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A study on the community structure of parasitic Hymenoptera in lawns from Kerala, India

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Abstract
Ornamental lawns are a form of urban greenery. Even though urban green spaces are becoming common, studies on their insect communities, especially the cryptic and little known groups like parasitic hymenoptera are scarce. This study aimed to assess the guild of parasitic hymenoptera in lawns, an intensively managed urban ecosystem. Two lawns in Kozhikode district, Kerala were sampled for six months, using yellow pan traps (YPTs). 25 YPT samples were taken from each lawn every month, from December 2013 to May 2014. Identifications were upto morphospecies level. The superfamilies Platygastroidea and Chalcidoidea ranked top, and among the families the most diverse was Platygastridae. As per the functional group analysis, egg parasitoids were more abundant than pupal, larval, larval-pupal, nymphal and egg-larval parasitoids. Parasitoids with any of their life stages having a direct association with soil, tended to dominate in lawns. Plant-prey interactions, host-parasitoid relationships and functional group analysis are all important in understanding the ecosystem dynamics

Keywords: lawn, parasitoids, urban entomology, diversity

Introduction
Urbanization is considered to be one of the reasons for the decline in arthropod populations even though limited information exists about arthropod communities in urban areas [1, 2]. Lawns are urban anthropogenic constructs that are maintained to aesthetic standards by intensive management, usually species poor and many conventional lawn management practices can be ecologically insensitive [3]. Insects belonging to several orders inhabit lawns such as ants, aphids, psyllids, flies, termites, parasitoids, grasshoppers, butterflies and occasionally spiders.
Previous studies of insects in turf-grass ecosystem has focused on pests such as Japanese beetle, *Popillia japonica* Newman in Michigan [4, 5] and mole crickets, *Seapteriseus* spp. in Florida [6, 7]. Studies were conducted on the occurrence of parasitic hymenoptera in residential turf grass in Georgia [8].
Parasitic hymenoptera play a key role in functioning of ecosystems by regulating host arthropod populations [9], by laying eggs on or in various stages of their hosts (egg/larva/pupa) eventually killing them.
This study aims to assess the parasitic hymenopteran community in an intensively managed urban ecosystem, the lawn.

Materials and methods
Two lawn grass ecosystems of "Doob grass" or "Bermuda grass" (*Cynodon dactylon*) separated by approximately 1 km were selected for this study in Kozhikode district (lat- 11.24°N long- 75.79°E). The lawns were of approximate area 550 m^2 and 200 m^2 respectively. Both were fully managed artificially with application of fertilizers and pesticides. Pesticides consisting of a mixture of Carbamates and Pyrethroids were applied in the first lawn where as the second lawn used only Pyrethroids. Fertilizers used were mainly bone meal and urea in both the lawns. The duration of the application was once in two months. The LD_{50} for the fertilizers were not taken into account in the study.
Collections were made once every month for a period of six months from December 2013 to May 2014. Specimens were collected from both the lawns using Yellow pan traps (YPTs). 25 YPT samples were taken from each lawn every month.
All parasitic hymenopterans were preserved in 70% alcohol and card mounted after drying. The specimens were sorted into family [10] and further into genus [11, 12] and arranged into

morphospecies using Leica M 205-A stereomicroscope at magnification 60-160X. The specimens studied were deposited at the National Zoological Collection at Zoological Survey of India, Kozhikode, Kerala.

Results and Discussion

The use of morphospecies is an alternative to taxonomic identification which is an integral part of biodiversity surveys [13]. Sorting into morphospecies is reliable and saves time and reduces burden on taxonomy [14]. A diverse community of parasitic wasps with a total of 76 morphospecies, 42 genera, 13 families and 6 superfamilies were recorded in the study (Table 1).

The most diverse family with 17 genera and 29 morphospecies was Platygastridae. The genera of parasitic hymenoptera collected from the lawns and their host ranges obtained from literature is detailed in Table 1.

Groups of species that perform similar role in ecosystem are known as functional types/functional groups [15, 16]. The functional groups assessed in this study were egg, egg-larval, larval, larval-pupal, pupal and nymphal parasitoids, with the egg parasitoids being most abundant (54%) (Figure 2). Out of the 6 superfamilies recorded from the study (Figure 1) Platygastroidea and Chalcidoidea were the most abundant. More than 85% of the Platygastroidea and 37% of Chalcidoids were exclusively egg parasitoids. Majority of the remaining parasitoids were larval-pupal, pupal followed by larval and egg-larval parasitoids. Insect eggs and pupae are more resistant to effects of pesticides than larvae because these two stages are inactive, immobile and in inaccessible areas such as underground, in cocoons or cases, and in cracks or crevices [17]. Orthopterans, especially Acrididae and Gryllidae lay eggs deep in soil, and several Platygastrids like *Duta* Nixon and *Calliscelio* Ashmead possess extremely long ovipositors to reach these deep seated eggs for parasitization [18].

The genera recorded from the lawns also serve as indicators of their hosts. Among the collected genera, the highest number of morphospecies (8) was recorded for the Diapriid genus *Trichopria* Ashmead, dipteran pupal parasitoids (Table 1). Second highest number of morphospecies (5) were reported for the Diapriid genus *Basalys* Westwood which are also parasitoids of Dipteran pupa. A large group of Diptera spend their immature developmental stages in the soil [19]. The Platygastrid genus *Idris* Förster known to be parasitoids of spider eggs, also recorded 5 number of morphospecies, pointing to the presence of spiders in the lawns. Natural enemy communities may be shaped temporally or spatially by direct natural enemy-prey or indirect host plant-prey interactions [20]. So host plants play a role in determining parasitism [21]. Hemipteran families-Aphididae and Cicadellidae [22, 23], orthopteran family, Acrididae [24] and lepidopteran family Noctuidae [25] have been reported to be pests of the grass *Cynodon dactylon*. An example for parasitoids of Hemipteran eggs (Cicadellidae and Delphacidae) are genera from the Mymarid family- *Gonatocerus* Nees (3 morphospecies) and *Mymar* Curtis (1 morphospecies) [25]. The families Aphelinidae (with the genus *Encarsia* Förster) and Encyrtidae (with the genera *Copidosoma* Ratzeburg and *Ooencyrtus* Ashmead) are known to parasitize many hemipteran families including Aphididae (Table 1).

Members of different families of parasitic hymenoptera have different parasitization strategies, depending on the hosts and their stages they attack. Some are species specific parasitizing only one species of host and some others have a wide host range. For example, *Telenomus* Haliday is a cosmopolitan genus of wasps that has a wide host range (Table 1) though one species of *Telenomus* Haliday is known to parasitize members within its single host order only [26]. The Eulophid genus, *Aprostocetus* Westwood parasitizes diverse groups and different life stages within the same insect order, and hence not possible to restrict it to any single functional group.

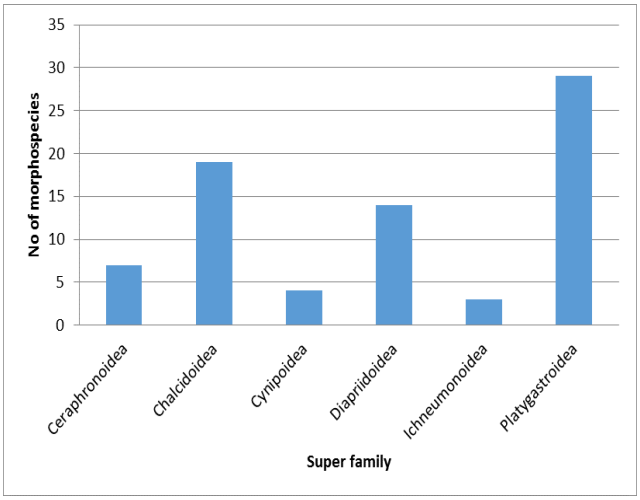

Fig 1: The diversity of parasitic hymenoptera superfamilies from the study

Maximum morphospecies were observed for the superfamily Platygastroidea followed by Chalcidoidea and least for superfamily Ichneumonoidea (Figure 1).

The influence of different lawn grass genotype on the occurrence of parasitic hymenoptera in Georgia [8], showed an abundance of superfamilies Chalcidoidea and Platygastroidea, which is in exact agreement to the result obtained from the present study.

Landscape features often influence population and community ecology of insect species seen [27]. The parasitoids that are dominant in the present study, had some of their life-stages directly associated with soil. A comparison of parasitic hymenoptera between a well-manicured lawn and a natural habitat, often differing in landscape features, would also differ in this pattern of dominance. In intensively managed lawns, chances for the presence of foliage other than grass and nectar-bearing flowers are quite low. Hence, it can be said that the bulk of parasitoids visiting lawns are those that arrive only for locating and parasitizing their respective host groups.

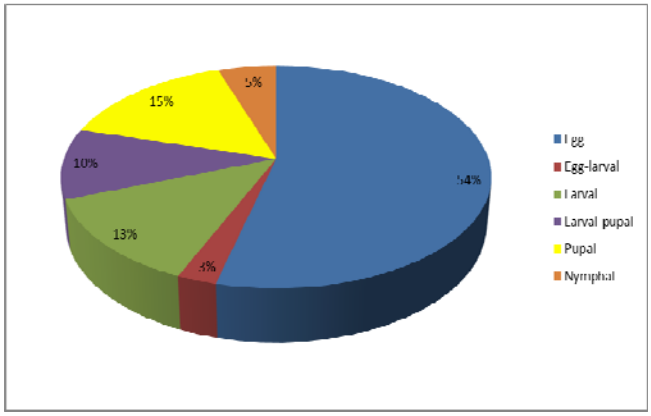

Fig 2: Distribution of the genera according to functional groups.

Conclusion

Our study indicates the presence of a healthy guild of parasitic hymenoptera, even in loci like lawns, which are defined by severe anthropogenic disturbances, and consistent insecticidal applications. However, parasitoids with any of their life stages

having a direct association with soil, tend to dominate in lawns. Since insect eggs are more resistant to insecticides than pupal or larval stages, egg parasitoids occupied a clear majority here. Linking the plant-prey interactions, host-parasitoid relationships and functional group analysis would certainly decipher ecosystem dynamics, in a better way.

Table 1: A list of the superfamily, family, genera, functional group with host orders and the literature from which the data was complied.*-Identification upto superfamily; **-The genera not considered for Figure 2; Host and functional group of *Dipara* Walker was unknown; functional group of *Aprostocetus* Westwood could not be assigned since it attacks more than one life stage in different orders. Functional group of *Lakshaphagus* Mahdihassan was not known; Number of morphospecies recorded within parenthesis.

Superfamily	Family	Genus	Functional group with host orders
Ceraphronoidea	Ceraphronidae	*Aphanogmus* Thomson (3)	Hyperparasitoid of Lepidopteran larva through various Hymenopteran or Dipteran primary parasitoids [28]
		Ceraphron Jurine (4)	Primary parasitoid of larva of Diptera (Cecidomyiidae) [29]
Chalcidoidea	Aphelinidae	*Encarsia* Förster (1)	Primary egg parasitoids of Hemipterans (Aleyrodidae, Aphididae, Diaspididae and Psyllidae) [30]
	Chalcididae	*Antrocephalus* Kirby (1)	Primary parasitoids larvae and pupae of Lepidopterans (Pyralidae, Oecophoridae, Limacodidae and Yponomeutidae) [31]
		Haltichella Spinola (1)	Primary parasitoids of Lepidopteranlarvae, secondary parasitoids of Braconid larva [32]
	Encyrtidae	*Adelencyrtus* Ashmead (1)	Primary parasitoids of nymph of Hemipterans (Diaspididae, Aleyrodidae and Pseudococcidae) [25]
		Anagyrus Howard (2)	Primary parasitoids of Hemipteran nymphs (Pseudococcidae, Cerococcidae, Margarodidae), Lepidoptera (Pyralidae, Gelechiidae) [25]
		Cheiloneurus Westwood (1)	Hyperparasitoid of larva of order Hemiptera (Pseudococcidae, Coccidae, Delphacidae) via Lepidoptera (Pyralidae), Hemiptera (Delphacidae) and Hymenoptera (Encyrtidae, Bethylidae, Dryinidae) [25]
		Copidosoma Ratzeburg (1)	Egg parasitoid of Hemiptera (Aphididae, Reduviidae, Lepidoptera (Hesperiidae, Limacodidae, Noctuidae, Notodontidae, Tortricidae, Pyralidae, Gelechiidae, Ypomomeutidae), Coleoptera (Scolytidae), Hymenoptera (Braconidae, Vespidae) [25]
Chalcidoidea		*Lakshaphagus* Mahdihassan** (1)	Parasitoids of Hemiptera (Kerriidae, Cerococcidae, Coccidae, Pseudococcidae, Asterolecaniidae) [25]
		Ooencyrtus Ashmead (1)	Primary egg parasitoids of Hemiptera (Triozidae, Aphididae, Alydidae, Coreidae, Pentatomidae), Diptera (Syrphidae), Lepidoptera (Noctuidae, Pterophoridae, Arctiidae, Hesperiidae), Coleoptera (Chrysomelidae) [25]
	Eulophidae	*Aprostocetus* Westwood**(1)	Primary parasitoid of Diptera (Cecidomyiidae), Coleoptera (Scolytidae), Dictyoptera (Blaberidae, Blattellidae, Blattidae), Orthoptera (Gryllidae), Hemiptera (Pseudococcidae), Hymenoptera (Cynipidae, Evaniidae) [25]
		Eulophus Geoffroy (1)	Primary parasitoid of larva of Lepidoptera (Noctuidae) [31]
	Mymaridae	*Gonatocerus* Nees (3)	Primary egg parasitoids of Hemiptera (Cicadellidae) [25]
		Mymar Curtis (1)	Primary egg parasitoids of Hemiptera (Delphacidae, Cicadellidae) [25]
	Pteromalidae	*Dipara* Walker ** (1)	Unknown [25]
		Systasis Walker (1)	Primary parasitoids of Dipteran pupa [32]
	Trichogrammatidae	*Trichogramma* Westwood(1)	Primary parasitoids of the eggs of Lepidoptera [33]
Cynipoidea	Figitidae	*Hexacola pallida* Quinlan (1)	Primary larval-pupalparasitoids of Diptera (Chloropidae Ephydridae) [34]
		Norlanderia Quinlan (2)	Primary larval-pupal parasitoids of Diptera (Agromyzidae) [35]
		Rhoptromeris Förster (1)	Primary larval-pupal parasitoids of Diptera (Chloropidae) [36]
Diaspididae	Diapriidae	*Basalys* Westwood (5)	Primary parasitoids of pupa of Diptera (Stratiomyidae) [37]
		Monelata Forster (1)	Primary parasitoids of pupa of Diptera [38]
		Trichopria Ashmead (8)	Primary parasitoids of pupa of Diptera (Muscidae) [37]
Ichneumonoidea	Braconidae	*Bracon* Fabricius (1)	Egg-larval parasitoids of Lepidoptera, Diptera, Coleoptera, Hymenoptera [39]
	Ichneumonidae	*Banchinae* Wesmael*	Primary parasitoids of the larva of Lepidoptera [40]

		(2)	
Platygastroidea	Platygastridae	*Calliscelio* Ashmead (1)	Primary parasitoids of Orthopteran (Gryllidae) eggs [41]
		Chakra Rajmohana & Veenakumari (1)	Egg parasitoids; host unknown [41]
		Dicroscelio Kieffer (1)	Egg parasitoids; host unknown [41]
		Duta Nixon (1)	Primary parasitoids of Orthopteran (Gryllidae) eggs [41]
		Fusicornia Risbec (1)	Egg parasitoids; host unknown [41]
		Gryon Haliday (4)	Primary parasitoids of Hemipteran eggs (Coreidae, Pentatomidae, Scutelleridae, Lygaeidae, Reduviidae, Phymatidae) [41]
		Idris Förster (5)	Primary parasitoids of Spider (Araneidae)eggs [41]
		Leptasis Förster (1)	Primary parasitoids of pupa of Dipterans (Cecidomyiidae) [42]
		Neoceratobaeus Rajmohana (1)	Primary parasitoids of Spider eggs [41]
		Opisthacantha Ashmead (1)	Egg parasitoids; host unknown [41]
		Palpoteleia Kieffer (1)	Egg parasitoids; host unknown [41]
		Paratelenomus Dodd (1)	Primary parasitoids of eggs of Hemiptera (Plataspididae) [41]
		Psilanteris Kieffer (1)	Primary parasitoids of Orthopteran eggs [41]
		Scelio Latreille (1)	Primary parasitoids of Orthopteran (Acrididae) eggs [41]
		Synopeas Förster (3)	Primary parasitoids of pupa of Diptera (Cecidomyiidae) [42]
		Telenomus Haliday (3)	Primary parasitoids of Lepidoptera, Hemiptera, Diptera and Neuropteran eggs [41]
		Titta Mineo, O'Connor & Ashe (2)	Primary parasitoids of eggs of Hemiptera [43]

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