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DIVERSITY AND ABUNDANCE OF POLLINATORS ON CARROT AND RADISH AT DHARWAD, KARNATAKA (INDIA) POLLINATOR FAUNA OF CARROT AND RADISH

Chava Asritha[1]*, D.N. Kambrekar[2], Subhash B. Kandakoor[3], S.M. Hiremath[4] and N.M. Ramesha[1]

[1]Department of Entomology, College of Agriculture, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
[2]ICAR-KVK, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
[3]ARS, Bailhongal, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
[4]Department of Horticulture, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
*Corresponding author E-mail : chavaasritha@gmail.com
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ABSTRACT

Species diversity and abundance of pollinators of carrot and radish were studied at University of Agricultural Sciences, Dharwad, Karnataka during 2021-2022. 5 species from 3 families and 2 orders make up the pollinator fauna of carrot. Among the 2 orders of insect pollinators, Hymenopterans were the most predominant (99.37%), followed by Diptera (0.3%). Among the order Hymenoptera, the family Apidae accounted for 2 species of honeybees and 2 species belonging to Halictidae. *Apis florea* was the major pollinator visiting carrot blooms. The maximum mean number of visitors/ m^2/ 5 min. was recorded at 1300-1400 h. While the lowest activity of *A. florea* was recorded at 0800-0900 h irrespective of the flowering period. In case of radish crop the pollinators belonging to the order Hymenoptera were more abundant with species *viz*., *A. florea*, *A. cerana indica*, *A. dorsata*, *Tetragonula* sp. and *Xylocopa* sp., while syrphid fly (*Ischidon scutellaris*) and *Danaus chrysippus* were also seen in low percentage. *A. florea* has the highest mean foraging rate and mean maximum foraging rate of all the pollinating species was observed during 1000-1100 h period of the day.

Key words : Carrot, Diversity, Foraging activity, Radish, Pollinators.

Introduction

Access to sufficient high-quality seeds is crucial for a successful vegetable industry. To produce such seeds, it is vital to have adequate cross-pollination of vegetable crops. Additionally, many vegetable crops cannot pollinate themselves as they are either completely or partially incompatible. This makes cross-pollination extremely important. In return, vegetable flowers provide bees with excellent sources of pollen and nectar (Atwal, 2000; Abrol, 2010). Insect pollination is responsible for 90% of animal pollination as stated by Buchmann and Nabhan in 1996. Carrot (*Daucus carota* L.) is an important vegetable crop from the Umbelliferae family, commonly cultivated in temperate regions in the spring-summer and autumn-winter, and in tropical and sub-tropical areas during the winter. Carrots are widely consumed as a fresh salad or cooked vegetable. The carrot plant is biennial, growing vegetatively in the first season and producing seed in the second. Carrot flowers are typically protandrous, leading to a limited occurrence of self-pollination. Consequently, insect pollinators are crucial for seed production (Free, 1993). Radish (*Raphanus sativus* L.) serves as an important root vegetable crop, utilized both in salads and as a cooked vegetable. Its nutritional and medicinal value is significant. The majority of commercially grown radish cultivars are self-incompatible (Crane and Marther, 1943). Four sepals and four petals make up the bisexual/hermaphrodite radish

flower. Because of the self-incompatibility of the sporophytic system, radish is a cross-pollinated vegetable crop and is highly entomophilous. The impact of insect pollination on seed yield has been documented by Prasad *et al*. (1989), Singh and Chamotre (1992), Verma and Phogat (1994), Kapila *et al*. (2002) and Sharma *et al*. (2010).

Materials and Methods

An experiment was conducted in the biodiversity park, University of Agricultural Sciences, Dharwad (15°26' North latitude, 75°07' East longitudes and at an altitude of 678 meters above mean sea level) during, *rabi* 2021-22. The experimental area is located in the Northern transitional zone (zone VIII) of Karnataka, which receives 700-800 mm average annual rainfall. The temperature and relative humidity range from 12-37 °C and 40 to 85 per cent, respectively.

The two root vegetables *i.e.* carrot and radish were studied for their pollinator diversity and abundance. Locally available varieties of the crops were grown for the study. The experimental plots of 3m x 3m were raised for both crops as per the package of practices except for the plant protection measures during the flowering period.

Observations : Visual count was done randomly in both the crops which were grown under open pollination conditions by selecting five spots of one square meter area for 5 min. Observations were recorded during time intervals of 0800-0900 h, 1000-1100 h, 1300-1400 h and 1600-1700 h at different flowering stages throughout the crop flowering period. During the period of observation, Samples collected were placed in a killing jar having ethyl acetate as the killing agent, pinned, preserved and identified by the taxonomical expert of the Division of Entomology, Dr. Yeshwanth, GKVK, Bangalore.

Relative abundance of insect pollinators

Relative abundance of pollinators was calculated by using the formula given below to know the dominance of species in carrot and radish ecosystems.

$$\text{Relative abundance} = \frac{\text{Abundance of the species}}{\text{Total abundance of all species}} \times 100$$

Data collected on species was used to calculate the Simpson index of diversity (1- D) and Shannon-Weiner diversity index (H) using the following procedures.

a. Shannon-Wiener diversity index (H)

The Shannon-Wiener diversity index is calculated by using the following equation:

$$\mathbf{H = -\Sigma\ pi\ ln\ pi}$$

Where,

pi = Proportion of the ith species of pollinator

ln = Natural log with base e=2.718

b. Simpson index of diversity (1-D)

$D = 1-\Sigma pi$

Results and Discussion

Diversity of insect anthophiles was observed in the present study on the carrot (Plate 1), where 5 species belonging to 3 families and 2 orders were listed in Table 1. Of the anthophiles, the order Hymenoptera was most dominant on the blooms of carrot which belong to two families namely Apidae and Halictidae. All anthophiles of the order Diptera belong to family Syrphidae (Fig. 1). Of all the anthophile honeybee species, *Apis florea* was a frequent visitor whereas *Tetragonula* sp. and *Lasioglosum* sp. were infrequent visitors (Fig. 2).

The foraging behaviour of major pollinators (*A. florea*, *Lasioglosum* sp. and others) visiting the carrot crop at 50, 75 and 90 per cent blooming at different time intervals with mean activities is presented in Table 2. The minimum mean activity (No. of visitors/m^2 /5min) of

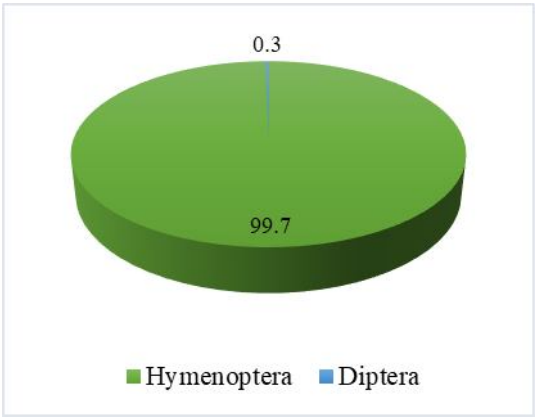


Fig. 1 : Relative abundance of pollinators on Carrot during different stages of flowering.

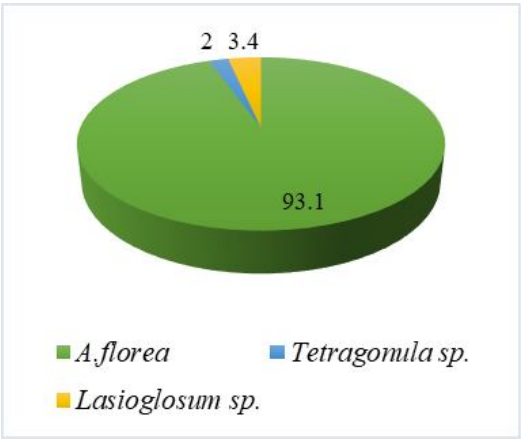


Fig. 2 : Species abundance of Hymenopteran pollinators on Carrot during different stages of flowering.

1a. ***Apis florea*** **1b.** ***Sphaerophoria macrogaster*** **1c.** ***Halictus*** **sp.**

Plate 1 : Pollinator recorded on carrot.

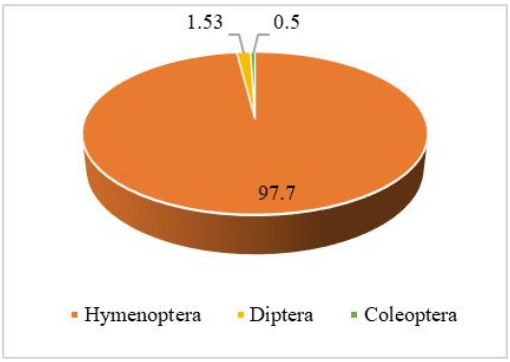


Fig. 3 : Relative abundance of pollinators on Radish during different stages of flowering.

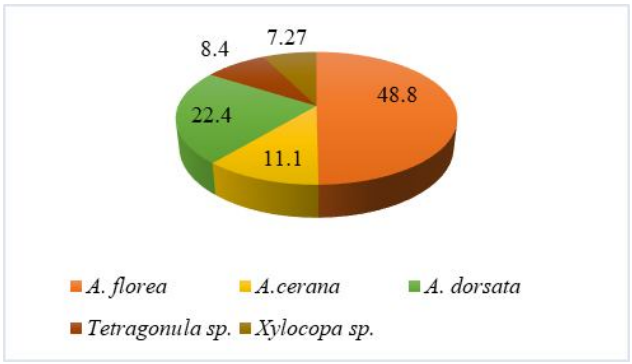


Fig. 4 : Species abundance of Hymenopteran pollinators on Radish during different stages of flowering.

Table 1 : Relative abundance of insect pollinator fauna of Carrot.

S. no.	Common name	Scientific name	Family	Order	Species abundance (%)	Relative abundance % (Order)
1	*A. florea*	*A. florea*	Apidae	Hymenoptera	93.1	99.7
2	*Tetragonula* sp.	*Tetragonula* sp.			2.0	
3	Halictid bee	*Lasioglosum* sp.	Halictidae		3.4	
4	Sweat bee	*Halictus sp.*			1.2	
5	Syrphid	*Sphaerophoria macrogaster*	Syrphidae	Diptera	0.3	0.3

pollinators was noticed during 0800-0900 h irrespective of the blooming period. A gradual peak was observed during 1600- 1700 h compared to morning hours. The maximum mean number of visitors/ m^2/ 5 min was recorded at 1300-1400 h followed by 1000-1100 h. Among the pollinators studied, *A. florea* constitutes maximum activity on carrot blooms with a mean number of visitors/ m^2/ 5 min of 22.1, 26.65 and 31.4 at 50, 75 and 90 per cent of flowering sequentially. Regardless of the per cent flowering, the activity of *A. florea* peaked during 1300-1400 h. Similarly, a second peak in number of visitors/ m^2/ 5 min was observed at 1000-1100 h. The low activity of *A. florea* was recorded at 0800-0900 h followed by 1600-1700 h irrespective of the flowering period. Overall, a total mean number of visitors/ m^2/ 5 min of 32.33 at 50, 37.06 at 75 and 45.46 at 90 per cent flowering were recorded on carrot blooms. Throughout the day, the activity (No. of visitors/m^2 /5min) of *Lasioglosum* sp. (1.35, 1.6 and 1.9 at 50, 75 and 90 per cent flowering in order) and other pollinators (0.8 at 50%, 0.55 at 75% and 0.8 at 90% flowering) were significantly less in comparison with *A. florea*.

The pollinator fauna and their abundance of carrot is well studied. Singh (2014) reported *A. florea* has the highest mean population at different flowering stages and it was the most frequent insect pollinator on carrot

Table 2 : Diurnal variation in activity of pollinators during different stages of flowering in Carrot.

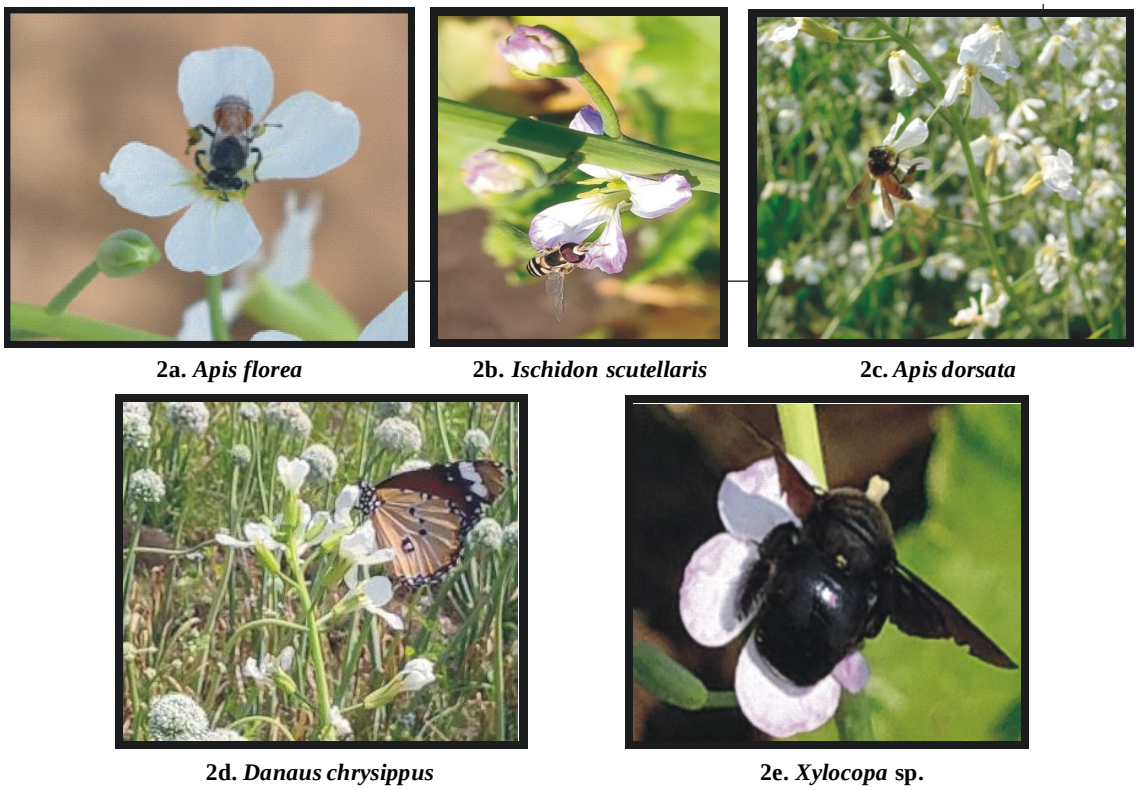
Species	50 % flowering					
	Number of visitors/m²/5 minutes					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	12.8	26.8	30.2	18.6	88.4	22.10±7.88
Lasioglosum sp.	00.4	01.8	02.0	01.2	05.4	01.35±0.72
Others	00.0	01.0	00.8	00.2	03.2	00.80±0.48
Total	13.2	29.6	31.6	20.0	97.0	24.25±8.58
Mean	04.60	09.86	10.53	6.66	32.33	08.08±2.78
75 % flowering						
Species	Number of visitors/m²/5 minutes					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	16.4	28.8	34.8	22.6	102.6	25.65±7.93
Lasioglosum sp.	0.6	2.0	2.2	1.6	6.4	1.6±0.71
Others	0.2	1.2	0.8	0.0	2.2	0.55±0.55
Total	17.2	32	37.8	24.2	111.2	27.8±8.99
Mean	5.73	10.66	12.6	8.06	37.06	9.26±3.00
90 % flowering						
Species	Number of visitors/m²/5 minutes					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	19.8	35.2	43.8	26.8	125.6	31.4±10.39
Lasioglosum sp.	01.8	02.4	02.6	00.8	07.6	01.9±0.81
Others	00.4	01.6	00.8	00.4	30.2	00.8±0.56
Total	22.0	39.2	47.2	28.0	136.4	31.1±11.27
Mean	7.33	13.06	15.73	9.33	45.46	11.36±3.76

Table 3 : Relative abundance of insect pollinator fauna of Radish.

S. no.	Common name	Scientific name	Family	Order	Species abundance (%)	Relative abundance % (Order)
1	Little bee	*A. florea*	Apidae	Hymenoptera	48.8	97.97
2	Indian bee	*A. cerana indica*			11.1	
3	Rock bee	*A. dorsata*			22.4	
4	Stingless bee	*Tetragonula* sp.			8.4	
5	Bumble bee	*Xylocopa sp.*			7.27	
6	Common hoverfly	*Ischidon scutellaris*	Syrphidae	Diptera	1.53	1.53
7	Plain tiger butterfly	*Danaus chrysippus*	Nymphalidae	Lepidoptera	0.5	0.5

blooms. *A. florea* was the most dominant visitor of carrot blossom (Sharma and Singh, 1999). According to Ahmad and Aslam (2002), Hymenoptera and Diptera accounted for the majority of insect pollinators on carrot. A study conducted by Grant (1949) revealed that insect pollinators belonging to order Hymenoptera and Diptera were major pollinators on carrot. It was confirmed that Hymenoptera and Diptera constituted bulk of visitors to umbels of wild and cultivated forms of carrot and fennel as studied by Sihag (1985).

The relative abundance of the order Hymenoptera was highest with 97.97 per cent (Fig. 3). Of the



2a. ***Apis florea*** **2b.** ***Ischidon scutellaris*** **2c.** ***Apis dorsata***

2d. ***Danaus chrysippus*** **2e.** ***Xylocopa*** **sp.**

Plate 2 : Pollinators recorded on Radish.

hymenopterans, the species abundance of *A. florea* was highest, followed by *A. cerana indica*, *A. dorsata*, *Tetragonula* sp. and *Xylocopa* sp (Fig. 4). While syrphid fly (*Ischidon scutellaris*) of order Diptera and *Danus chrysippus* of order Lepidoptera were recorded in very low percentage on radish (Table 3; Plate 2).

Data on the foraging rate of different honeybee species on radish flowers is presented in Table 4. The mean highest foraging rate was observed for *A. florea* followed by *A. dorsata*, *A. cerana*, *Tetragonula* sp. and *Xylocopa* sp. The mean maximum foraging rate of all the pollinating species was observed during 1000-1100 h followed by 1300-1400 h. Meanwhile, the minimum foraging rate was during 0800-0900 h. Similarly, the activity of *A. florea* was also at its peak during 1000-1100 h.

The present results are in agreement with the earlier works. According to Radechenko (1966), honeybees constitute approximately 77 to 99 per cent of all insect visitors and serve as principal pollinators of radish flowers. It was discovered that *A. florea* was the predominant visitor. In addition, Sihag (1986) and Priti *et al*. (2001) noted that Hymenopterans and Dipterans were the most frequent visitors to radish flowers. According to Muhammad *et al*. (1973), 77 to 94 per cent of the pollinators on radish comprised of honeybees. Apoidea was responsible for the majority of insect visitation to radish blooms (73.82%), making them the most prevalent insect group Verma and Poghat (1994). *A. cerana* foraged on radish flowers between 1100 and 1400 h. (Pratap and Verma, 1994).

The Shannon-Wiener index and Simpson index of diversity were utilized to calculate the diversity indices for both the radish and carrot crops (Table 5). Upon analyzing and comparing the indices for the two crops, it became apparent that the radish crop harbours a more varied and extensive pollinating fauna compared to the carrot crop. Furthermore, it was observed that the diversity within each crop fluctuates with the stage of flowering, but only to a minimal degree.

The Shannon Weiner index (H) describes the diversity of a species in a given community. It raises with number of species and the evenness of their abundance. The higher the index, the more diverse the species are in the habitat. If the index is equal to 0, only one species is present in the community (No diversity). The Simpson index of diversity (1-D) is also a simple measure that can be used to measure diversity. The value of 1-D ranges from 0-1, where with an increase in index value diversity increases.

Table 4 : Diurnal variation in the activity of pollinators during different stages of flowering in radish.

	Initiation of Flowering					
Species	**Number of visitors/m² /5 minutes**					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	5.4	11.0	10.6	6.8	33.8	8.45±2.77
A. cerana indica	1.6	2.2	2.0	1.8	7.6	1.9±0.26
A. dorsata	2.2	4.8	4.4	3.0	14.4	3.6±1.211
Tetragonula sp.	1.0	2.2	2.0	1.2	6.4	1.6±0.58
Xylocopa sp.	0.6	2.2	2.0	0.8	5.6	1.4±0.82
Total	10.8	22.4	21	13.6	67.8	16.95±5.63
Mean	2.16	4.48	4.2	2.72	13.56	3.39±1.13
Peak Flowering						
Species	**Number of visitors/m² /5 minutes**					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	7.4	12.8	11.0	8.8	40	10±2.38
A. cerana indica	2.4	5.2	4.6	2.8	15	3.75±1.36
A. dorsata	3.2	7.0	6.4	3.8	20.4	5.1±1.88
T. iridipennis	1.4	3.2	2.8	1.8	9.2	2.3±0.84
Xylocopa sp.	0.6	3.0	2.6	1.4	7.6	1.9±1.10
Total	15	31.2	27.4	18.6	92.2	23.05±7.53
Mean	3.0	6.24	5.48	3.72	18.44	4.61±1.51
Cessation of Flowering						
Species	**Number of visitors/m² /5 minutes**					
	08.00-09.00 h	**10.00-11.00 h**	**13.00-14.00 h**	**16.00-17.00 h**	**Total**	**Mean**
A. florea	4.2	9.4	9.0	6.2	28.8	7.2±2.45
A. cerana indica	1.2	2.0	1.8	1.4	6.4	1.6±0.36
A. dorsata	2.0	4.4	4.0	2.8	13.2	3.3±1.10
T. iridipennis	0.8	2.0	1.4	1.0	5.2	1.3±0.53
Xylocopa sp.	0.2	2.0	1.6	0.4	4.2	1.05±0.88
Total	8.4	19.8	17.8	11.8	57.8	14.45±5.27
Mean	1.68	3.96	3.56	2.36	11.56	2.89±1.05

Table 5 : Diversity indices of pollinators at different flowering stages in carrot and radish.

Crop	**Diversity Indices**	**Stages of flowering**		
		Initiation	**Peak**	**Cessation**
Radish	Shannon-Wiener index (H)	**1.42**	**1.50**	**1.38**
	Simpson index of diversity (1-D)	**0.69**	**0.73**	**0.68**
		50 %	75 %	90 %
Carrot	Shannon-Wiener index (H)	**0.36**	**0.40**	**0.39**
	Simpson index of diversity (1-D)	**0.15**	**0.17**	**0.16**

Conclusion

The radish flowers attract a wider variety of pollinators than the carrot flowers. However, in both carrot and radish plants, the *A. florea* species is the most common pollinator. It is important to protect this species by considering conservative agricultural practices to improve seed yield. Having information about the types of pollinators and their peak activity times will help in conserving them naturally or rearing them artificially and in scheduling crop protection measures.

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