

The Diversity of Bees (Hymenoptera: Apoidea) of Home Gardens of Batticaloa District, Sri Lanka

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ABSTRACT

Pollination is very important for plant reproduction, and subsequent fruit setting. Bee fauna in Batticaloa district of Sri Lanka has never been studied. Therefore, the present research was designed to investigate the diversity of bees and their abundance in home gardens of Batticaloa district. Bees were surveyed from home gardens in Koddakallur, Onthachimadam, Kaluwanchikudy, Kalluthavallai and Periyakallur in Batticaloa during September and December, 2014. Samples were collected from each location and each site was visited three times during the study period. In total ninety one bees were collected and identified. They belong to twenty seven species and fifteen genera in three families. The collected bees belong to families, Apidae, Halictidae and Megachilidae. Genus *Apis* (35 incidences) and *Ceratina* (12) were the most abundant genera, followed by *Ceylactus*, *Megachile*, *Lasioglossum*, *Xylocopa*, each recorded in similar abundance (6). The highest bee diversity ($H' = 2.017$) and evenness (0.712) recorded from Koddakallur area. The species diversity decreased as Kalluthavallai > Onthachimadam > Kalluwanchikudy > Periyakallur. The abundance of bee species were not significantly different among the locations ($\chi^2 = 12.328$, $DF = 4$, $P = 0.137$). The abundance of bees was significantly different within each location ($p < 0.05$); bees belong to family Apidae was significantly higher than in Family Halictidae or Megachilidae. Although the bee abundance was not significantly different among the location, the highest bee count was recorded from Kalluthavallai. The bee abundance decreased as Kalluthavallai > Kalluwanchikudy > Onthachimadam > Koddakallur = Periyakallur. This information on bees will be useful to correct use of cultural practices to promote, enhance and protect the existing bees within the vegetable based agro-ecosystems.

KEYWORDS: Bees, Pollination, Species diversity, Sri Lanka

Introduction

Pollination is a very important process in plant reproduction and in quality seeds and fruit production of plant species including agricultural crops. Some vegetables (i.e. Cucurbits) are cross pollinated and produce well shaped and sized fruits if only when pollination occurs. Most animal-mediated pollination is based on mutualistic relationships between plants and animals (Buchmann and Nabhan, 1996; Kearns and Inouye, 1997). Both invertebrates and vertebrates working as pollinators. Invertebrates, such as ants, bees, wasps, beetles, butterflies, moths, flies, mosquitoes, and midges all act as pollinators. The most recognized pollinators are the various species of bees, which are plainly adapted to pollination (Klein *et al.*, 2007).

Improving plant diversity in agricultural fields may enhance the attraction of pollinators. It has also been understood that the presence of natural areas and organically managed buffer strips adjacent to croplands are correlated with increased pollinator diversity and the success in cropping systems. There is increasing evidence that wild pollinators are threatened by human land-use practices, exotic species, and some other factors. Loss of native habitats within agricultural landscapes may be of particular importance, because crop pollination by wild species is provided locally and is constrained by the forage ranges of pollinators. Thus understanding the magnitude, patterns and mechanisms of pollination services as well as other benefits that the ecosystems are providing to agriculture is crucial for the future of food production.

Statement of the Problem

Although the role of crop pollinators has been studied, only few baseline data are available about the species diversity of bee pollinators (Hymenoptera: Apidae) and their abundance in vegetable agro-ecosystems in Sri Lanka. Further, bee fauna in Batticaloa District has never been studied; therefore, the present research was designed to investigate the diversity of bee pollinator species and their abundance in vegetable cropping systems of Batticaloa District of Sri Lanka.

Objectives

To identify bee pollinator species associated with vegetable cropping system in Batticaloa District of Sri Lanka.

Literature review

Pollination and Pollinators

Pollination is transfer of pollen from the anther to the stigma of a flower. Pollination ensures the fertilization of plant and develops seed through pollination. There are two types of pollination occurring in plants such as self-pollination and cross pollination. Crop pollinators include a range of insects (e.g. beetles, flies, butterflies), as well as birds and bats. The majority of crops are most effectively pollinated by bees (Klein *et al.*, 2007). The relationship between bees and flowers is mutualistic, the former for food and the latter for pollination, which is a key aspect in the sexual production of plants, enabled by appropriate structural and functional characteristics. Plant-pollinator interactions are very complex and nearly three-quarters of Angiosperms rely on animal vectors to move pollen among flowers. Colour, shape, and odour are well-known characteristics of flowers partly determine the type of animal pollinators that visit them.

Bee pollinators

Bees are an ancient group of insects that originated about 120 million years ago. The specialized hairs on different parts of the body enable bees to carry pollen, making them different from all other hymenopterans. Honey bees and wild bees are considered as important pollinators (Free, 1993). Most of the bees visit flowers for food. Nectar is mostly sugar in aqueous solution, is the carbohydrate fuel for flight of pollinators, although lipids sometimes play a role. If nectar is rich the of sugar are very high, pollinators may visit fewer flowers (Pankiw *et al.*, 2001; Feldlaufer *et al.*, 2004). For example, a bat pollinated plant produces large quantities of nectar that may provide all the resource needs of a bee, but eliminate the need for the bee to visit another plant (Marten-Rodriguez *et al.*, 2009).

Diversity of bees

There are about 16,325 species of described bees in the world. Four of the seven families Colletidae, Halictidae, Megachilidae and Apidae are present in Sri Lanka. It was found that 132 species in 25

genera belong to above 4 families have been recorded in Sri Lanka (Wijesekara, 2001). Honeybee, mainly *Apis mellifera*, remain the economically most valuable pollinators of crop monocultures, worldwide (McGregor, 1976; Watanabe, 1994). However, wild bees, exactly like the much better known honey bee, are playing an important role as pollinators for lots of important horticultural crops.

Significance of bee pollinators in agriculture

Native bees show mixed responses to environmental changes. Additionally, only a few staple food crops depend on pollinator services, and most crops that are grown in small scales in diversified agro-ecosystems that are likely to support healthy pollinator communities. There can be highly managed systems that are largely independent of wild pollinators. Consequently, justifying conservation action on the basis of deteriorating pollinator services might be misplaced. Nevertheless, existing initiatives to monitor pollinators are well founded, given the uncertainty about the dynamics of pollinator populations (Ghazoul, 2005).

In most vegetable plants, seed or fruit development depends on pollination and fertilization. Pollen is also used as a source of protein by a wide spectrum of insects. It is especially important to bee species, specializing in pollen collection. In the process of collecting this valuable food source, these insects provide the pollen transportation link that many plants need for reproduction.

Threat on bees in agricultural field

Concerns have been raised that invertebrate pollinators of crops and wild plants are in decline as a result of modern agricultural practices, habitat degradation, and introduced pests and diseases (Ghazoul, 2005). The destruction and fragmentation of natural or semi-natural habitats is expected to cause reduced species richness and abundance as well as changes in species composition of pollinators in these habitats.

Various approaches have been introduced worldwide for the pollinator conservation and to increase the availability of pollinators (Southwick and Southwick 1992; Osborne *et al.*, 1991; Williams *et al.*, 1991). In Europe, preservation and management of habitats, thought suitable for bees' forage or nesting sites have been repeatedly proposed as a method to maintain or to increase pollinator numbers (Westrich, 1996). Enhancing native pollinator populations by habitat management is a potentially cost-effective option that deserves attention, and may become essential if honey bees become not readily available (Corbet, 1991).

Methodology

Bees in vegetable gardens were surveyed during September to November, 2014. The collected bees were studied in the laboratory. The vegetable agro-ecosystems located in Koddaikallar, Onthachimadam, Kaluwanchikudy, Kalluthavallai and Periyakallar areas were selected for the sampling (Table 1).

Table 1: Major vegetable crops cultivated in each sampling site

Location	Vegetable crops
Koddaikallar	Brinjal, bitterguard
Onthachimadam	Chilli, Pumpkin
Kaluwanchikudy	Chilli, Brinjal
Kalluthavallai	Brinjal, Legumes
Periyakallar	Chilli, Okra

Sampling

Bees were collected with a standard insect net for 15 minutes, following observation. Captured bees were killed in ethyl acetate fumes inside killing jars. Samples were collected from each site during morning session (9 am to 11 am) and each site was visited three times during the study period.

Species identification

Collected pollinators were identified using the keys from Karunaratne and Edirisinghe (2008). Other

pollinators were also identified using published keys and data bases. In addition, reference specimen collections of pollinators in the Insect Museum, Department of Agricultural biology, University of Peradeniya were used for confirming the identity of species. Pollinators collected during the survey were used to prepare a check list of pollinators for sampling sites. Pollinator diversity was assessed by calculating Shannon diversity index (Shannon and Weaver, 1949). Abundance of pollinators among different locations was compared using a Chi-square test.

Results and Discussion

A total of 91 bees; belonging to 27 species, 3 families in 15 genera were collected and identified during the study (Table 2)

Table 2: Number of bees collected under each genus during the field survey of Batticaloa District of Sri Lanka.

Family	Genus	Number of Bees
Apidae	<i>Apis</i>	35
	<i>Amegilla</i>	12
	<i>Braunsapis</i>	1
	<i>Ceratina</i>	2
	<i>Thyreus</i>	1
	<i>Xylocopa</i>	4
Halictidae	<i>Ceylactus</i>	6
	<i>Curvinomis</i>	1
	<i>Halictus</i>	1
	<i>Hoplonomia</i>	1
	<i>Lasioglossum</i>	5
	<i>Patellapis</i>	1
Megachilidae	<i>Coelioxys</i>	1
	<i>Lithurgus</i>	1
	<i>Megachile</i>	6
	Others	13
Total	15	91

Source : field Survey(2014)

The collected bees belonged to three families, Apidae, Halictidae and Megachilidae. Genera, *Apis* (35) and *Ceratina* (12) were the most abundant, followed by *Ceylactus*, *Megachile*, *Lasioglossum*, *Xylocopa*, and each was recorded in similar abundance (6). The lowest abundances were recorded in pollinator bee genera; *Ceratina*, *Braunsapis*, *Thyreus*, *Curvinomis*, *Halictus*, *Hoplonomia*, *Patellapis*, *Coelioxys* and *Lithurgus*.

The bee species collected during the study

Hymenoptera: Apidae

1. Genus -*Apis*

1. *Apis cerana* (Fabricius, 1793)

2. *Apis florea* (Fabricius, 1787)

2. Genus- *Amegilla*

3. *Amegilla comberi* (Cockerell, 1911)

4. *Amegilla puttalama* (Srand, 1913)

5. *Amegilla scintillans* Lieftinck, 1977

6. *Amegilla* sp.1

7. *Amegilla* sp.2

8. *Amegilla* sp.3

9. *Amegilla* sp.4

3. Genus-*Braunsapis*

10. *Braunsapis* sp.1

4. Genus- *Ceratina*-

11. *Ceratina binghami* (Cockerell, 1910)

12. *Ceratina smaragdula* (Fabricius, 1787)
5. Genus-*Thyreus*
13. *Thyreus mistriansis*
6. Genus-*Xylocopa*
14. *Xylocopa ruficornis* Fabricius, 1804
15. *Xylocopa* sp.1
16. *Xylocopa* sp.2
- Hymenoptera: Halictidae
1. Genus-*Ceylactus*
17. *Ceylactus* sp.1
18. *Ceylactus* sp.2
2. Genus-*Curvinomis*
19. *Curvinomis tridicens*
3. Genus-*Halictus*
20. *Halictus* sp.1
4. Genus-*Hoplonomia*
21. *Hoplonomia westwoodi* (Gribodo, 1894)
5. Genus-*Lasioglossum*
22. *Lasioglossum* sp1
6. Genus-*Patellapis*
23. *Patellapis* sp.
- Hymenoptera: Megachilidae
1. Genus-*Coelioxys*
24. *Coelioxys* sp.
2. Genus-*Lithurgus*
25. *Lithurgus* sp.
3. Genus-*Megachile*
26. *Megachile vigilans* Smith, 1878
27. *Megachile* sp.

Diversity of pollinators in different vegetable based agro-ecosystems

The table 3 provides the value of Shannon index and the evenness of respective sampling sites. According to the values, the highest Shannon Index ($H' = 2.017$) and Evenness (0.712) was obtained from Koddai kallar site. The decreasing trend of species diversity was, Kalluthavallai > Onthachimadam > Kalluvanchikudy > Periya kallar. Evenness seems to be decreasing due mainly to the dominance of some species within the system. The decreasing trend of evenness was, Koddai kallar > Kalluthavallai > Onthachimadam > Periya kallar > Kalluvanchikudy.

Table 3: Shannon Diversity Index and Evenness of the bee fauna in different sampling sites

Site No	Location	Value of Shannon Diversity Index(H')	Evenness(E)
1	Koddai kallar	2.017	0.712
2	Onthachimadam	1.769	0.612
3	Kalluvanchikudy	1.762	0.598
4	Kalluthavallai	1.937	0.647
5	Periya kallar	1.731	0.611

The evenness value of Periya kallar was fairly low ($E = 0.611$), where the lowest species diversity ($H' = 1.731$) was recorded.

Pollinator abundance in different vegetable agro-ecosystems

Abundance of pollinators of different insect bee families of different sampling locations. The abundance of bee species was not significantly ($\text{Chi-Sq} = 12.328$, $\text{DF} = 4$, $\text{P-Value} = 0.137$) vary among the locations.

However, the abundance of bees was significantly different ($p < 0.05$) within the sampling locations. It was found that the Family Apidae was significantly high, compared to the Family Halictidae and Megachilidae. *Apis florea* was the leading bee pollinator (35%) in all locations. Although the bee abundance was not significantly different among the locations, the highest bee count was recorded from Kalluthavallai (Figure 1). The decreasing trend of the bee abundance in different locations was Kalluthavallai > Kalluvanchikudy > Onthachimadam > Koddai kallar = Periyakallar.

Number of bees

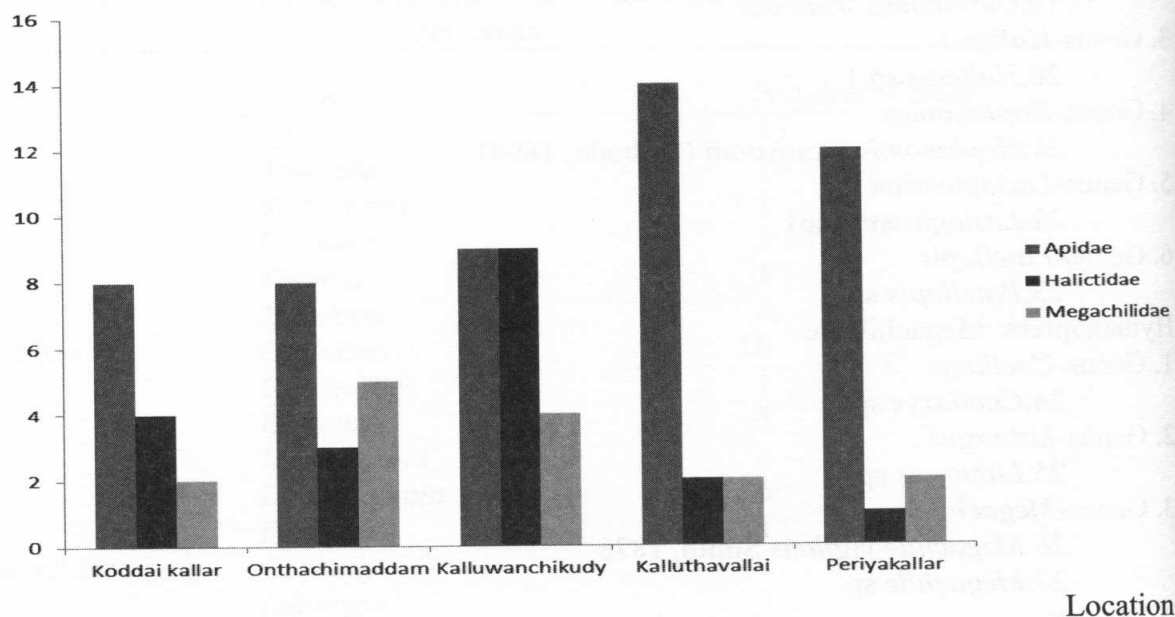


Figure 1: Variation of the abundance of bees in different sampling locations

Conclusions and recommendations

Bee fauna of Baticaloa District is comprised of three families: Apidae, Halictidae, and Megachilidae, of which family Apidae represented the largest number of collected bees. Most of them belonged to the genera *Apis* and *Amegilla*. The bee species richness is high in each location and the highest values in bee species diversity and evenness were observed in Koddai kallar area. The abundance of bee species did not significantly vary among the tested locations. *Apis florea* was the leading bee pollinator in all locations, except Koddai kallar area. However, there was a considerable proportion of bee fauna represented by wild bee species. The findings of this study are useful in the correct use of cultural practices to promote, enhance and protect the existing pollinators within the vegetable based agro-ecosystems.

References

- Buchmann, S. L. & Nabhan, G. P. (1996). The forgotten pollinators. Washington, DC: Island Press.
- Corbet, S. A. (1991). Bees and the pollination of crops and wild flowers in the European.
- Feldlaufer, M. F., Pettis, J. S., Kochansky, J. P. and Kramer, M. (2004). Residue levels in honey after colony treatment with the antibiotic tylosin. American Bee Journal. 144, 143-145.
- Free, J. B. (1993). Insect pollination of crops. 2nd edition. Academic Press, London.
- Ghazoul, J. (2005). Buzziness as usual? Questioning the global pollination crisis. Trends Ecol. Evol. 20, 367-373.
- Karunaratne, W. A. I. P and Edirisinghe, J. P (2008). Keys for the identification of common bees of Sri Lanka. Journal of National Science Foundation. 36 (1), 69-89
- Kearns, C. A., and D. W. Inouye. (1997). Pollinators, flowering plants, and conservation biology. BioScience 47, 297-307.
- Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C. and Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B-Biological Sciences 274, 303-313.
- Marten-Rodriguez, S., Almarales-Castro, A. and Fenster, C. B. (2009). Evaluation of pollination

syndromes in Antillean Gesneriaceae: Evidence for bat, hummingbird and generalized flowers. *Journal of Ecology*. 97, 348-359.

McGregor, S. E. (1976). *Insect pollination of cultivated crop plants*. U.S. Government Printing Office, Washington, DC.

Osborne, J. L., Williams, I.H., and Corbet, S.A. (1991). Bees, pollination and habitat change in the European community. *Bee World*. 72, 99-116.

Pankiw, T., K. D. Waddington, and Page, R. E., (2001). Modulation of sucrose response thresholds in honey bees (*Apis mellifera* L.): influence of genotype, feeding, and foraging experience. *Journal of Comparative Physiology a-Sensory Neural and Behavioral Physiology* 187, 293-301.

Shannon C.E. and Weaver W. (1949). *The mathematical Theory of Communication*. Urbana, University of Illinois press.

Southwick, E. E. and L. Southwick, J. R. (1992). Estimating the economic value of honey bees (*Hymenoptera: Apidae*) as agricultural pollinators in the United States. *Economic Entomology* 85, 621-633.

Watanabe, M. (1994). Pollination worries rise as honey bees decline. *Science*. 265, 1170.

Westrich, P. (1996). Habitat requirements of central European bees and the problems of partial habitats.

In *The conservation of bees* (ed. A. Matheson, S. L. Buchmann, C. O'Toole, P. Westrich & H. Williams), pp. 1-16. London, UK: Linnean Society of London and the International Bee Research Association by Academic Press.

Wijesekara, A. (2001). An annotated list of bees (*Hymenoptera: Apoidea: Apiformes*) of Sri Lanka, *Tijdschrift voor Entomologie* 144, 145-158.

Williams, I. H., Corbet, S. A. and Osborne, J. L. (1991). Beekeeping, wild bees and pollination in the European Community. *Bee World* 72, 170-180.