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Major groups of pollinators in moringa ecosystem in Thoothukudi, Tamilnadu

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Abstract

Moringa is one of the major vegetable crop which rely primarily on insect pollination. The present investigations were performed at Kayamozhi, Thoothukudi, Tamil Nadu, India to know the proportion of different insect pollinators covering different insect groups. The results showed that in the study location the major pollinators fall under four major categories namely, *Apis* Hymenopterans, Non-*Apis* Hymenopterans, Dipterans and Lepidopterans. Amongst the observed pollinators, the members of *Apis* Hymenopterans were the most abundant in the moringa ecosystem followed by Lepidopterans. Dipteran pollinators were the least abundant. However, all the pollinator groups were even in all the hours of the day and the diversity was maximum at 1400-1500 hours and the lowest diversity was recorded 1000-1100 hours.

Keywords: *Apis mellifera*, pollination, moringa, diversity

Introduction

Pollination is the process of transferring of pollen to the stigma and is estimated to be associated with 60-90 percent of flowering plants (Buchmann and Nabhan, 1996) [3]. Insect pollination has indeed been identified as a critical element in increasing agricultural output. Honey bees set an excellent example of pollinating insects since they may be used in big quantities whenever and wherever they are needed. Honey bees are responsible for around 90% of pollination in diverse cross pollinated plants (Deodikar and Suryanarayana, 1977) [5]. Pollinators are compulsory to contribute for 15-30 per cent of the food supply of this globe (Greenleaf and Kremen, 2006) [8].

Moringa oleifera Lam (Moringaceae) is a highly coveted plant found in many tropical and subtropical areas and has a wide range of medical applications and is abundant in nutrients (Anwar *et al.*, 2007; Fuglie, 2005) [1, 7]. It is a multifunctional crop that is perennial (Chowdhury *et al.*, 2020; Rashid *et al.*, 2008) [4, 12]. Moringa oleifera, sometimes known as the "horseradish tree" or "drumstick tree," is a plant with its origin to northern India's sub-Himalayan region; it has been used as a traditional culinary item in India for approximately 5000 years (Chowdhury *et al.*, 2020) [4]; is currently a prominent vegetable in the regions of South India. Andhra Pradesh has the most area and production of Moringa in India, followed by Karnataka and Tamil Nadu (Pandey *et al.*, 2011) [11]. It is grown in Dindigul, Thoothukudi, Karur, and Erode districts of Tamil Nadu. Since it is a highly cross pollinated and entomophilous crop (Sharma, 2019) [14], it provides food source for a variety of pollinators and flower visitors from diverse groups of insect orders as this crop blooms for around six months each year. A variety of insect pollinators were observed as major pollinators in the moringa orchard by different researchers which includes *Apis cerana indica* F. (Sowmiya *et al.*, 2018) [16], *A. florea* (Bhatnagar *et al.*, 2018) [2], *Xylocopa latipes* and *X. pubescens* (Suneetha and Raju, 2019) [17], *A. dorsata* and *A. mellifera* (Sharma, 2019) [14]. Some birds (*Mellisuga* sp. and sunbirds) were also found pollinating moringa flowers (Jyothi *et al.*, 1990; Krieg *et al.*, 2017; Sharma, 2019) [9, 10, 14].

Materials and Methods

Pollinator diversity on moringa inflorescence was surveyed and monitored in Kayamozhi (8° 30' 32" N and 78° 2' 43" E), Thoothukudi district, where moringa is widely cultivated. During peak blooming in July 2021, five trees in the moringa orchard were chosen at random and marked. Five inflorescences were chosen at random from each tree to examine the pollinator diversity (FAO, 2008) [6]. In all of the five trees, natural pollinator visitation per five inflorescences every 5 minutes was recorded, and the final data was represented as pollinator

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count/ 25 inflorescences/5 minutes. From 6 a.m. to 6 p.m., this data was recorded every hour and recorded for ten days, with each day's data acting as a replication, for a total of ten replications.

Diversity indices

(a) Shannon's diversity index (H)

The proportion of species *i* relative to the total number of species (*pi*) was calculated and was summed across species and multiplied by -1 (Shannon and Weaver, 1963) [13].

$$H = - \sum_{i=0}^S pi \ln pi$$

The total number of species in the community was recorded, which is known as species richness (S). Shannon's equality (E_H) is determined by dividing H by H_{max} (here $H_{max} = \ln S$), with a value between 0 and 1 where 1 indicates complete evenness.

$$EH = \frac{H}{H_{max}} = \frac{H}{\ln(S)}$$

(b) Simpson's diversity index (D)

The proportion of species *I* relative to the number of species (*pi*) was calculated and squared. The squared proportions for all the species were summed and the reciprocal was taken (Simpson, 1949) [15].

$$D = \frac{1}{\sum_{i=1}^S pi^2}$$

Equitability (ED) was calculated by taking Simpson's index (D) and it as a proportion of maximum value D could assume if individuals in the community were completely evenly distributed (D_{max}) which equals S.

$$ED = \frac{D}{D_{max}}$$

Results and Discussion

The Moringa orchard in Kayamozhi (8° 30' 32" N and 78° 2' 43" E), Thoothukudi district was flourished with a total of nineteen insect pollinator species during July 2021, which were recognized by the taxonomist at the Biosystematics unit of Department of Agricultural Entomology, TNAU, Coimbatore.

The observations on the pollinator species in the moringa orchard revealed that there were nineteen pollinator species prevailing in the location which included *Apis cerana indica*, *A. mellifera*, *A. florea*, *A. dorsata*, *Xylocopa* sp., *Hylaeus* sp., *Sphecodes* sp., *Vespa orientalis*, *Episyrrus* sp., *Sarcophaga* sp., *Lucilia papuensis*, *Musca domestica*, *Papilio polytes*, *Catopsilia pyranthe*, *Euploea core*, *Junonia lemonias*, *Danaus chrysippus*, *Pelopidas sinensis* and *Suastus gremius*. These pollinator species were considered as four groups namely, *Apis* Hymenopterans, Non-*Apis* Hymenopterans, Dipterans, and Lepidopterans.

Among the observed pollinator groups, *Apis* Hymenopterans stood superior over other groups depicting their highest abundance (6.57/25 inflorescence/5 min), also it was statistically significant from other pollinator groups. This was followed by Lepidopteran pollinators with a mean pollinator population of 1.48 insects/25 inflorescence/5 min and by Non-*Apis* Hymenopterans (1.13/25 inflorescence/5 min). The Dipteran pollinators recorded the least pollinator abundance (0.92/25 inflorescence/5 min). However, both Non-*Apis* Hymenopterans and Dipterans showed no statistical difference between them indicating they were less abundant and equal in distribution. The mean population of the insect pollinators peaked between 0900-1000 hours of the day (4.93) and the lowest was recorded in 0600-0700 hours (0.55) (Table 1, Fig.1).

Table 1: Population of major pollinator groups at different times of the day (Kayamozhi, Thoothukudi district, July, 2021)

S. No.	Species/ Time of day	Pollinator population in 25 inflorescence / 5 min*											Mean	
		0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700		1700-1800
T1	<i>Apis</i> Hymenopterans	1.30 (1.28)	3.40 (1.88)	11.00 (3.34)	13.40 (3.71)	12.80 (3.63)	7.90 (2.87)	2.90 (1.73)	2.20 (1.57)	2.20 (1.58)	5.60 (2.42)	8.10 (2.82)	8.00 (2.87)	6.57 (2.48) ^a
T2	Non <i>Apis</i> Hymenopterans	0.30 (0.86)	0.20 (0.81)	0.70 (1.02)	1.60 (1.38)	1.60 (1.31)	2.10 (1.58)	1.70 (1.42)	1.00 (1.15)	1.50 (1.35)	1.30 (1.22)	0.80 (1.05)	0.80 (1.12)	1.13 (1.19) ^c
T3	Dipterans	0.10 (0.76)	1.50 (1.38)	1.30 (1.25)	1.50 (1.38)	0.80 (1.11)	0.80 (1.11)	0.60 (0.96)	0.70 (1.05)	0.80 (1.09)	1.10 (1.23)	1.00 (1.19)	0.80 (1.11)	0.92 (1.13) ^c
T4	Lepidopterans	0.50 (0.95)	0.50 (0.95)	2.10 (1.45)	3.20 (1.78)	2.60 (1.63)	2.10 (1.52)	1.60 (1.36)	1.10 (1.21)	0.90 (1.12)	1.30 (1.25)	1.60 (1.36)	0.20 (0.81)	1.48 (1.28) ^b
	Mean	0.55 (1.02) ^F	1.40 (1.31) ^E	3.78 (1.99) ^{BC}	4.93 (2.14) ^A	4.45 (2.08) ^{AB}	3.23 (2.05) ^{AB}	1.70 (2.00) ^{AB}	1.25 (1.91) ^C	1.35 (1.83) ^C	2.33 (1.76) ^D	2.88 (1.78) ^D	2.45 (1.72) ^D	
		Insect Species					0.068							
		Hours					0.118							
		I * H					0.235							

*Mean of ten days observations, figures in parentheses are square root transformed values; in a column, means followed by common lower case alphabet (s) are not significantly different (p= 0.05). In a row, means followed by a common upper case / alphabet are not significantly different (p=0.05).

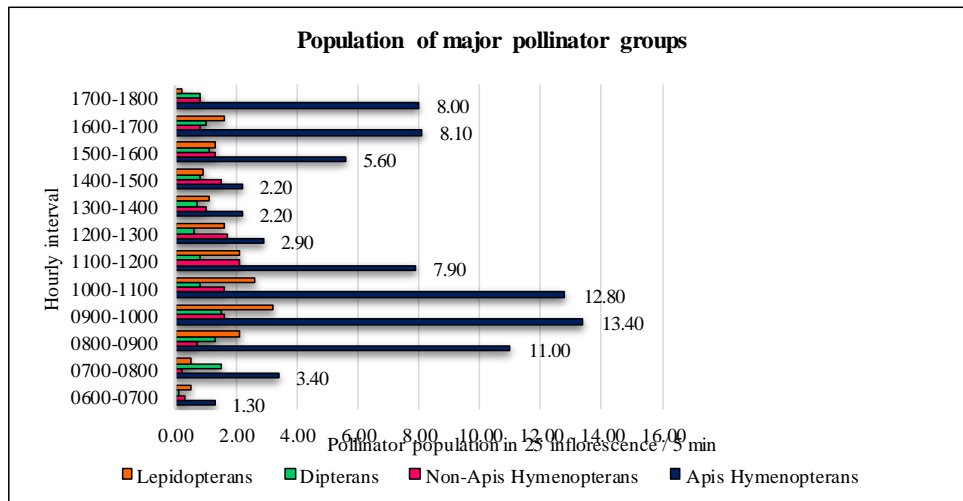


Fig 1: Population of major pollinator groups

Table 2: Diversity of pollinator groups at different time of the day (Kayamozhi, Thoothukudi on July, 2021)

Species/Time of day	Pollinator population in 25 inflorescences / 5 min*											
	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300	1300-1400	1400-1500	1500-1600	1600-1700	1700-1800
Apis Hymenopterans	1.30	3.40	11.00	13.40	12.80	7.90	2.90	2.20	2.20	5.60	8.10	8.00
Non Apis Hymenopterans	0.30	0.20	0.70	1.60	1.60	2.10	1.70	1.00	1.50	1.30	0.80	0.80
Dipterans	0.10	1.50	1.30	1.50	0.80	0.80	0.60	0.70	0.80	1.10	1.00	0.80
Lepidopterans	0.50	0.50	2.10	3.20	2.60	2.10	1.60	1.10	0.90	1.30	1.60	0.20
Diversity indices												
Species richness (S)	4	4	4	4	4	4	4	4	4	4	4	4
Simpson's D	1.80	2.71	1.64	1.74	1.53	1.98	2.80	3.10	3.36	2.33	1.74	1.64
Simpson's E	0.45	0.68	0.41	0.43	0.38	0.49	0.70	0.78	0.84	0.58	0.44	0.41
Shannon's H	0.85	1.12	0.79	0.85	0.71	0.94	1.18	1.26	1.29	1.09	0.85	0.79
Shannon's E	0.62	0.81	0.57	0.61	0.51	0.68	0.85	0.91	0.93	0.78	0.61	0.57

*Mean of ten observations

The species richness was equal (4) in all the hours of a day, specifying that all pollinator groups were present in different times of the day irrespective of the abundance of individual pollinator species. The diversity index Simpson's D illustrated that, more diverse number of insect pollinator species with Simpson's D value 3.36 observed in between 1400 hours to 1500 hours, followed by 3.10 at 1300-1400 hours. At the same time, the Shannon's H showed 1.29 and 1.26 at 1400-1500 hours and 1300-1400 hours. The lowest diverse group of insect pollinators were observed during 1000-1100 hours. The present investigation revealed that *Apis* hymenopterans accessed the moringa inflorescence. The findings are consistent with those of Krieg *et al.*, (2017) and Sowmiya *et al.*, (2018) [10, 16]. Honey bees are the primary pollinators in moringa fields, which is consistent with results of Sharma (2019) [14] that honey bees are the primary pollinators in moringa, which includes *A. dorsata*, *A. mellifera*, and *A. cerana*. In addition, Krieg *et al.*, (2017) [10] stated that the most common visitors to moringa blossoms were carpenter bees, stingless bees, sunbirds, wasps, and moths, which contradicts the current findings.

Conclusions

These findings and discussion suggested that *Apis* Hymenopterans prove to be the dominant pollinators in the moringa ecosystem, also moringa serves as a better nectar source inviting diverse groups of pollinators towards it. So, managed pollination by commercial beekeepers may undergo the same in moringa ecosystem to improve the crop yield and

also to get increased honey yield from the corresponding bee colonies.

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