a).

A non-significant positive correlation existed between the number of pollen foragers of *A. dorsata, A. florea* and *A. cerana*at hourly intervals with hourly temperature (r=0.18, 0.21 and 0.17), whereas, they had a non –significant negative correlation with hourly relative humidity (r=-0.13,-0.15 and -0.13) and hourly wind speed (r=-0.18,-0.16 and -0.20).Similarly, a significant positive correlation existed between the numbers of pollen foragers of *T. iridipennis*at hourly intervals with hourly temperature (r=0.60*) at five per cent level (Table 2a), whereas, they had a non-significant positive correlation with hourly wind speed (r=0.25) and a non-significant negative correlation with hourly relative humidity (r=-0.54).

Table 2: Nectar and pollen forager activity of *Apis*and non-*Apis* species of honey bees (no. /5min. /4 inflorescence) on wild *S. cumini*at GKVK, Bengaluru during 100% flowering at different hours of the day (2018)

Time (hr)	Wild *S. cumini* at GKVK							
	Nectar foragers				Pollen foragers			
	A. d	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***
0600-0700	8	0	0	0	0	0	0	0
0700-0800	13	4	0	0	0	0	0	0
0800-0900	16	6	4	7	0	0	9	3
0900.1000	7	5	5	5	15	8	12	9
1000-1100	5	4	6	4	18	12	20	14
1100-1200	4	3	5	3	21	14	26	21
1200-1300	2	2	4	2	23	19	19	19
1300-1400	1	2	0	2	12	9	16	11
1400-1500	6	0	0	10	3	8	12	0
1500-1600	7	0	8	8	0	6	0	0
1600-1700	15	0	11	6	0	13	0	0
1700-1800	12	0	5	4	0	5	0	0
1800-1900	8	0	0	3	0	2	0	0
Mean ± SD	8.00±4.74	2.00±2.08	3.69±3.54	4.15±3.00	7.08±9.22	7.38±6.02	8.77±9.41	5.92±7.92

Apis- species: *A.d-A. dorsata, A.f –A. florea, A.c – A. cerana*: non-*Apis* species*: T.i –T. iridipennis*

Table 2a: Correlation between the nectar and pollen forager activity of *Apis* and non -*Apis* species of honey bees on wild *S. cumini*at GKVK, Bengaluru during 100% flowering at different hours of the day with prevailing weather parameters (2018)

Weather parameter	Wild *S. cumini* at GKVK							
	Nectar foragers				Pollen foragers			
	A. d	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***
Temp(°C)	-0.29 (NS)	-0.39 (NS)	0.37 (NS)	0.50 (NS)	0.18 (NS)	0.60*	0.21 (NS)	0.17 (NS)
R.hum (%)	0.27 (NS)	0.46 (NS)	-0.36 (NS)	-0.47 (NS)	-0.13 (NS)	-0.54 (NS)	-0.15 (NS)	-0.13 (NS)
WS (nautical miles/hr)	-0.08 (NS)	-0.57*	0.39 (NS)	0.67*	-0.18 (NS)	0.25 (NS)	-0.16 (NS)	-0.20 (NS)

Note: * Significant at 5%, NS- Non significant,*Apis*-species: *A.d-A. dorsata, A.f –A. florea,A.c– A. cerana*: non-*Apis* species*: T.i –T. iridipennis*Temp: Temperature, R.hum: Relative humidity, WS: Wind speed.

Nectar and pollen foraging activity of *Apis* and non -*Apis* species of honeybees on cultivated variety, GKVK-1

The nectar forager activity of *A. dorsata, T. iridipennis, A. florea* and *A. cerana*were observed from 0600-1900hr, 0700-1200hr, 0800-1800hr and 0900-1800hr, respectively on the flowers of cultivated variety, GKVK-1 (Table 3). The first peak in the nectar foragers of *A. dorsata* ((24/5min. /4infl.), *T. iridipennis* (8/5min. /4infl.) and *A. florea* (10/5min. /4infl.) was observed during 0800-0900hr, whereas in case of *A. cerana*nectar foragers, the first peak was recorded during 0900-1000 hr (3/5min. /4infl.) of the day. The number of nectar forgers declined during afternoon hours of the day.

The second peak in the nectar foragers of *A. dorsata* (26/5min./4infl.), *A. florea* (10/5min. /4infl.) and *A. cerana*(8/5min. /4infl.) was recorded during 1600-1700hr of the day. The mean number of nectar foragers of *A. dorsata*(13.46 ± 8.74/5min. /4infl.) were maximum, followed by *A.florea*(4.00±4.18/5min. /4infl.), *A. cerana* (2.00 ± 2.61/5min. /4infl.) and lowest (1. 77 ± 2.89/5min. /4infl.) was recorded in case of *T. iridipennis*.

The pollen forager activity of *A. cerana, A. dorsata, A. florea* and *T. Iridipennis*were observed from 0900-1300hr, 0900-1400hr, 0900-1500hr and 0900-1800hr, respectively on the flowers of cultivated variety, GKVK-1 (Table 3). The first peak in the pollen foragers of *A. dorsata*was observed during 0900-1000 hr (21/5min. /4infl.), whereas in case of *A. cerana*(10/5min. /4infl.) and *A. florea* (14/5min. /4infl.) pollen foragers, the first peak was recorded during 1100-1200hr of the day. Similarly, the first peak in the pollen forager activity of *T. iridipennis*was observed during 1000-1100hr (10/5min. /4infl.) and the second peak during 1500-1600hr (12/5min. /4infl.) of the day. The mean number of pollen foragers of *A. dorsata*(5.77±8.24/5min. /4infl.) were maximum, followed by *T. iridipennis*(5.15 ± 4.20/5min. /4infl.), *A. florea* (4.46 ± 5.50/5min. /4infl.) and lowest (2.15 ± 3.72/5min. /4infl.) was recorded in case of *A. cerana*.

Correlation between the nectar and pollen foraging activity of *Apis* and non-*Apis*species of honeybees on cultivated variety, GKVK-1with prevailing weather parameters

A non-significant negative correlation existed between number of nectar foragers of *A. dorsata*on cultivated variety, GKVK-1at hourly intervals with hourly temperature (r=-0.22) and hourly wind speed (r=-0.29), whereas, they had a non-significant positive correlation with hourly relative humidity (r=0.17). The number of nectar foragers of *T. iridipennis*at hourly intervals had a significant negative correlation with hourly temperature (r=-0.63*) at five per cent level and significant positive correlation with hourly relative humidity (r=0.67*) at five per cent level (Table 3a), whereas, they had a non-significant negative correlation with hourly wind speed (r=-0.42).

A non-significant positive correlation existed between number of nectar foragers of *A. florea*and *A.cerana*at hourly intervals with hourly temperature (r=0.04 and 0.35) and hourly wind speed (r=0.15 and 0.39), whereas, they had a non-significant negative correlation with hourly relative humidity (r=-0.05 and -0.38)

The number of pollen foragers of *A. dorsata* and *A. florea* on cultivated variety, GKVK-1at hourly intervals had a non-significant positive correlation with hourly temperature (r=0.23 and 0.51) and hourly wind speed (r=0.47 and 0.49), whereas, they had a non–significant negative correlation with hourly relative humidity (r=-0.18 and -0.45).

A significant positive correlation existed between the number of pollen foragers of *T. iridipennis* at hourly intervals with hourly temperature (r=0.59*) at five per cent level and a significant negative correlation with hourly relative humidity (r=-0.56*) at five per cent level, whereas, they had a highly significant positive correlation with wind speed (r=0.71**) at one per cent level (Table 3a). A non-significant positive correlation existed between the number of pollen foragers of *A. cerana* at hourly intervals with hourly relative humidity (r=0.05) and hourly wind speed (r=0.30), whereas, they had a non – significant negative correlation with hourly temperature (r=-0.03).

Nectar and pollen foraging activity of *Apis* and non -*Apis* species of honeybees on cultivated variety, GKVK-2

The nectar forager activity of *A. dorsata*, *T. iridipennis*, *A. florea* and *A. cerana*were observed from 0600-1900hr, 0700-1300hr, 0800-1800hr and 0900-1800hr, respectively on cultivated variety, GKVK-2 (Table 3). The first peak in the nectar foragers of *A. dorsata*(26/5min. /4infl.) and *T. iridipennis* (11/5min. /4infl.) was observed during 0800-0900hr,whereasin case of *A. florea* nectar foragers, first peak was recorded during 0900-1000hr (11/5min. /4infl.) and for *A. cerana* nectar foragers, it was observed during 1000-1100 hr (4/5min. /4infl.) of the day. The number of all the nectar foragers declined during afternoon hours. The second peak in the nectar foragers of *A. dorsata* (28/5min. /4infl.), *A. florea* (14/5min. /4infl.) and *A. cerana*(10/5min. /4infl.) was recorded during 1600-1700hr. The mean number of nectar foragers of *A. dorsata*(14.69 ± 9.66/5min. /4infl.) were maximum, followed by *A. florea* (4.15 ± 5.24/5min. /4infl.), *A. cerana* (2.38 ± 3.25/5min. /4infl.) and lowest (2.23 ± 3.68/5min. /4infl.) was recorded in case of *T. iridipennis*.

The pollen forager activity of *A. cerana*, *A. dorsata*, *A. florea* and *T. iridipennis*were observed from 0900-1300hr, 0900-1500hr, 0900-1500hr and 0900-1800hr, respectively on cultivated variety, GKVK-2 (Table 3). The first peak in the pollen foragers of *T. iridipennis*(14/5min. /4infl.) and *A. florea (*14/5min. /4infl.) was observed during 1000-1100 hr of the day, whereas, the first peak in the pollen foragers of *A. dorsata* (26/5min. /4infl.) and *A. cerana* (12/5min. /4infl.) was recorded during 0900-1000hr and 1100-1200 hr, respectively. The second peak in the pollen foraging activity was observed only in case of *T. iridipennis* pollen foragers *(*10/5min. /4infl.) during 1600-1700hr of the day. The mean number of pollen foragers of *A. dorsata* (6.85 ± 9.49/5min. /4infl.) were maximum, followed by *T. iridipennis* (5.69 ± 4.96/5min. /4infl.), *A. florea* (4.15 ± 5.50 /5min. /4infl.) and lowest forager number (2.62 ± 3.72/5min. /4infl.) was recorded in case of *A. cerana*.

Correlation between the nectar and pollen foraging activity of *Apis* and non-*Apis* species of honeybees on cultivated variety, GKVK-2with prevailing weather parameters

A non-significant positive correlation existed between the numbers of nectar foragers of *A. dorsata*on cultivated variety, GKVK-2 at hourly intervals with hourly relative humidity (r=0.03) and hourly wind speed (r=0.18), whereas, they had a non-significant negative correlation with hourly temperature (r=-0.09). The number of nectar foragers of *A. florea* and *A. cerana*had a non-significant positive correlation with hourly temperature (r= 0.12 and 0.41) and hourly wind speed (r= 0.11 and 0.39), whereas, they had a non-significant negative correlation with hourly relative humidity (r=-0.13 and -0.44).A non-significant negative correlation existed between the numbers of nectar foragers of *T. iridipennis*with hourly temperature (r=-0.50) and hourly wind speed (r= -0.49), whereas, they had a significant positive correlation with hourly relative humidity ($r=0.57^{*}$) at five per cent level (Table 3a).

A non-significant positive correlation existed between the number of pollen foragers of *A. dorsata*on cultivated variety, GKVK-2 (Table 3a) with hourly temperature (r= 0.01) and hourly relative humidity (r= 0.11), whereas, they had a non-significant negative correlation with hourly wind speed (r=-0.27). Similarly, the numbers of pollen foragers of *T. iridipennis* had a non-significant positive correlation with hourly temperature (r=0.40) and hourly wind speed (r=0.09), whereas, they had a non-significant negative correlation with hourly relative humidity(r=-0.39). A non-significant negative correlation existed between the number of pollen foragers of *A. florea*and *A. cerana* with hourly relative humidity (r= -0.22 and -0.05) and hourly wind speed (r=-0.11 and -0.16), whereas, they had a non-significant positive correlation with hourly temperature (r=0.25 and 0.05).

Table 3: Nectar and pollen forager activity of *Apis* and non-*Apis* species of honey bees (no. /5min. /4 inflorescence) on cultivated varieties of *S. cumini,* GKVK-1 and GKVK-2 at GKVK, Bengaluru during (100% flowering) different hours of the day (2018)

Time (hr)	Cultivated variety, GKVK-1								Cultivated variety, GKVK-2							
	Nectar foragers				Pollen foragers				Nectar foragers				Pollen foragers			
	A. d	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***
0600-0700	14	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0
0700-0800	20	6	0	0	0	0	0	0	21	9	0	0	0	0	0	0
0800-0900	24	8	10	0	0	0	0	0	26	11	8	0	0	0	0	0
0900.1000	7	6	7	3	21	4	5	3	5	4	11	2	26	9	4	6
1000-1100	5	2	6	2	18	10	12	6	4	2	4	4	22	14	14	8
1100-1200	3	1	2	2	17	9	14	10	6	2	2	2	16	12	12	12
1200-1300	2	0	1	1	12	8	11	9	5	1	0	0	13	9	10	8
1300-1400	5	0	0	0	7	6	10	0	4	0	0	0	10	5	8	0
1400-1500	8	0	0	0	0	4	6	0	7	0	0	2	2	4	6	0
1500-1600	18	0	8	4	0	12	0	0	20	0	3	3	0	3	0	0
1600-1700	26	0	10	8	0	8	0	0	28	0	14	10	0	10	0	0
1700-1800	22	0	8	6	0	6	0	0	25	0	12	8	0	8	0	0
1800-1900	21	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0
Mean ± SD	13.46 ± 8.74	1.77 ± 2.89	4.00 ± 4.18	2.00 ± 2.61	5.77 ± 8.24	5.15 ± 4.20	4.46 ± 5.50	2.15 ± 3.72	14.69 ± 9.66	2.23 ± 3.68	4.15 ± 5.24	2.38 ± 3.25	6.85 ± 9.49	5.69 ± 4.96	4.15 ± 5.26	2.62 ± 4.27

Apis-species: *A.d-A. dorsata, A.f –A. florea, A.c – A. cerana*: non-*Apis* species*: T.i –T. iridipennis*

Table 3a: Correlation between the nectar and pollen forager activity of *Apis* and non -*Apis* species of honey bees on cultivated varieties of *S. cumini*, GKVK-1 and GKVK-2at GKVK, Bengaluru during (100% flowering) different hours of the day with prevailing weather parameters (2018)

Weather parameter	Cultivated variety, GKVK-1								Cultivated variety, GKVK-2							
	Nectar foragers				Pollen foragers				Nectar foragers				Pollen foragers			
	A. d	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***
Temp (°C)	-0.22 (NS)	-0.63*	0.04 (NS)	0.35 (NS)	0.23 (NS)	0.59*	0.51 (NS)	-0.03 (NS)	-0.09 (NS)	-0.50 (NS)	0.12 (NS)	0.41 (NS)	0.01 (NS)	0.40 (NS)	0.25 (NS)	0.05 (NS)
R.hum (%)	0.17 (NS)	0.67*	-0.05 (NS)	-0.38 (NS)	-0.18 (NS)	-0.56*	-0.45 (NS)	0.05 (NS)	0.03 (NS)	0.57*	-0.13 (NS)	-0.44 (NS)	0.11 (NS)	-0.39 (NS)	-0.22 (NS)	-0.05 (NS)
WS (nautical miles/hr)	-0.29 (NS)	-0.42 (NS)	0.15 (NS)	0.39 (NS)	0.47 (NS)	0.71**	0.49 (NS)	0.30 (NS)	0.18 (NS)	-0.49 (NS)	0.11 (NS)	0.39 (NS)	-0.27 (NS)	0.09 (NS)	-0.11 (NS)	-0.16 (NS)

Note: ** Significant at 1 %, * Significant at 5%, NS: Non -significant, *Apis*-species: *A.d-A. dorsata, A.f –A. florea, A.c – A. cerana*: non -*Apis* species*: T.i –T. iridipennis*, Temp: Temperature, R.hum: Relative humidity, WS: Wind speed.

Nectar and pollen foraging activity of *Apis* and non -*Apis* species of honeybees on cultivated variety, K-45

The nectar forager activity of *A. dorsata, T. iridipennis, A. florea* and *A. cerana*were observed from 0600-1900hr, 0700-1200hr, 0800-1800hr and 0900-1800hr, respectively on cultivated variety, K-45 (Table 4). The first peak in the nectar foragers of *A. dorsata*(18/5min. /4infl.), *A .florea* (10/5min. /4infl.), *T. iridipennis*(9/5min. /4infl.) and *A. cerana*(5/5min. /4infl.) was observed during 0800-0900hr, 0900-1000hr, 1000-1100hr and1100-1200hr, respectively. The number of all the nectar foragers was declined during afternoon hours. The second peak in the nectar foragers of *A. dorsata* (26/5 min. /4infl.), *A. florea* (10/5min. /4infl.) and *A. cerana*(7/5min. /4infl.) was recorded during 1700-1800hr of the day. The mean number of nectar foragers of *A. dorsata*(9.92 ± 8.23/5min. /4infl.) was maximum, followed by that of *A. florea* (3.77 ± 3.81/5min. /4infl.), *A. cerana* (1.77 ± 2.42/5min. /4infl.) and lowest forager number (1.62 ± 2.79/5min. /4infl.) was recorded in case of nectar foragers of *T. iridipennis*.

The pollen forager activity of *A. cerana, A. florea, A. dorsata*and *T. iridipennis*were observed from 0900-1300hr, 0900-1400hr, 0900-1500hr and 0900-1800hr, respectively on cultivated variety, K-45 (Table 4). The first peak in the pollen forager activity of *A. dorsata* (21/5min. /4infl.), *A. florea* (16/5min. /4infl.) and *A. cerana* (8/5min. /4infl.) was observed during 0900-1000hr,1000-1100hr and 1100-1200hr of the day, respectively.

Similarly, the first peak in pollen forgers of *T. iridipennis*(7/5min. /4infl.) was observed during 1100-1200hr, whereas, its (12/5min. /4infl.) second peak was observed during1700-1800hr. The mean number of pollen foragers of *A. dorsata* (5.46 ± 7.76/5min. /4infl.) were maximum, followed by *A. florea* (3.54 ± 5.59/5min. /4infl.), *T. iridipennis*(3.31 ± 3.68/5min. /4infl.) and lowest number (1.38 ± 2.66/5min. /4infl.) was recorded in case of pollen foragers of *A. cerana*.

Correlation between the nectar and pollen foraging activity of *Apis* and non-*Apis* species of honeybees on cultivated variety, K-45 with prevailing weather parameters

A non-significant negative correlation existed between the numbers of nectar foragers of *A. dorsata*on cultivated variety K-45 (Table 4a) with hourly temperature (r=-0.006) and hourly relative humidity (r=-0.06), whereas, they had a non-significant positive correlation with hourly wind speed (r=0.07).Similarly, the number of nectar foragers of *T. iridipennis* exhibited a non-significant negative correlation with hourly temperature (r=-0.33) and hourly wind speed (r=-0.42), whereas, they had a non-significant positive correlation with hourly relative humidity (r=0.32). The number of nectar foragers of *A. florea* and *A. cerana*had a non-significant positive correlation with hourly temperature (r=0.02 and 0.35) and hourly wind speed (r=0.01 and 0.31), whereas, they had a non-significant negative correlation with hourly relative humidity (r=-0.03 and -0.39).

The number of pollen foragers of *A. dorsata* on cultivated variety K-45 at hourly intervals (Table 4a) exhibited a non-significant negative correlation with hourly temperature (r=-0.11) and hourly wind speed (r=-0.29), whereas, they had a non-significant positive correlation with hourly relative humidity (r=0.22). Similarly, the number of pollen foragers of *T. iridipennis* at hourly intervals had a non-significant positive correlation with hourly temperature (r=0.48) and hourly wind speed (r=-0.24), whereas, they had a non-significant negative correlation with hourly relative humidity (r=-0.49).A non-significant negative correlation existed between the numbers of pollen foragers of *A. florea* and *A. cerana* with hourly relative humidity (r=-0.08 and -0.14) and hourly wind speed (r=-0.23 and -0.06) respectively, whereas, they had a non-significant positive correlation with hourly temperature (r=0.07 and 0.16) respectively.

Nectar and pollen foraging activity of *Apis* and non-*Apis* species of honeybees on cultivated variety, N-20

The nectar forager activity of *A. dorsata, T. iridipennis, A. florea* and *A. cerana*were observed from 0600-1900hr, 0700-1300hr, 0800-1800hr and 0900-1800hr, respectively on cultivated variety, N-20 (Table 4**).** The first peak in the nectar foragers of *A. dorsata* (25/5min. / 4infl.) and *T. iridipennis* (6/5min. /4infl.) was observed during

0800-0900hr, whereas, in case of *A. florea* (12/5min. /4infl.) and *A. cerana*(3/5min. /4infl.) nectar foragers, the first peak was recorded during 0900-1000hr of the day. The number of all the nectar foragers declined during afternoon hours. The second peak in the nectar foragers of *A. dorsata* (23/5 min. /4infl.) and *A. cerana* (10/5min. /4infl.) was recorded during 1600-1700hr,whereas in case of *A. florea* (8/5min. /4infl.), it was during1700-1800hr of the day. The mean number of nectar foragers of *A. dorsata*(11.38±8.52/5min. /4infl.) were maximum, followed by that of *A. florea* (3.23 ± 4.36/5min. /4infl.), *A. cerana* (1.85 ± 3.02/5min. /4infl.) and the lowest (1.77 ± 2.35/5min. /4infl.) was recorded in case of the nectar foragers of *T. iridipennis*.

The pollen foragers of *A. cerana, A. dorsata, A. florea* and *T. iridipennis*were observed from 0900-1300hr, 0900-1400hr, 0900-1500hr and 0900-1800hr, respectively on cultivated variety, N-20 (Table 4). The first peak in the pollen foragers of *T. iridipennis*(10/5min. /4infl.), *A. florea* (15/5min. /4infl.) and *A. cerana* (9/5min. /4infl.) was observed during1100-1200 hr, whereas in case of *A. dorsata*(22/5min. /4infl),the first peak in the pollen foragers was recorded during 1000-1100hrof the day. The second peak in pollen forager activity was observed only with regard to *T. iridipennis* (8/5min./4infl.) during 1500-1600hrof the day. The mean number of pollen foragers of *A. dorsata* (6.54 ± 8.98/5min. /4infl.) were maximum followed by *T. iridipennis*(4.46 ± 3.69/5min. /4infl.), *A. florea* (4.38 ± 5.75/5min. /4infl.) and lowest (1.98±3.38/5min. /4infl.) was recorded in the pollen foragers of *A. cerana*.

Correlation between the pollen and nectar foraging activity of *Apis* and non-*Apis* species of honeybees on cultivated variety, N-20 with prevailing weather parameters

The number of nectar foragers of *A. dorsata*and *A. florea* on cultivated variety, N-20 at hourly intervals exhibited a non-significant negative correlation with hourly temperature (r= -0.28 and -0.17) and a non–significant positive correlation with hourly relative humidity (r=0.25 and 0.17). Similarly, the number of nectar foragers of *A. dorsata*had a non-significant positive correlation with hourly wind speed(r=0.004), whereas the number of nectar foragers of *A. florea* had a non-significant negative correlation with hourly wind speed (r=-0.13). A non-significant positive correlation

existed between numbers of nectar foragers of *A. cerana* with hourly temperature (r=0.32) and hourly wind speed (r=0.28), whereas, they had a non-significant negative correlation with hourly relative humidity (r=-0.34). The number of nectar foragers of *T. iridipennis* exhibited a significant positive correlation with hourly relative humidity(r=0.56*) at five per cent level and a significant negative correlation with hourly wind speed (r=-0.56*) at five per cent level (Table 4a), whereas, they had a non-significant negative correlation with hourly temperature (r=-0.51).

A non-significant negative correlation existed between the numbers of pollen foragers of *A. dorsata, A. florea* and *A. cerana* on cultivated variety, N-20,with hourly relative humidity (r=-0.03, -0.18 and -0.11) and hourly wind speed (r=-0.27, -0.16 and -0.10), whereas, they had a non-significant positive correlation with hourly temperature (r=0.05,0.21 and 0.13).Similarly, the number of pollen foragers of *T. iridipennis* exhibited a significant positive correlation with hourly temperature (r=0.64*) at five per cent level and a significant negative correlation with hourly relative humidity (r=-0.59*) at five per cent level (Table 4a), whereas, they had a non-significant positive correlation with hourly wind speed (r=0.42).

Table 4: Nectar and pollen forager activity of*Apis* and non-*Apis* species of honey bees (no. /5min. /4 inflorescence) on cultivated varieties of *S. cumini,* K-45 and N-20 at GKVK, Bengaluru during (100% flowering) different hours of the day (2018)

Time (hr)	Cultivated variety, K-45								Cultivated variety, N-20							
	Nectar foragers				Pollen foragers				Nectar foragers				Pollen foragers			
	A. d	*T. i*	*A. f*	*A. c*	*A. d*	*T. i*	*A. f*	*A. c*	*A. d*	*T. i*	*A. f*	*A. c*	*A. d*	*T. i*	*A. f*	*A. c*
0600-0700	6	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0
0700-0800	13	2	0	0	0	0	0	0	18	5	0	0	0	0	0	0
0800-0900	18	4	7	0	0	0	0	0	25	6	10	0	0	0	0	0
0900.1000	6	5	10	2	21	1	5	1	9	5	12	3	19	3	6	2
1000-1100	5	9	8	2	19	6	16	3	3	4	7	2	22	8	13	6
1100-1200	4	1	4	5	12	7	14	8	2	2	1	1	19	10	15	9
1200-1300	4	0	3	0	10	5	6	6	2	1	0	0	14	9	12	8
1300-1400	1	0	0	0	8	3	5	0	1	0	0	0	11	6	8	0
1400-1500	2	0	4	0	1	2	0	0	3	0	1	0	0	4	3	0
1500-1600	5	0	2	2	0	1	0	0	15	0	2	2	0	8	0	0
1600-1700	21	0	1	5	0	6	0	0	23	0	1	10	0	6	0	0
1700-1800	26	0	10	7	0	12	0	0	18	0	8	6	0	4	0	0
1800-1900	18	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0
Mean ± SD	9.92 ± 8.23	1.62 ± 2.79	3.77 ± 3.81	1.77 ± 2.42	5.46 ± 7.76	3.31 ± 3.68	3.54 ± 5.59	1.38 ± 2.66	11.38 ± 8.52	1.77 ± 2.35	3.23 ± 4.36	1.85 ± 3.02	6.54 ± 8.98	4.46 ± 3.69	4.38 ± 5.75	1.92 ± 3.38

Apis-species: *A.d-A. dorsata, A.f –A. florea, A.c – A. cerana*: non-*Apis* species*: T.i –T. iridipennis*

Table 4a: Correlation between the nectar and pollen forager activity of *Apis* and non-*Apis* species of honey bees on cultivated varieties of *S. cumini*, K-45 and N-20 at GKVK, Bengaluru during (100% flowering) different hours of the day with prevailing weather parameters (2018)

Weather parameter	Cultivated variety, K-45								Cultivated variety, N-20							
	Nectar foragers				Pollen foragers				Nectar foragers				Pollen foragers			
	A. d	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***	***A. d***	***T. i***	***A. f***	***A. c***
Temp (°C)	-0.006 (NS)	-0.33 (NS)	0.02 (NS)	0.35 (NS)	-0.11 (NS)	0.48 (NS)	0.07 (NS)	0.16 (NS)	-0.28 (NS)	-0.51 (NS)	-0.17 (NS)	0.32 (NS)	0.05 (NS)	0.64*	0.21 (NS)	0.13 (NS)
R.hum (%)	-0.06 (NS)	0.32 (NS)	-0.03 (NS)	-0.39 (NS)	0.22 (NS)	-0.49 (NS)	-0.08 (NS)	-0.14 (NS)	0.25 (NS)	0.56*	0.17 (NS)	-0.34 (NS)	-0.03 (NS)	-0.59*	-0.18 (NS)	-0.11 (NS)
WS (nautical miles/hr)	0.07 (NS)	-0.42 (NS)	0.01 (NS)	0.31 (NS)	-0.29 (NS)	0.24 (NS)	-0.23 (NS)	-0.06 (NS)	0.004 (NS)	-0.56*	-0.13 (NS)	0.28 (NS)	-0.27 (NS)	0.42 (NS)	-0.16 (NS)	-0.10 (NS)

Note: * Significant at 5%, NS- Non- significant,*Apis*-species: *A.d-A. dorsata, A.f –A. florea, A.c – A. cerana*: non-*Apis* species: *T.i –T. iridipennis*, Temp: Temperature, R.hum: Relative humidity, WS: Wind speed.

Overall correlation between nectar and pollen foraging activity of *Apis* and non-*Apis* species of honeybees on wild and cultivated varieties of *S. cumini*

The number of nectar foragers of *A. dorsata*recorded at hourly intervals had a non-significant negative correlation {on wild *S. cumini* at GKVK (r=-0.29), GKVK-1 (r=-0.22), GKVK-2 (r=--0.09) and K-45 (r=-0.006) and N-20 (r=-0.28**)}** with hourly temperature. They had a non-significant positive correlation {on wild *S.cumini* at GKVK(r=0.27), (r=0.17), GKVK-1 (r=0.17), GKVK-2 (r=0.03) and N-20 (r=0.25**)}** and a non-significant negative correlation {on K-45 (r=-0.06)} with hourly relative humidity. Similarly, a non-significant positive correlation{on GKVK-2 (r=0.18), K-45 (r=0.07) and N-20 (r=0.004)} and a non-significant negative correlation **{**on wild *S. cumini* at GKVK (r=-0.08) and GKVK-1 (r=-0.29)}existed between the number of nectar foragers of *A. dorsata* at with hourly wind speed.

A significant negative correlation {on GKVK-1 (r=-0.63*)} at five per cent level and a non-significant negative correlation {on wild *S. cumini* at GKVK(r=-0.39), GKVK-2 (r=-0.50), K-45 (r=-0.33)and N-20 (r=-0.51**)}** existed between the number of nectar foragers of *T. iridipennis* with hourly temperature. They had a significant positive correlation {on GKVK-1 (r=0.67*), GKVK-2 (r=0.57*) and N-20 (r=0.56*)} at five per cent level and a non-significant positive correlation{on wild *S. cumini* at GKVK (r=0.46) and K-45 (r=0.32**)}** with hourly relative humidity. Similarly, the number of nectar foragers of *T. iridipennis* had a significant negative correlation {on wild *S. cumini* at GKVK (r=-0.57* and N-20 (r=-0.56*)} at five per cent level and a non-significant negative correlation {on GKVK-1 (r=-0.42), GKVK-2 (r=-0.49) and K-45 (r=-0.42)} with hourly wind speed. Contrary to the present findings on the correlation of *T. iridipennis* with hourly temperature, Fidalgo and Kleinert (2010) stated that the number of nectar loads carried by stingless bees was positively correlated with air temperature (r = 0.24*).

The number of nectar foragers of *A. florea* at hourly intervals had a non-significant positive correlation {on wild *S. cumini* at GKVK (r=0.37), GKVK-1 (r=0.04), GKVK-2 (r=0.12) and K-45 (r=0.02)} and a non-significant negative correlation {on N-20 (r=-0.17)} with hourly temperature. They had a non-significant negative correlation {on wild *S. cumini* at GKVK (r=-0.36), GKVK-1 (r=-0.05), GKVK-2 (r=-0.13), and K-45 (r=-0.03)} and a non-significant positive correlation {on N-20 (r=0.17)} with hourly relative humidity. Similarly,

the number of nectar foragers of *A. florea* at hourly intervals had a non-significant positive correlation {on wild *S. cumini* at GKVK (r=0.37), GKVK-1 (r=0.15), GKVK-2 (r=0.11) and K-45 (r=0.01)} with hourly wind speed. They had a non-significant negative correlation {on N-20 (r=-0.13) with hourly wind speed. A non-significant positive correlation and a non-significant negative correlation existed between the number of nectar foragers of *A. cerana* with hourly temperature {(r=0.40, 0.50, 0.35, 0.41, 0.35, and 0.32)} and hourly relative humidity {(r=,-0.23, -0.47, -0.38, -0.44, -0.39 and -0.34)} respectively on all wild (*S. cumini* at GKVK) and cultivated varieties of *S. cumini*(on GKVK-1, GKVK-2, K-45 and N-20), whereas, they had a significant positive correlation {on wild *S. cumini* at GKVK ($r=0.67^{*}$)} at five per cent level and a non-significant positive correlation {on GKVK-1 (r=0.39), GKVK-2 (r=0.39), K-45 (r=0.31) and N-20 (r=0.28)} with hourly wind speed. The findings on the correlation of nectar foragers of *A. cerana* with hourly temperature and hourly relative humidity are supported by HaftomGebremedh, *et al*. (2014) stated that the number of bees that collected nectar from *Guizotiaabyssinica* (L.F.) had a positive association with air temperature (r=0.67; P=0.01) and negative relationship with relative humidity (r=-0.59; P=0.001).

The number of pollen foragers of *A. dorsata*exhibited a non-significant positive correlation {on wild *S. cumini* at GKVK (r=0.18), GKVK-1 (r=0.23), GKVK-2 (r=0.01), and N-20 (r=0.05)} and a non-significant negative correlation{on K-45 (r=-0.11)} with hourly temperature. They had a non-significant positive correlation {on GKVK-2 (r=0.11) and K-45 (r=0.22)} and a non-significant negative correlation {on wild *S. cumini* at GKVK (r=-0.13), GKVK-1 (r=-0.18) and N-20 (r=-0.03)} with hourly relative humidity. Similarly a non-significant negative correlation {on wild *S. cumini* at GKVK (r=-0.180), GKVK-2 (r=-0.27), K-45 (r=-0.29) and N-20 (r=-0.27)} and a non-significant positive correlation {GKVK-1(r=0.71)}existed between the number of pollen foragers of *A. dorsata*with hourly wind speed.

A significant positive correlation{on wild *S. cumini* at GKVK ($r=0.60^{*}$), GKVK-1 ($r=0.59^{*}$) and N-20 ($r=0.64^{*}$)} at five per cent level and a non-significant positive correlation {on GKVK-2 (r=0.40) and K-45 (r=0.48) existed between the number of pollen foragers of *T. iridipennis*with hourly temperature. They had a significant negative correlation {on GKVK-1 ($r=-0.56^{*}$) and N-20 ($r=-0.59^{*}$)} at five per cent level and a non-significant negative correlation {on wild *S. cumini* at GKVK (r=-0.54), GKVK-2 (r=-0.39) and K-45 (r=-0.49)}

with hourly relative humidity. Similarly, the number of pollen foragers of *T. iridipennis* at hourly intervals had a highly significant positive correlation {on GKVK-1 ($r=0.71^{**}$)} at one per cent level and had a non-significant positive correlation {on wild *S. cumini* at GKVK (r=0.25), GKVK-2 (r=0.09), K-45 (r=0.24) and N-20 (r=0.42)} with hourly wind speed. Contrary to the findings on the correlation of *T. iridipennis* with hourly temperature and hourly relative humidity in the present study, Fidalgo and Kleinert (2010) had earlier stated that the number of pollen loads carried by stingless bees increased as relative humidity rose (r = 0.40), while high temperatures had negative influence on the number of pollen loads collected (r = -0.23) by *T. iridipennis.*

The number of pollen foragers of *A. florea* at hourly intervals had a non-significant positive correlation and a non-significant negative correlation with hourly temperature {r=0.21. 0.51, 0.25, 0.07, and 0.21)} and hourly relative humidity{(r=-0.11, -0.15, -0.45, -0.22, -0.08 and-0.18), respectively on all wild (*S. cumini* at GKVK) and cultivated varieties of *S. cumini*(GKVK-1, GKVK-2, K-45 and N-20). Similarly, a non-significant negative correlation existed between the number of pollen foragers of *A. florea* with hourly wind speed on all the wild {*S. cumini* at GKVK (r=-0.30)}and cultivated varieties of *S. cumini*{GKVK-2 (r=-0.11), K-45 (r=-0.23) and N-20 (r=-0.16)}, with the exception of a non-significant positive correlation with hourly wind speed on GKVK-1 (r=0.49).

A non-significant positive correlation {on wild *S. cumini* at GKVK (r=0.17), GKVK-2 (r=0.05), K-45 (r=0.16) and N-20 (r=0.13)} and a non-significant negative correlation {on GKVK-1 (r=-0.03)}existed between the number of pollen foragers of *A. cerana*with hourly temperature. They had a non-significant negative correlation with hourly relative humidity{(r=-0.09, -0.13, -0.05,-0.14 and -0.11)} and hourly wind speed{(r=-0.28, -0.20, -0.16, -0.06 and -0.10)} on all wild (*S. cumini* at GKVK) and cultivated varieties of *S. cumini*(GKVK-2, K-45 and N-20), with the exception of a non-significant positive correlation with hourly relative humidity (r=0.05) and hourly wind speed (r=0.30) on GKVK-1. The findings of correlation of *A. florea* pollen foragers on GKVK-1 with hourly temperature and correlation of hourly relative humidity on GKVK-1 are supported by the earlier reports of HaftomGebremedh, *et al*. (2014) who stated that the number of bees that collected pollen from *Guizotiaabyssinica* (L.F.) had negative association with air temperature (r =-0.72; P=0.001) and positive correlation with relative humidity (r=0.62; P=0.001)

4. CONCLUSION

The nectar forager activity of *A. dorsata, A. florea* and *A. cerana* was observed on wild and cultivated varieties of *S. cumini* whichhad two peaks, first peak during 0800-1200hr and second peak during 1400-1800hr, with the exception of *T. iridipennis,*which had one peak during 0800-0900hr.The pollen forager activity of *A. dorsata, A. florea* and *A. cerana*had one peakduring 0900-1200/1300hr, with the exception of *T. iridipennis*, which had two peaks during 1000-1200hr and 1500-1800hr. The prevailing hourly temperature and wind speed affected the nectar foragers whereas relative humidity favours the nectar foragers of *T. iridipennis*atfive per cent level of significance. The nectar foragers of *A. cerana*had a significant positive correlation on wild *S. cumini* at GKVK at five per cent level of significance with hourly wind speed.The prevailing wind speed and temperature favours the pollen foraging activity and the relative humidity affected the pollen foraging activity of *T. iridipennis* on wild and cultivated varieties of *S. cumini*at one andfive per cent level of significance. The prevailing relative humidity and wind speed greatly affected the foraging activity of *T. iridipennis*compare to *A. cerana, A. dorsata* and *A. florea*.

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