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Insect Visitor's Diversity on Blossom of *Acacia senegal* (L.) Willd (Kumat) in Rajasthan, India

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ABSTRACT: The insects are the most dominant and important animals on the earth and affects the human life directly or indirectly. *Acacia senegal* flowers are cross-pollinated and visited by number of insect for collecting nectar and pollen rewards. It has low fruit set ratio due to a high degree of self-incompatibility and largely depends on cross pollination by insects for fruit setting. Present study focuses on studying diversity of insect visitors of *A. senegal*. The data collected revealed that the most predominantly insects visiting the blossom belongs to insect order Hymenoptera & Diptera. Among Hymenoptera different species of honey bees are the most abundant flower visiting insects.

Keywords: *Acacia senegal*, Insect visitors.

INTRODUCTION

In nature, the majority of flowering plant species sets seeds only by cross pollination aided by insect pollinators. Without this facility, cross pollinated tree species will not be able to survive and uphold their status in ecosystem. The climate of Rajasthan is usually hot and dry with low amount of rainfall and extreme temperatures in both summer and winter. However, even in the adverse climatic conditions this "Marudhar" offers diverse flora for maintaining insect biodiversity. As insect multiplicity forms an important component of the terrestrial ecosystem therefore it is of immense importance to assess composition of inhabiting insect visitors of important cross pollinated tree species of Rajasthan.

A. senegal (L.) Willd. is a deciduous tree belonging to family Leguminosae. Its pods are one of the most important ingredients of the famous Panchkutta and Trikuta Marwari vegetable and hold nutritional importance, therefore considered as a very important tree species of Rajasthan. It is distributed in the hilly and plain tracts in Aravalli and western Rajasthan (Bhandari, 1978). It grows to a height of 15 m and bears yellowish-white fragrant flowers arranged in axillary spikes. A. *senegal* is self-incompatible and fruit set is low because of insufficient pollination (Shivanna *et al*., 2001). As it is cross-pollinated in nature and largely depends on pollination by insects for successful fertilization and fruit set, hence assessment of insect visitor's diversity on its blossom holds high importance. Also, pollination service provided by insects is widely acknowledged, not only for normal functioning of ecosystem, but also for the betterment of species by way of cross pollination. Pollinators comprise highly diverse groups of animal species that transfer pollen in flowering plants (Ollerton, 2017). There is a mutual interaction between plants and pollinator which is valued for increasing food production and maintaining ecosystem functions to support global biodiversity (Ollerton, 2017). Gómez *et al*., (2007); Celep *et al*., (2020) reported that plants visited by a diverse pollinator community produce higher quality and quantity of seeds .Thus for conserving and supporting biodiversity in our nature as well as for predicting the effects of loss in biodiversity in view of climate change there is a need to study interactions between plants and their insect pollinators (Fründ *et al*., 2010) in particular areas. Around the globe there is a dependency upon insect pollinators for enhancing fruit setting in crops (Potts *et al*., 2009) and a decline in pollinator abundance and diversity will definitely have a bad impact on productivity of crops as well as trees. Anthropogenic modifications in nature have already affected the biodiversity of many insect pollinators (Biesmeijer *et al*., 2006). Therefore present study is officious at this juncture to record diversity and abundance of insect visitor's of *A. senegal* in forest habitats of this area to conserve their biodiversity.

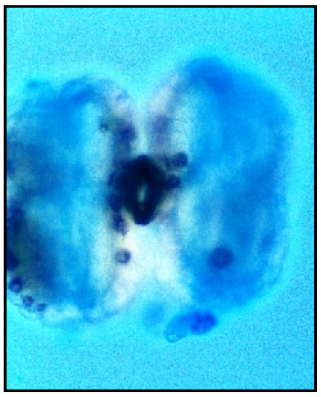
MATERIAL AND METHODS

The field experiment was carried out on *Acacia senegal* at Kaylana Kumathiya enclosure, Jodhpur, Rajasthan. For assessing the diversity insect specimens were collected during the blossoming period of *A.senegal* in the month of August-September at different hours of day starting from early morning till evening (data were recorded 6 days after anthesis up to 90% flowering was over). The entire specimen collected were arranged systematically and identified. Abundance of prevalent insect orders visiting *A. senegal* flowers was also recorded. For this purpose, the field experiment was laid in RBD design and five plots of 30×30m were selected randomly. Thereafter, three branches on trees of each plot were marked and the numbers of insects visiting the flowers of each plot within 5 minutes were recorded in forenoon, afternoon and evening. The data was subjected to ANNOVA and evaluated at 5% significance.

RESULT AND DISCUSSION

A. senegal bears creamy-white, bisexual and pentamerous flowers which are arranged spirally on a spicate inflorescence. Every anther is eight loculed and each one locule bears one polyad, holding 16 pollen grains. Flowering was observed in the end of July and it continued till September offering both nectar and pollen grains as rewards for visiting insects. Studies on insect diversity on *Acacia senegal* flowers revealed that visitors activity started at flower anthesis stage and continued till flower dehiscence.

A. senegal flowers



Anthers

Pollen

On *A. senegal* 50 species of insect visitors belonging to 5 insect orders *viz*., 5 families: 15 genus of order Hymenopteran; 5 families: 7 genus of order Coleopterans; 6 families: 18 genus of order Lepidopteran; 4 families: 4 genus of order Diptera and 1 family: 1 genus of order Hemiptera (Table 1) were recorded. Earlier Parihar and Singh (1998) have reported only 15 species of insects visiting the flowers of *A. senegal*. Tak and Jindal (2014) studied that *A. senegal* is a cross-pollinated tree species and pollination service is being done mostly in day time by insect visiting it. Tandon and Shivanna (2001) studied the pollination biology and breeding system of *A. senegal* and reported that *Apis dorsata*, is the effective pollinator in *A. senegal*.

Though bees belonging to insect order hymenoptera are most abundant insect visitor on *A. senegal* and are also believed to be the most effective pollinators; however, other insect visitors *viz*, are butterflies & moths (Lepidoptera), some flies (Diptera), and beetles (Coleoptera) role in pollination cannot be considered negligible, as they help to boost pollination and in return gets pollen and nectar as floral rewards (Rader, 2016; Mallinger, 2019; Jacques, 2017; Cook, 2020). Insect pollinator diversity augments pollination at the time of environmental and climatic swings and also improves quality and quantity of fruit/pod yield. Therefore knowledge of insect pollinators of local tree species and their conservation is of utmost importance.

Below are the insect orders and insect families which were observed during present study on *A. senegal.*

Hymenopteran: In this order following families of insect were recorded visiting the blossom of *A.senegal* either for collecting pollen or nectar or both.

1. Family Apidae: It is the largest family within the super family Apoidea (Danforth *et al*., 2013). The *Apis* spp. for the reason that they are abundant in number and has distinct morphology for the collection of pollen *i.e* pollen basket and hairy body & visit many flowering plants owing to varied food preference, represent the most important group of insect pollinators (Singh *et al*., 1999; Bosch *et al*., 2006).The family includes some bees, including bumblebees and honey bees, and also includes stingless bees, carpenter bees, orchid bees, cuckoo bees (Danforth *et al*., 2013; http:// BugGuide.Net assessed on 27.1.2022).

Sub-family Xylocopinae: It includes Carpenter bees belonging to the genus Xylocopa (Apidae: Xylocopinae) (Leys *et al*., 2000). Carpenter bees have several advantages in comparison with other non-

Apis bees, in pollination of crops, as they feed on a wide range of plant species. Somanathan (2019) described that carpenter bees also have the ability to buzz-pollinate flowers. Resende (2001) and Beggs (2001) reported that they can behave as flower visitors as well as predators.

2. Family Megachilidae: It is a cosmopolitan family and frequently known as mason bees and leafcutter bees. Megachilds are solitary bees and have scopa on the ventral surface of abdomen for carrying pollen. Megachilds can be carder bees or resin bees.

3. Family Halicitidae: It is the second biggest group of metallic and non-metallic bees. They build nest in the soil and sometimes in rotting wood. They may be solitary or semi-social communal or eusocial (Michener 1974; Schwarz *et al.,* 2007). They have a strongly curved basal vein in the wing as a distinctive feature (https:// entnemdept.ufl.edu/ creatures/ misc/ bees/ halictid_bees.htm., assesed on 2.2.22)

4. Family Formicidae: The ants are characterized by elbowed antennae, a peduncle between the thorax and the abdomen, a narrow constriction between the gaster and thorax and a petiole (http://ces.iisc.ernet.in/thresi/antsOfIISc/Diagnostic_characters_of_Formicidae.htm, assessed on 2.2.2022). Formicidae are considered as the most divergent ecosystem engineers playing a very imperative role in improving soil quality and aiding in decomposition process (Watanasit *et al*., 2000). Ants are regarded as decomposer and pollinator (Mohyuddin *et al*., 2020).

5. Family: Vespidae: This family includes eusocial wasps and solitary wasps (Pickett *et al*., 2004). They have a noticeable 'U-shape' to the posterior margin of the pronotum and forewings fold in half longitudinally. Many species in this family are reported to be pollen vectors of a number of plants and considered as effective pollinators (Suhs *et al.,* 2009), while some others are important predators *viz*., yellow jackets wasp, paper wasps, potter wasps etc.

Lepidoptera: It includes both moths and butterflies. The butterflies are thought to be good indicators of environment change. Butterflies are seen as the most enthralling and beautiful insects. By means of their wings butterflies serve as pollinators (Santos *et al*., 2020).

1. Family Nymphalidae: It is the largest family of butterflies and called as "Four Footed Butterflies" (Wolfe *et al*., 2011). Many nymphalid species are judged as model systems in evolutionary and ecological reports (Boggs *et al*., 2003).

2. Family Papilionidae: The swallowtail butterflies are relatively large in size with characteristic "tail" on the back of each hind wing. All species feeds on nectar and are mostly non-migrant species (Rajeswari and Jeyabalan 2017).

3. Family Pieridae: Butterflies of this family are white, yellow or orange in color, often with black spots (Carter, 2000). They pollinate the flowers on which they feed (Shah *et al*., 2001).

4. Family Lycaenidae: It is the second-largest family of butterflies and is known as 'blues' or gossamer-winged, while some species may be popular by the names as 'coppers or hairstreaks butterflies. The top surface of their wings is usually blue, but sometimes it may be purple or red (https://www.ento.csiro.au/education/insects/ lepidoptera_families/ lycaenidae.html, assessed on 2.2.2022).

5. Family Crambidae: They are the family of grass moth. They have scales on the proboscis at base and tympanal organs at base of abdomen (http:// BugGuide.Net assessed on 27.1.2022)

6. Family Geometridae: It is macrolepidopterans family of moths (Van Nieukerken *et al*., 2011). They have typically uniform shape & posture and have triangular forewings. While resting their wings are stretched out and flat against the surface. Many adults are green in colour with speckled designs to mélange with their background (ento.csiro.au/ education/ insects/ lepidoptera_families/ geometridae.html, assessed on 2.2.2022).

Coleoptera: Coleoptera are the most diverse insect orders and their part in pollination is gradually being acknowledged. Beetles contribute to pollination of more than 184 species of angiosperms (Dieringer *et al*., 1999).

1. Family Buprestidae: It is a family of jewel beetles or metallic wood-boring beetles for the reason that their body colors are lustrous and sparkling. Adult body shape is usually cylindrical to ovoid. Adult jewel beetles primarily feed on plant foliage or nectar. Some can also be observed visiting flowers for pollen gathering. Buprestids are mostly metallic in shade, rigid and heavily sclerotized with varying size and shape. (Karam *et al*., 2010).

2. Family Meloidae: It is a family of blister beetles. Meloids are elongate, parallel-sided beetles with a slender pronotum.. Blister beetles are hypermetamorphic and their adult beetles feed on nectar and pollen of various floral resources.

3. Family Scarabaeidae: They are often called scarabs or scarab beetles**.** They have stout-body metallic colour, and clubbed antennae (lamellae). Adult are nocturnal except flower chafers and leaf chafers. Some adults have horns on the head or pronotum are present to battle over mates or resources (bugguide.net Family Scarabaeidae - Scarab Beetles, accessed on 2.2.22).

Hemiptera: Only few reports quote hemipterans as pollinators (Yasunaga, 1997). Fahn and Shimony (2001) accounted that hemipteran are the main flower visitors in *Ecballium elaterium* (Curcurbitaceae), yet their contribution as pollinators is doubtful. Additionally Anderson *et al.,* (2003) illustrates that

hemipteran larvae noshing on pollen aid selfing in *Roridula* (Roridulaceae). Ishida *et al*., (2009) stated that the most abundant flower visitors of Macaranga (Euphorbiaceae) inflorescences were *Orius atratus* (Anthocoridae, Hemiptera), followed by *Decomioides schneirlai* (Miridae, Hemiptera).

1. Family Pentatomidae: It is the largest family in the superfamily Pentatomoidea (Foottit and Adler, 2009). Pentatomids have piercing sucking mouthparts, 5-segmented antennae, triangular scutellum, shield like body, 3 tarsal segments on each foot (https://bugguide.net retrieved on 25.1.22).

Diptera: Flies continually have played noteworthy roles as food for wildlife, as primary and secondary consumers, recyclers of nutrients (Anderson and Vondracek, 1999; Batzer *et al*., 1992; De Szalay and Resh, 1997; Euliss *et al*., 1991). The flies are directly significant as pollinator (Sengupta *et al*; 2019) of many crops. Today, flies are positioned as the third largest and most diverse animal groups in the world (Skevington and Dang, 2002) comprising over 160,000 named species in approximately 150 families (Evenhuis *et al*., 2008).

1. Family Syrphidae: It is one of the largest families of the insect order Diptera and commonly known as hoverflies, flower flies or Sun flies. They have a Vena spuria as a distinctive feature in membranous wing. Hoverflies are regarded as the most anthophilous family (Larson, *et al*., 2001). *Episyrphus balteatus* DeGeer is one of the most common hoverfly species and is considered as a potential insect pollinator of many crops all over the globe (Hodgkiss, 2018). In India hoverflies build up 4.90% of the known Dipteran fauna (Sengupta *et al*., 2016a, Banerjee *et al*., 2018). Though they are acknowledged as the second most important insect pollinator group after bees, but the data on the pollination potential of syrphids is still lacking (Raguso, 2020; Klecka *et al*., 2018) and their contribution towards food security is ignored.

2. Family Muscidae: It is one of the main dipteran families having three-segmented antennae and aristate. House fly, *M. domestica* (Muscidae), play a significant role in mango pollination, and considered as effective as bees in mango pollination (Dag and Gazit 2000).

3. Family Calliphoridae: Heine (1937) has reported Calliphorids foraging in the wild with large amounts of pollen on their bodies. They have an extending proboscis with sponging or lapping mouth parts that helps to make broad contact with the interior of the flower (Graham-Smith, 1930). They have several body setae which vary with species type (Lutz *et al*., 2018)

4. Family Bombyliidae: They are commonly called as bee flies. At rest, many species keep their wings at a "swept back" angle. They vary in size from very small (2 mm) to very large (40 mm) (Weaving *et al*., 2003; Hull and Montgomery, 1973).

Abundance of insect pollinators: During blooming period of *Acacia senegal*, insect visitors were recorded foraging for nectar or pollen or both on the flowers. In present study insect visitor's assemblages were diverse with representatives from the orders Hymenoptera, Diptera, Lepidoptera, hemiptera and Coleoptera visiting the bloom (Table 2, Fig. 1). Abundance of hymenopteran insect visitors dominates in forenoon, afternoon and evening time followed by dipteran, hemiptera and lepidoptera. Among Hymenoptera different species of honey bees are the most abundant flower visiting insects. The minimum number of insect visiting the bloom was of order coleoptera. On *A.senegal* insect flowers visitors were observed belonging to three main groups: pollen and flower feeders (bees, flies and beetles), nectar feeder (butterflies and bees) and opportunistic feeders (ants and wasp).

The above study is in line with the previous studies by different researchers. Though honey bees are vital insect pollinators of many crops and fruit plants (Shaheen *et al*., 2017, Khan *et al*., 2012), flies are also key pollinators of more than 100 cultivated plants, including fruit trees and crops like mango, cashew, tea, cacao, apple, onions, and strawberries (Larson *et al*., 2001). In a study on diversity and abundance of beneficial insects in forest ecosystem of Madhya Pradesh, Kumar and Bhowate (2020) reported that in forest ecosystem *Apis dorsata* plays an important role as a key stone species. Duara (2017) reported that among all groups butterflies were found to be more in forest area of nambor wild life sanctuary, Assam and Urban areas. There is a positive correlation between plant species richness and diversity of plant-visiting insects (Fründ *et al*., 2010). Also, pollinator diversity plays an important role in seed production in flowering plants (Blitzer *et al*., 2016). Therefore to combat anthropogenic alterations in climates and habitats which has resulted in reductions in the pollinator population abundance and biodiversity of many pollinator families worldwide (Biesmeijer *et al*., 2006), we need to focus on studies related to diversity, richness and conservation of insect pollinators in their natural habitat.

Table 1: Diversity of various insect visitors on *Acacia senegal* flowers at Kaylana Kumathiya enclosure, Jodhpur Rajasthan.

Insect visitors of *Acacia senegal*				
Sr. No.	**Scientific name**	**Common names**	**Order**	**Family**
1.	*Danaus chrysippus*	Plain Tiger/African Monarch	Lepidoptera	Nymphalidae
2.	*Papilio demoleus*	Swallowtail butterfly	Lepidoptera	Papilionidae
3.	*Cepora nerissae*	common gull butterfly	Lepidoptera	Pieridae
4.	*Colotis fausta*	large salmon Arab	Lepidoptera	Pieridae
5.	*Colatis etrida*	Small orange tip	Lepidoptera	Pieridae
6.	*Catopsilia pyranthe*	African migrant (Lemonish white)	Lepidoptera	Pieridae
7.	*Belenois aurota*	The Pioneer White	Lepidoptera	Pieridae
8.	*Eurema hecabe*	Grass yellow or common grass yellow	Lepidoptera	Pieridae
9.	*Delias eucharis*	The Common Jezebel	Lepidoptera	Pieridae
10.	*Euploea core core*	The Common Indian Crow	Lepidoptera	Nymphalidae
11.	*Hypolimnnas misippus*	The Danaid Eggfly	Lepidoptera	Nymphalidae
12.	*Junonia coenia*	Common buckeye	Lepidoptera	Nymphalidae
13.	*Phalanta phalantha*	Common leopard	Lepidoptera	Nymphalidae
14.	*Tarucus nara*	Blue pierrots	Lepidoptera	Lycaenidae
15.	*Azanus ubaldus*	Bright babul blue	Lepidoptera	Lycaenidae
16.	*Euchrysops cnejus*	Blue butterfly	Lepidoptera	Lycaenidae
17.	*Spoladea recurvalis*	Beet Webworm Moth	Lepidoptera	Crambidae
18.	*Campaea margaritata*	Light emerald moth	Lepidoptera	Geometridae
19.	*Lucilia sp.*	Blow fly	Diptera	Calliphoridae
20.	*Musca domestica*	House fly	Diptera	Muscidae
21.	*M. Sorbens*	Bush fly	Diptera	Muscidae
22.	*Eristalinus megacephalus*	Syrphid	Diptera	Syrphidae
23.	*Eristalinus laetus*	Syrphid	Diptera	Syrphidae
24.	*Exoprosopa collaris*	bee flies or humbleflies	Diptera	Bombyliidae
25.	*Apis dorsata*	Giant honey bee	Hymenoptera	Apidae
26.	*Apis florea*	Small honey bee	Hymenoptera	Apidae
27.	*Polistes hebraeus*	Paper wasp	Hymenoptera	Vespidae
28.	*Vespa orientalis*	Oriental hornet	Hymenoptera	Vespidae
29.	*Megachile laterille*	leafcutter bee	Hymenoptera	*Megachilidae*
30.	*Nomia elliotii*	Solitary bee	Hymenoptera	Halictidae
31.	*Camponotus compressus*	Black ants	Hymenoptera	Formicidae
32.	*Xylocopa aestuans*	Carpenter bee	Hymenoptera	Xylocopinae
33.	*Xylocopa fenestrata*	Carpenter bee	Hymenoptera	Xylocopinae
34.	*Braunsapis mixta*	Cuckoo bee	Hymenoptera	Apidae
35.	*Coelioxys gilensis*	leafcutter bee	Hymenoptera	*Megachilidae*
36.	*Megachile studiosa*	leafcutter bee	Hymenoptera	*Megachilidae*
37.	*Lassioglossum sp*	Sweet bee	Hymenoptera	*Halicitidae*
38.	*Halictus lucidipennis*	Sweat bee	Hymenoptera	*Halicitidae*
39.	*Thyreus histrio*	Cuckoo bee	Hymenoptera	Apidae
40.	*Amegilla niveocincta*	Cuckoo bee	Hymenoptera	Apidae
41.	*Delta esuriens*	Solitary wasp	Hymenoptera	Vespidae
42.	*Eumenes latreille*	Potter wasps	Hymenoptera	Vespidae
43.	*Oxycetonia versicolour*	Flower chafer beetle	Coleoptera	Scarabaeidae
44.	*Acmeodera aurifera*	Metallic wood borer	Coleoptera	Buprestidae
45.	*Mylabris pustula*	blister beetles	Coleoptera	Meloidae
46.	*Epicanta pennsylavanica*	Black blister beetle	Coleoptera	Meloidae
47.	*Julodis euphratica*	Sulphurous jewel beetle	Coleoptera	Buprestidae
48.	*Sternocera chrysis*	Jewel beetle	Coleoptera	Buprestidae
49.	*Clytra Succincta*	Leaf beetle	Coleoptera	Chrysomelidae
50.	*Bagrada cruciferarum*	Painted bug	Hemiptera	Pentatomidae

Table 2: Average abundance of pollinators order *in Acacia senegal.*

Insect order	Abundance of pollinators *in Acacia senegal* per plot per 5 min			
	Time Interval			
	Forenoon	Afternoon	Evening	Mean
	A	A	A	
Lepidoptera	2.75	2.17	1.68	2.20
Diptera	3.89	2.66	2.02	2.86
Hymenoptera	5.31	3.50	2.90	3.90
Coleoptera	2.87	2.19	1.16	2.07
Hemiptera	3.88	3.22	1.78	2.96
Mean	3.74	2.748	1.908	2.79
SEM SEd CV CD@5% Significance @5%	0.19 0.27 12.03 0.63 S			

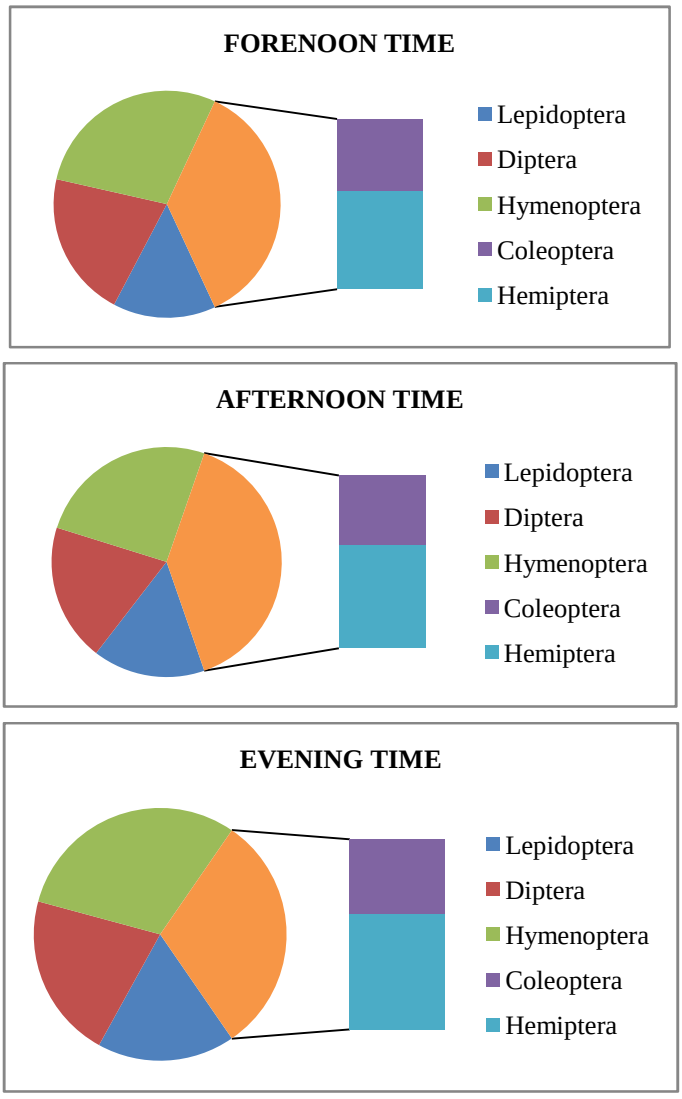


Fig. 1. Graphical representation of abundance of insect visitors in different time interval.

CONCLUSION

As little is known about the diversity and abundance of insect pollinators in forest habitats in this area, the present study was focused on forest ecosystems, which are least disturbed by humans and livestock. Wild native insect visitors are also listed in study as all of them contribute to overall pollination in natural forest

as well as plantation ecosystems. Thus current study serves as a baseline for future conservation programs regarding sustainable forest management in the region as insect pollinators not only provide an essential ecosystem service but also play a part in the maintenance of biodiversity and ensures the survival of plant species.

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Conflict of Interest. None.

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