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Insect biodiversity in flowering teak (*Tectona grandis* L.f.),. and insects pollinating efficiency on Teak. Comparison in disturb area and undisturbed area of teak insect pollinators in Aligarh Muslim University Campus (U.P.) India

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Abstract
The present study is based on the insect pollinators of Teak (*Tectona grandis* L. f.) encountered in and adjacent to the A.M.U Aligarh campus along with Aligarh fort. The study was carried out from year 2014-2015. The total number of insect collected from the teak flowers were 1382, belonging to hymenoptera, Diptera, Lepidoptera and others insect orders. Among 1382 insects, 447 individuals were non-pollinators and 935 were pollinators. The active pollinators are recorded belongs to *Hymenoptera* (family*: Apidae, Vespidae)*, *Lepidoptera* (family*: Pieridae, Papilionidae*) and Diptera (Family: Sarcophagidae, Calliphoridae,). This study provides the information related to insects site selection for foraging of bees, butterflies and Flies of Aligarh Muslim University disturb and undisturbed Area.

Keywords: Teak, hymenoptera, lepidoptera, diptera, Apidae, campus, fort. Aligarh

1 Introduction
Aligarh Muslim University (AMU) is a public central university. The main campus of AMU is located in the city of Aligarh and lies between 27 °34'N to 28°11'N latitudes and 77°26'E to 78°58'E longitudes. Spread over 467.6 hectares. The fort of Aligarh stands some 3km. to the north of the railway station. Aligarh fort is located 400m away from the Law faculty of Aligarh Muslim University. During the recent year the area within the fort has been utilized as an agricultural farm by the university. Now a day the fort is under the control of the Botany Department of Aligarh Muslim University, and is developed into a Botanical garden. The total area of fort is about 11.5 hectares.

The AMU Campus has well established plantation of various forest tree species representing more than 20 important timber species. Principle plantation species include *Tectona grandis*, *Eucalyptus* spp., *Dalbergia sissoo*, *Acacia* spp, Other commonly planted broadleaf are *Azadirachta indica*, *Alstonia* spp,. *Shorea robusta*, *Casuarina equisetifolia*, *Populus* spp, *Prosopis* spp, *Termanalia* spp, *Mangifera indic*a, *Cassia fistula* are also available in AMU Campus and also rich flora of herbs and shrubs. The rich flora of AMU campus attracts the insects.

The flora of India is more varied than that of many other countries of an equal area in the Eastern hemisphere, if not in the globe (Hooker, 1904). This is because of varied rainfall, temperature, geology and topography, which influence the floristics and vegetation differently in various regions. A comprehensive and up-to-date flora is an essential tool for the study of plants of any area and assesses their utility. There have been some reports on the impacts of forest plantations on the diversity and abundance of insects but most of these studies have been conducted in Africa (e.g. Nummelin and Hanski, 1989 [20]; Nummelin and Borrowiec, 1991 [18]; Nummelin and Fursch, 1992 [19]; Eggleton *et al*., 1995, 1996 [7]; Nummelin,1996) [17] with only a few recent studies being done in Asia (Holloway *et al*., 1992 [13]; Hill *et al*., 1995 [12]; Chey *et al*., 1997 [4]; Hamer *et al*., 1997 [10]; Intachat *et al*., 1997) [15]. Among tropical hardwood plantation forest trees, teak is one of the most common native or introduced species (Tewari, 1992) [25].

2. Material and Methods

2.1. Study area

The main campus of AMU is located in the city of Aligarh and lies between 27 °34'N to 28°11'N latitudes and 77°26'E to 78°58'E longitudes. Spread over 467.6 hectares. AMU Campus is rich in plant flora. The work was carried at four locations in the campus of Aligarh Muslim University and its visinity Viz, (1) Ecologically disturbed area (A) near Zakir Hussain college of Engineering & Technology and (B) behind the Arts faculty (2) Ecologically undisturbed area (A) AMU Aligarh Fort and (B) Nakvi Park, each offering diverse habitats for insects during July, 2014 to December, 2015.

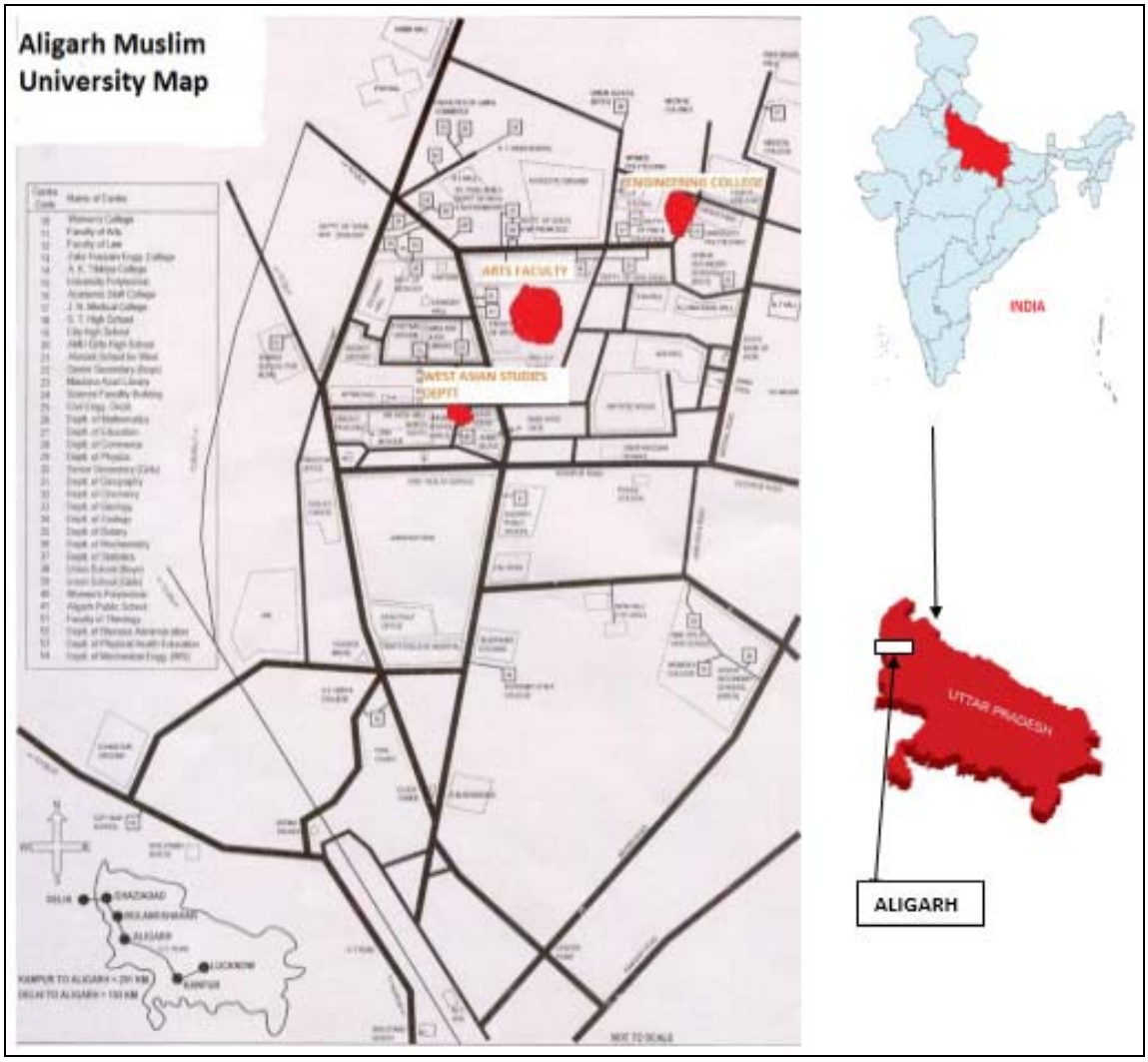

Fig 1: Map showing AMU Study area (Red spotted area are study sites).

2.2 Method of observations

The survey were conducted during the year from July, 2014 to December,2015 following the 'Pollard Walk' methodology proposed by Pollard *et al*., (1975) and adopted by various other authers (Kunte *et al*., 1999; Arun., 2003). The sites selected were composed of trees between 15 and 20 years old and hight of plants were in between 12m to 15m approximately. Observations were made during the receptive period of teak flowers (Tangmitcharoen and Owens, 1997) [24] at from 9:amx` to 12:pm and 3:pm to 5:pm on a minimum of 10 inflorescences per tree. In order to determine the common pollinators, the number of a group of insects per flower visits was observed by counting the number of insects visiting flowers on each tree.

2.3 Net Sweeping

Bees, butterflies, Flies and other present insects were collected through net sweeping in flowering plants of Teak from the localities of selected study sites. Sweepings were done in the morning and in afternoon. Speed of sweeps and direction kept uniform in each case.

After collection insects were killed in a bottle having Ethyl acetate (CH_3–COO–CH_2–CH_3). After setting identification of insects were made upto lowest possible taxa using identification keys. In addition help was also taken from already identified collection of insects at Aligarh Muslim University Insect Museum and university Professors, Forest Research Institute (FRI) Dehradun and recent published faunistic work on insects of Teak. All the identification work was done under the Binocular and stereoscope. Furthermore identified insect species were photographed with the help of DLSR Camera and. Identified collection have been deposited at Department of Zoology, AMU. Museum.

Table 1: Data recoded by collected insects from teak flowers to obseve insects biodiversity.

S. No	Location	Insect on Teak flower	Number of individuals sampled	Total number of Insects
1	AMU Fort	Hymenoptera Lepidoptera Diptera Hemiptera Coleoptera Hemiptera	246 159 43 26 20 10	504
2	Nakvi Park	Hymenoptera Lepidoptera Diptera Coleoptera Other order	177 103 54 31 07	372
3	Z.H.E.C AMU	Hymenoptera Lepidoptera Diptera Hemiptera	148 86 41 06	281
4	Arts Faculty	Hymenoptera Lepidoptera Diptera Coleoptera	114 62 41 08	226

Table 2: Insects visited repeatedly on teak flowers in the vicinity of Aligarh Muslim University Campus and selected sites during the Flowering time from July to December.

S. No.	Insect order	family	species
1	*Hymenoptera*	*Apidae*	*Apis florae* *Apis mellifera* *Apis cerana indica* *Apis dorsata* *Bambus spp.*
		Vespidae	*Polistes stigma* *Allorhynchium spp.* *Vespa tropica*
		formicidae	*Camonotus spp.*
2	*Lepidoptera*	*Pieridae*	*Pieris brassicae* *Pieris canidia* *Pieris rapae* *Aporia peloria* *Delias eucharis*
		Nymphalidae	*Danaus plexippus* *Danaus petila* *Danaus chrysippers*
		Papilionidae	*Papilio machaon* *Papilio Troilus* *Papilio memnon* *Papilio demodocus* *Ornithoptera euphorion*
		Lycaenidae	*Phengaris arion* *Liphyra brassolis*
3	*Diptera*	*Muscidae*	*Musca domestica*
		Sarcophagidae	*Sarcophaga spp.*
		Calliphoridae	*Chrysomya spp.* *Rhinia spp.*
		Syrphidae	*Asarcina aegrota* *Simosyrphus grandicornis* *Episyrphus balteatus*
		Tabanidae	*Tabanus sp*
		Tachinidae	*Tachina spp.*
4	*Hemiptera*	*Pyrrhocoridae*	*Dysdercus spp.*
4	*Coleoptera*	*Coccinellidae*	*Coccinella septempunctata*

3. Results and Discussion

Different and most Teak pollinators insect species belonging to the Order *Hymenoptera, Lepidoptera*, and *Diptera*, were collected from the Teak flowers during 18 observation days (Table. 1). The number of individuals from every recorded were abundantly found in the ecologically undisturbed compared to disturbed area. Most were obserbed at from 9:am to 12:pm and 3:pm to 5:pm and the Bees, butterflies and flies, Particularly the bees ,small carpenter bees (*Apis cerana indica*) and *Apis dorsata* were the most common insect found; They forage for pollen and nector all day. The number of pollen grain on insect bodies was quite variable among insects groups. Generally only *Hymenopteran, dipteran* and *Lepidoptera* had pollen on their bodies and *Hymenoptera* and some *Diptera* had more pollen. *Lepidoptera* (some Butterflies), *Formicidae* (Ants) some dipteral played a little or no role in the transfer of teak pollen. The microscopic study revealed that the Teak pollen were present on the lower body of bees, vesp and flies and on the long proboscis of butterflies. The potential pollinators are recorded belongs to *Hymenoptera (*family*: Apidae, Vespidae)*, *Lepidoptera (*family*:, Papilionidae,*) and Diptera (Family: *Sarcophagidae, Calliphoridae*). Forest management may affect pollinators. Fermon *et al*. (2000) [9] reported that species richness of butterflies in unmanaged forests is higher than that in forests managed by thinning. S. Tangmitcharoen (2006). Our results also support this conclusion.

3.1. Pollination efficiency on Teak: The abundance of various species on Teak flowers are recorded and pollen were collected from the body part of insects and compared. Observation revealed that the bees are active pollinators which carry more pollens than that of others insects. Butterflies and Flies play a little role in teak pollination.

Table 3: Showing the efficiency of insects pollinators on teak.

	Order	Species
Highly efficient	*Hymenopteran*	*Apis mellifera* *Apis cerana indica* *Apis dorsata* *Vespa spp.*
Moderately efficient	*Hymenopteran*	*Bambus spp.* *Allorhynchium spp.* *Vespa tropica*
	Diptera	*Sarcophaga spp.* *Chrysomya spp.* *Asarcina aegrota* *Simosyrphus grandicornis*
	Lepidoptera	*Papilio machaon* *Pieris brassicae*
Lesser efficient	*Hymenopteran*	*Apis florae*
	Lepidoptera	*Pieris canidia* *Pieris rapae* *Aporia peloria* *Delias eucharis*
	Diptera	*Musca domestica* *Simosyrphus grandicornis* *Episyrphus balteatus*
Highly inefficient	*Hemiptera*	*Pyrrhocoridae*
	Coleoptera	*Coccinellidae*
	Lepidoptera	*Danaus plexippus* *Danaus petila* *Danaus chrysippers*
	Hymenopteran	*Camonotus spp.* *Polistes stigma*

Conclusion

During the Course of observation at Aligarh Muslim University campus and selected site (Nakvi park and Aligarh fort)., (U.P.) on the occurrence and pollinating activities of insects on teak plantations, grown as avenue and beautification of university campus, various species representing different orders and family were collected. Most numerous in species were Hymenopterous families: Apidae, Vespidae, Formicidae., Lepidopterous families: Nymphalidae, Pieridae, Papilionidae and dipterous families: Sarcophagidae, Muscidae, Calliphoriae and little were Coleopterous and Hemipterous. Families represented by the most efficient pollinators were Apidae, Vespidae, Papilionidae. Apis dorsata and A. mellifera (Honey bee) were the efficient pollinators, But they only the major factors with others in the Aligarh Muslim University campus and selected site (Nakvi park and Aligarh fort) because of their high abundance in the area. In most areas a combination of honey bee colonies adjacent to teak tree and elimination of bloom may be the most practical method to inceasing the Teak pollination.

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