Comparison of Insects Species Composition in Natural, Semi-Natural and Man-Made Ecosystems at Kuttiady Village, Kozhikode District, Kerala, Southern India

S R Sreelakshmi[1] and J Roopavathy[2*]
[1] M.Sc., Student, PG and Research Department of Zoology, Nirmala College for Women (Autonomous), Coimbatore-18, Tamil Nadu
[2] Assistant Professor, PG and Research Department of Zoology, Nirmala College for Women (Autonomous), Coimbatore-18, Tamil Nadu, *E-mail: jroopavathy27@gmail.com

Abstract:

A study investigated to explore the comparison of insect species composition in natural, semi natural and Man-made ecosystems at Kuttiady village, Kozhikode district of Kerala state, Southern India. Collection of insects belonging to different order and family was made by using variety of collection equipments and methods due to the diversity in their habitate. Study was carried out at selected habitats from August 2020-January 2021. A total of 51 insect species belonging to 8 different orders and 34 different families were recorded in the study area. Among these, 23 species were identified from natural ecosystem (12 families), 17 from semi-natural ecosystem (12 families) and 11 from Man-made ecosystem (11 families). During the present investigation high species composition was recorded in natural ecosystem followed by semi-natural ecosystem whereas the minimum species composition was noticed in Man-made ecosystem. The study conclude that the natural ecosystem support the existence of rich insect species might be due to favourable environmental and habitat conditions. Therefore, the continuous monitoring and conservation of natural ecosystems is highly essential for the sustenance of rich flora and fauna.

Key Words: Insects, Natural ecosystem, Semi-natural ecosystem, Man-made ecosystem

Introduction

Biodiversity of insects means the variety or total array of different species of them that evolution has brought into existence. This is the most striking feature of insect life in the earth. This biodiversity is rather distributed heterogeneously across the earth (Ambrose, 1995). The class insecta is a huge and highly diversified group of animal Kingdom with 1.5 million species representing nearly 90% of the fauna (Mani, 1982). Till now about 8,00,000 species of living insects (Mandal, 2006) and 2,000 species of fossil insects have been recorded and yet the large number of species to be discovered in future (Tembhare, 1997). Biodiversity is the variability among living organisms from all sources including interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this include diversity within species between species and ecosystem. The members of the class -insecta are arranged in 29 orders (Grimaldi, 2005; Arillo, 2006). Four of these orders are the Coleoptera, Diptera, Hymenoptera, and Lepidoptera account for 81% of all the described species of living insects. The order Lepidoptera is one of the most species-rich groups of insects, with an estimated number of species close to 146,000 (Bakowski and Doku-Marfo, 2009).

Insects are extremely diverse and important to ecosystems (Spellerberg and Fedor, 2003) and they are what make the ecosystems tick, remarked (Samways, 1994). Understanding the extent of insect diversity is one of the major challenges in modern ecology. They have permeated the diverse and essential natural processes that sustain biological systems, making up over 75% of known species of animals. Thus, the diversity and ecological importance of insects makes them very valuable for studies of biodiversity. Similarly, Insects have great potential for understanding ecosystems and as measures of ecosystem health, but the incompleteness of knowledge and the limitation of resources increase the difficulty of work on insect biodiversity (Danks, 1996). The present study dealt the comparative short-term assessment on the species composition of insects in three different ecosystems such as natural, semi-natural and Man-made

ecosystems at Kuttiady village, Kozhikode district, Kerala. The identification was done and the insects were arranged according to their order and family.

Materials and Methods

Study Area

Present work was made in Kuttiady (Lat. 11.6543° N; Long. 75.7535° E) village, Kozhikode district, Kerala, India. Three areas were selected for the investigtion. The natural ecosystem is purely natural that is Kuttiady river side was selected for this study and their formation is not in any way influenced by human activity. Semi-natural ecosystem had retained most of original flora and fauna (grass land present in Kuttiady village). Banana plantation in same village was selected as the Man-made ecosystem. Study was carried out at selected habitats from August 2020-January 2021.

Collection of Insects

Collection of insects from different order and family is done by using variety of collection equipments and methods because of the diversity in their habitate. The flying insects such as dragonflies, butterflies, moths and wasps were collected mainly using aerial nets. The crawling and dwelling insects were collected by pitfall method (Sabu and Shiju, 2010). Also other methods like yellow pan trap (Roulston et al. 2007; Saunder and Luck, 2013), and light trap (Kato et al., 2000) were used for compleation of collection at proper time.

Identification of Insects

Pertinent details such as the binomial name of insect, collected ecosystem and other relevent data of the insect were recorded. The insects were collected and identified using the stand key (Tikader 1986) and further confirmed by taxonomist (Dr. R. Nagarajan, AVC College, Mannampandal, Mailaduthurai, Tamil Nadu, India) by analysing their morphological features and habitates. Hand lens was used for the identification process. The collected insects were photographed by using camera (Canon 50D) and Handset (Redmi note 7s).

Result

The study was conducted in three different ecosystems (i) Natural Ecosystem, (ii) Semi-Natural Ecosystem, (iii) Man-made Ecosystem in Kuttiady village, Kozhikode district, Kerala. A total of 51 insect species belonging to 8 orders and 34 families were recorded in the study area. Among these, 23 species (Fig. 1) were identified from Natural ecosystem (12 families), 17 species (Fig. 2) from Semi-natural ecosystem (12 families) and 11 species (Fig. 3) from Man-made ecosystem (11 families).

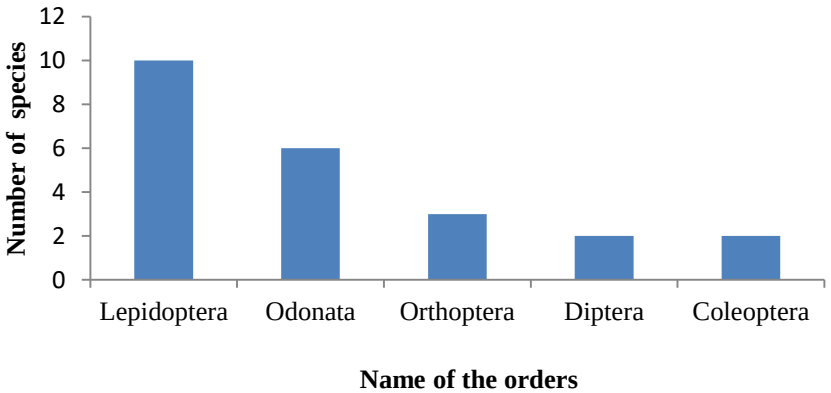

Fig. 1 Order-wise distribution of identified insect species in natural ecosystem

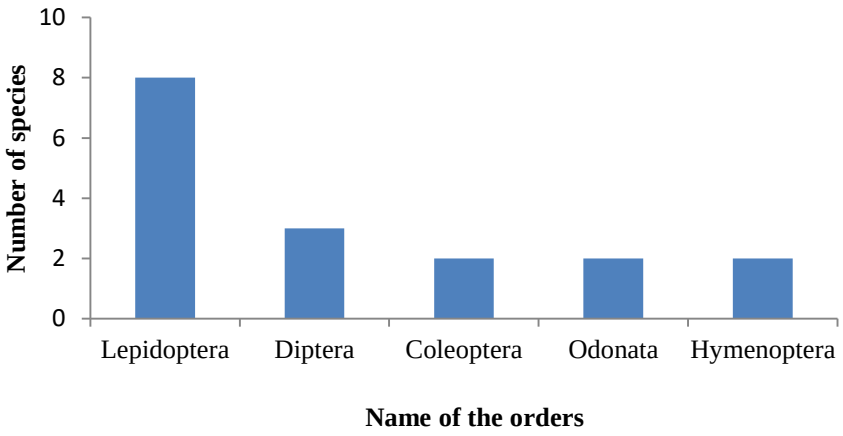

Fig. 2 Order-wise distribution of identified insect species in semi-natural ecosystem

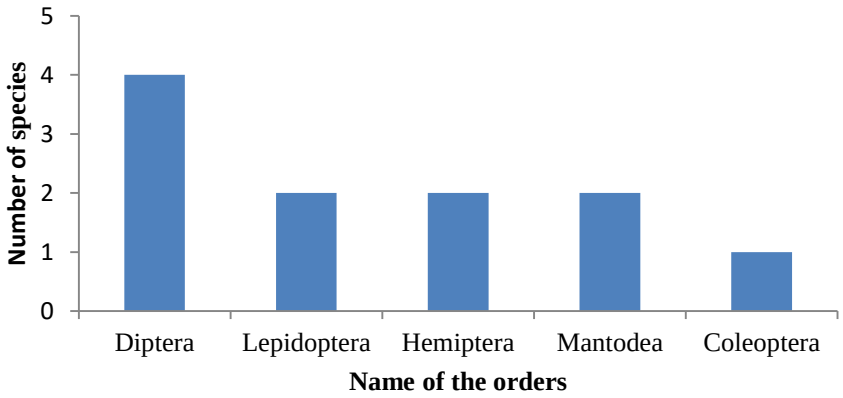

Fig. 3 Order-wise distribution of identified insect species in man-made ecosystem

During the present investigation high species composition (23 species) was recorded from Natural ecosystem (Table 1). Semi-natural ecosystem results the second highest species composition (17 species) (Table 2). Minimum number of species composition (11 species) were recorded in Man-made ecosystem (Table 3).

Compare to other two ecosystems maximum number of insects are identified from natural ecosystem (Kuttiady river side). Total of 23 species are recorded from 5 orders (Fig. 4) and 12 different families. From this 5 orders, Lepidoptera was the highest order in natural ecosystem, 10 species are belongs to this order. There are three families namely Nymphalidae, Pieridae and Riodinidae were reported in Lepidoptera. Most of the species represent the family Nymphalidae (7 species) and 2 species are in family Pieridae. Only a single species was represent the family Riodinidae. The second largest order in natural ecosystem is Odonata. It comprised total 6 species from two different families. In these two families, Libellilidae was the highest family with 5 species and family Gomphidae with a single species. Order Orthoptera contain three species each from three different families, they are Tettigoniidae, Rhaphidophoridae, and Acrididae.

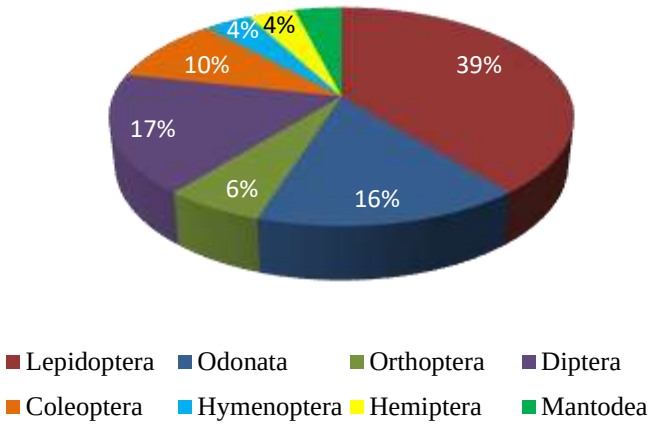

Fig. 4 Percentage composition of insects in natural, semi-natural and man-made ecosystems

Diptera and Coleoptera contain two species each, which belonging to different family. The species from the order Diptera represent the family Micropezidae and Celyphidae and the species from Coleoptera represent the family Coccinellidae and Curculionidae (Table 1).

Table 1: Species composition of insects from natural ecosystem

Sl. No.	Common Name	Scientific Name	Order	Family
1.	Common evening brown	*Melanitis leda*	Lepidoptera	Nymphalidae
2.	Pallas sailor	*Neptis sappho*	Lepidoptera	Nymphalidae
3.	Common sailor	*Neptis hylas*	Lepidoptera	Nymphalidae
4.	Grey count	*Tanaecia lepidea*	Lepidoptera	Nymphalidae
5.	Medus brown	*Orsotriaena medus*	Lepidoptera	Nymphalidae
6.	Common crow	*Euploea core*	Lepidoptera	Nymphalidae
7.	Common fourring	*Ypthima huebneri*	Lepidoptera	Nymphalidae
8.	Common grass yellow	*Eurema hecabe*	Lepidoptera	Pieridae
9.	Psyche	*Leptosia nina*	Lepidoptera	Pieridae
10	Twospot plum judy	*Abisara bifasciata*	Lepidoptera	Riodinidae
11.	Slender skimmer	*Orthetrum sabina*	Odonata	Libellulidae
12.	Pied paddy skimmer	*Neurothemis tullia*	Odonata	Libellulidae
13.	Ditch jewel	*Brachythemis contaminata*	Odonata	Libellulidae
14.	Crimson tailed-marsh hawk	*Orthetrum pruinosum*	Odonata	Libellulidae
15.	Blue tailed forest hawk	*Orthetrum triangulare*	Odonata	Libellulidae
16	Indian common clubtail	*Ictinogomphus rapax*	Odonata	Gomphidae
17.	Asian bush Cricket	*Ducetia* sp.	Orthoptera	Tettigoniidae
18.	Camel cricket	*Rhaphidophora* sp.	Orthoptera	Rhaphidophoidae
19.	Unknown	*Traulia* sp.	Orthoptera	Acrididae
20.	Stilt-legged fly	*Rainieria antennaepes*	Diptera	Micropezidae
21.	Metallic blue beetle fly	*Spaniocelyphus palmi*	Diptera	Celyphidae
22.	Hadda beetle	*Henosepilachna vigintioctopunctata*	Coleoptera	Coccinellidae
23.	Palm weevil	*Rhynchophorus* sp.	Coleoptera	Curculionidae

The semi-natural ecosystem comprise second largest number of species composition. Totally 17 species were identified from this ecosystem belongs to 5 orders and 12 different families. Like natural ecosystem, semi-natural also contains highest number of species in the order Lepidoptera (8 species). In this order both the family Papilionidae and Erebidae provide three different species and two species are from the family Geometridae. The order Diptera was the second largest order followed by order Lepidoptera which contain three species from three different families such as Stratiomyidae, Muscidae and Diopsidae.

The species belongs to order Coleoptera, Odonata and Diptera are also present in semi-natural ecosystem. Coleoptera contain two species from the families Chrysomelidae and Lampyridae and Odonata with two species from family Libellulidae and Coenagrionidae. Family Pompilidae and Evaniidae are the two families in the order Hymenoptera, both of them are contain a single species of organism (Table 2).

Table 2: Species composition of insects from semi-natural ecosystem

Sl. No.	Common Name	Scientific Name	Order	Family
1.	Indian blue Mormon	*Papilio polymnestor*	Lepidoptera	Papilionidae
2.	Common Mormon	*Papilio polytes*	Lepidoptera	Papilionidae
3.	Common blue bottle	*Graphium sarpedon*	Lepidoptera	Papilionidae
4.	Clearwing wasp moth	*Syntomoides imaon*	Lepidoptera	Erebidae
5.	Footman moth	*Nepita conferta*	Lepidoptera	Erebidae
6.	Banded tiger moth	*Rajendra perrottetii*	Lepidoptera	Erebidae
7.	Wave moth	*Scopula* sp.	Lepidoptera	Geometridae
8.	Blue tiger moth	*Dysphania percota*	Lepidoptera	Geometridae
9.	Iridescent centurion	*Sargus iridatus*	Diptera	Stratiomyidae
10.	Stable fly	*Stomoxys* sp.	Diptera	Muscidae
11.	Stalk-eyed fly	*Teleopsis pallifacies*	Diptera	Diopsidae
12.	Oides (leaf beetle)	*Oides affinis*	Coleoptera	Chrysomelidae
13.	Winter firefly	*Ellychnia corrusca*	Coleoptera	Lampyridae
14	Yellow –patched lieutenant	*Brachydiplax chalybea*	Odonata	Libellulidae
15	Orange-tailed marsh dart	*Ceriagrion cerinorubellum*	Odonata	Coenagrionidae
16	Unknown	*Pepsis* sp.	Hymenoptera	Pompilidae
17.	Ensign wasp	*Evania appendigaster*	Hymenoptera	Evaniidae

The minimum number of species are identified from Man-made ecosystem. Totally 11 species from 5 orders and 11 families were recorded. Diptera was the order that share highest number of species (4 species) from four different families. Family Psychodidae contain 1 species, likewise each of the family Dolichopodidae, Stratiomyidae and Callipharidae share one individual species. The order Lepidoptera, Hemiptera and Mantodea, are the other orders with same number of species. Lepidoptera contain family Lycaenidae and Uraniidae, and both provide single species of organism. Hemiptera contain family Cercopidae and Pyrrhocoridae both of them with one insect species. Likewise order Mantodea share one species from each of the family Mantidea and Hymenopodidae. Comparatively order Coleoptera contain less number of species in Man-made ecosystem. In order Coleoptera there was only one family Erotylidae with a single species was present (Table 3). Among the total 51 species collected from three ecosystems, Lepidoptera (39%) was found to pre-dominate followed by Diptera (17%), Odonata (16%), Coleoptera (10%), Orthoptera (6%), Hemiptera, Hymenoptera and Mantodea (4% each).

Table 3: Species composition of insects from Man-made ecosystem

Sl. No.	Common Name	Scientific name	Order	Family
1.	Drain fly	*Psychoda alternata*	Diptera	Psychodidae
2.	Unknown	*Condylostylus* sp.	Diptera	Dolichopodidae
3.	Unknown	*Ptecticus* sp.	Diptera	Stratiomyidae
4.	Bottle fly	*Calliphora* sp.	Diptera	Callipharidae
5.	Common pierrot	*Castalius rosimon*	Lepidoptera	Lycaenidae
6.	Asian spotted swallow tail moth	*Micronia aculeata*	Lepidoptera	Uraniidae
7.	Spittle bug	*Phymatostetha deschampsi*	Hemiptera	Cercopidae
8.	Red bug	*Dindymus rubiginosus*	Hemiptera	Pyrrhocoridae
9.	Asian mantis	*Hierodula patellifera*	Mantodea	Mantidea
10	Flower mantis	*Creobroter* sp.	Mantodea	Hymenopodidae
11.	Pleasing fungus beetle	*Megalodacne* sp.	Coleoptera	Erotylidae

Discussion

The present study showed that a total of 51 insect species belonging to 8 orders and 34 families were recorded in the study area. From these, 23 species were identified from Natural Ecosystem (12 families), 17 from Semi-Natural Ecosystem (12 families) and 11 from Man-made Ecosystem (11 families). Total of 8 orders in which Lepidoptera is the dominant order (39%) and Hymenoptera, Hemiptera and Mantodea are the least dominant order (4%).

Compare to other two ecosystems maximum number of insects are identified from natural ecosystem (Kuttiady river side). Total of 23 species are recorded from 5 orders and 12 different families. From this 5 orders, Lepidoptera is the highest order in natural ecosystem, 10 species are belongs to this order. There were three families are founded in Lepidoptera they are Nymphalidae, Pieridae and Riodinidae. Most of species represent the family Nymphalidae (7 species) and 2 species are in family Pieridae. Only a single species is represent the family Riodinidae. The second largest order in natural ecosystem is Odonata. It comprise total 6 species from two different families. In this two families, Libellilidae is the highest family with 5 species and family Gomphidae with a single species. Order Orthoptera contain three species each from three different families, they are Tettigoniidae, Rhaphidophoridae, and Acrididae. Diptera and Coleoptera contain two species each, which belonging to different family. The species from the order Diptera represent the family Micropezidae and Celyphidae and the species from Coleoptera represent the family Coccinellidae and Curculionidae (Table 1).

In the present study the highest number of insects were recorded belongs to the order Lepidoptera. Among the 51 species recorded from three ecosystems, 20 species belongs to Lepidoptera. Eight different families were noticed from the order Lepidoptera. Among this more number of species falls under the family Nymphalidae. Similarly, authors (Usha and Vimala, 2015) have documented a total of 529 individual insects belonging to 9 order and 38 families and 58 species. The most dominant orders were Coleoptera and Lepidoptera and the least dominant one were Phasmida. Authors (Singh and Chib, 2014) prepared the preliminary checklist of butterflies that recorded 125 species from 78 genera belong to 5 families. In the current study, a banana plantation was selected as the Man- made ecosystem which also accounted only less number of butterfly species than the natural ecosystem. Studies conducted on man-made ecosystem of Sikkim, produced similar result (Chettri *et al.*, 2018).

A total of 51 species were collected from three ecosystem, of which 20 species belongs to the order Lepidoptera. Among this 14 species are butterflies and 6 species are moth. It may be due to adaptation and habitat preference of the species. Similar result made by (Mathew *et al.*, 2004). They identified 301 species of insects, collected from Sanctuary and these include 202 species of butterflies and moth. In Hymenoptera six wasp and three bee species were recorded from the sanctuary. In the present study, semi-natural ecosystem results two wasp and none of the bee species in three ecosystem. Veenakumari *et al.* (1997) studied insect diversity in the mangroves of Andaman and Nicobar island of India and reported the following results: Lepidoptera-50%, Coleoptera-20%, Hemiptera-15%, Diptera-5%, Hymenoptera-3%, Orthoptera-5%, Thysanoptera-2%. The result revealed by the above study is almost similar to that of the present study, which estimate: Lepidoptera-39%, Diptera-17%, Odonata-16%, Coleoptera-10%, Orthoptera-6%, and Hemiptera, Hymenoptera, Mantodea are 4% respectively.

Bhaskar Jyoti Das et al. (2018) have made a diversity study on insects pollinators of rabi crops cultivated in surrounding areas of Barpeta town in Assam, India. The result revealed that Lepidoptera were found to be more diverse followed by Hymenoptera. Diptera as well as Coleoptera showed less diversity. By comparing the result of above data with present study Hymenoptera was less dominant, which constitute only 4% of total collected population. Diptera and Coleoptera take up second and fourth position respectively. Maneechan *et al.* (2015) studied about diversity and distribution of aquatic insects in streams of the Mae Klong watershed, Western Thailand. Overall, 11,153 individuals belonging to 64 families and nine order were examined. Among the aquatic insects collected from the three streams, the order Trichoptera was most diverse in numbers of individuals, followed by Ephemeroptera, Hemiptera, Odonata, Coleoptera, Diptera, Placoptera, Megaloptera and Lepidoptera. The present study was conducted differently from the above study, focusing on diversity of insects in terrestrial ecosystem. But the result also contain some of the orders that mentioned above for example Hemiptera, Odonata, Coleoptera, and Diptera.

Pamungkas (2015) have reported the diversity and distribution of dragonflies (Odonata) in Bromo forest area Central Java. Authors reported 21 species from Bromo forest area. Among these, Libellulidae was the richest family with 12 species and Orthretum was the most common genera. During the course of present study Odonata identified as third dominant order (16 %). Eight species are collected from three ecosystem

and they belongs to three different families. Libellulidae was the dominant family with 6 species. Bose and Kakkassery (2019) studied the diversity and abundance of Odonata in three different geographical division in Kerala indicating that maximum species richness was observed in the eastern highlands, followed by central midlands and western coastal plains. The maximum values of diversity indices were recorded from eastern highlands, followed by central midlands and western coastal plains (Bose and Kakkassery, 2019). Likewise in the present study maximum number of Odonata species were present in Natural ecosystem followed by Semi natural ecosystem. They were absent in Human modified ecosystem.

Banerjee (2014) reported the diversity and comparison of beetles (Order: Coleoptera) of Durgapur, West Bangal, India. The study conducted in three different site (college campus, township area and wetland). The second site showed the highest diversity of beetles and it is also noted that the highest diversity was found during monsoon in all three sites. Present study showed 10% of coleopteran and equal contribution of both the Natural and Semi-natural ecosystem. When compared to other two ecosystems, Man-made ecosystem contain less number of species in Coleoptera. Thakkar *et al.* (2015) have conducted a study on diversity of Orthoptera fauna in South Gujarat, India. A total of 45 species belonging to 33 genera under 7 families were recorded. The family Acrididae was found to be the most dominant and was represented with 18 species, second dominant family was Tettigonidae and Gryllidae with 9 species. Pygromorphidae stood at third rank with 3 species and family Tetrigidae, Gryllotalpidae and Rhaphidophoridae was represented by 2 species each. In the present study 3 species are collected from Natural Ecosystem which belongs to the family Tettigoniidae, Acrididae and Rhaphidophoridae. Orthoptera is the fifth dominant order (6%) in overall collection.

Ramar *et al.* (2018) have reported the biodiversity of insects and distribution pattern from Sirumallai hills, Eastern Ghats, Tamil Nadu, South India. In this study the total of 9 taxa belonging to hemiptera (true bugs), coleopteran (beetles) and odonata (dragonfly) were collected in all the three sites. Hemipteran group contributed 62% of the total community, while the values coleoptera and odonata were 33 and 5%. The present study collected more numbers of order and the orders that mentioned above contains 4% (Hemiptera), 10% (Coleoptera) and 16% (Odonata) respectively. Similar studies are reported by Cheng and Kirton (2007) on overview of insect biodiversity research in Peninsular Malaysia. Result mainly focused on diversity of only a few major insect orders, such as Lepidoptera (butterflies and moth), Isoptera (termites) and Phasmida (stick insects). Little is known of other important insect orders, such as Coleoptera (beetle), Hymenoptera (bees, wasps and ants), Diptera (flies) and Hemiptera (bugs).

El-Moursy *et al.* (2001) recorded insect diversity in Zaranik Protectorate, Northern Sinai, Egypt. In the result 34% of the known faunal richness is accounted for by order Coleoptera (63 species), Diptera or flies comprises (16%), Lepidoptera (12%), Hymenoptera (9%), Heteroptera (8%), Orthoptera (6%), and Neuroptera (5%). The other insect order made up 9.6% of all recorded species. Gerlach *et al.* (2013) collected a total of 120 species under 98 genera in 37 families of insects from industrial and non- industrial areas of West Bengal, India. Binary data of 5 orders revealed that the species richness of Hemiptera, Orthoptera and Lepidoptera is higher in non-industrial zone in comparison to that of industrial zone. Aculeate Hymenoptera shows no particular trend whereas Coleoptera shows higher species richness in industrial areas. Likewise the present study shows higher number of Lepidoptera species in Natural Ecosystem and it is comparatively less in Human modefied ecosystem it's may be due to the usage of pesticides to control pest like black sigatoka. The species in the order Lepidoptera and Odonata cannot survive in this situation.

Insects form an important part of the food chain, especially for many amphibians, birds, mammals and reptiles because they are found almost in each habitat (Contreras and Vlisidou, 2008). Foottit and Adler (2009) explained that, in many food webs and food chain lengths insects dominate, and have a big importance due to their diversity, ecological roles and influence on the agriculture, natural resources and human health. Characteristically, insects are the dominant constituent of biodiversity in terrestrial ecosystems and play imperative roles in ecosystem processes, they cycle nutrients, pollinate plants, disperse seeds, maintain soil structure and fertility, control populations of other organisms, provide a major food source for other taxa (Babin-fenske and Anand, 2010). Furthermore they maintain the

structure and composition of ecosystem (Adjaloo, 2012). Present study yield valuable information of insect species composition in the difference ecosystems. This short-term data will be helpful for researchers to study on this topic.

Conclusion:

The present study inferred that the natural ecosystem significantly support the existence of rich insects species composition when compared to both semi-natural and man-made ecosystem. The study conclude that the prevailing environmental and habitat conditions occurring in the natural ecosystem is favourable to the occurrence of high insects species composition. The findings of the present study can be suggested that the natural ecosystems should be conserved for the sustainable production of insects.

Acknowledgements:

We are gratefully acknowledge the Head, Department of Zoology, Principal and authorities of Nirmala College for Women (Autonomous), Coimbatore-18, for the facility provided.

Conflicts of interest:

We declare that we have no conflict of interest

References

I. Adjaloo M K, Oduro W, Mochiah M B, 2012, Spatial distribution of insect assemblage in cocoa farms in relation to natural forest, *Journal of Applied Bioscience*, Volume 54 pp 3870-3879.

II. Ambrose D P, 1995, Insect diversity and conservation, *Zoo's print*, pp 9-11.

III. Arillo A, Engel M S, 2006, American Museum Novitates, 3539 pp 1-10.

IV. Babin-fenske J, Anand M, 2010, Terrestrial insect communities and the restoration of an industrially perturbed landscape: Assessing Success and Surrogacy, *Journal of Restoration Ecology*, Volume 18 pp 73-84.

V. Bakowski M and Doku-Marfo E, 2009, A Rapid Biodiversity Assessment of the Ajenjua Bepo and Mamang River Forest Reserves. *Conservation International*, pp 30-33.

VI. Banerjee M, 2014, Diversity and Composition of Beetles (Order: Coleoptera) of Durgapur, West Bengal, India. *Psyche*, http://dx.doi.org/10.1155/2014/792746: 1-6.

VII. Bose, N C and Kakkassery K, 2019, Study on the diversity and abundance of Odonata in three different geographical divisions in Kerala. Biodiversity of Kerala after Deluge-Concerns, *International Journal of Scientific Research and Reviews*, Volume 8(1) pp 2373-2381.

VIII. Chettri P K, Sharma K, Dewan S and Acharya B K, 2018, Butterflies diversity in human modified ecosystem of Southern Sikkim, the eastern Himalaya, India, Journal of Threatened Taxa, Volume 10(5) pp 11551-11565.

IX. Contreras MS, Vlisidou I, 2008, The diversity of insect-bacteria interactions and its applications for disease control, Biotechnology Genetic Engineering Reviews, Volume 25 pp 203-244.

X. Danks H V, 1996, How to assess insect biodiversity without wasting your time. Biological Survey of Canada (Terrestrial Arthropods), Document series, No.5, 1G12, pp 22.

XI. Das B J, Paul K, Baruah N and Basumatary B K, 2018, Diversity study of insect pollinators of Rabi crops cultivated in surrounding areas of Barpeta town in Assam, India, International Journal Research and Analytical Reviews, Volume 5 (4) pp 172-177.

XII. El-Moursy AM, El-Hawagry M, Abdeldayem, Fadl H, 2001, Insect diversity in Zaranik Protectorate, Northern Sinai, Egypt.Egyptian Journal of Natural History, Volume 3, pp 62-80.

XIII. Foottit RG, Adler PH, Insect biodiversity science and society. Wiley-Blackwell, Oxford, UK, 2009.

XIV. Gerlach, J., Samways, M., and Pryke, J. (2013). Terrestrial invertebrates as bioindicators: An overview of available taxonomic groups. *Journal of Insect Conservation*, Volume 17 pp 831–850.

XV. Grimaldi D A and Engel M S, 2005, Evolution of the insects. Cambridge University press, New York. 2005.

XVI. Kato M, Itioka T, Sakai S, Monose K, Yamane S, Hamid AA, Inoue T, 2000, Various population fluctuations patterns of light attracted beetle in a tropical lowland dipterocarp forest in Sarawak, *Popular Ecology*, Volume 42 pp 97-104.

XVII. Mandal DK Ray S, 2006, An introduction to bio-diversity In: Bio-diversity and Biotechnology, Ray S, Ray A K (Eds.), Tembhare D B. Modern Entomology. Himalaya Pub. House, Mumbai. 1997.

XVIII. Maneechan W and Prommi T O, 2015, Diversity and Distribution of Aquatic Insects in Streams of the Mae Klong Watershed, Western Thailand, Psyche, 2015; http://dx.doi.org/10.1155/2015/912451: 1-7.

XIX. Mathew. G, Chandran R, Brijesh C M and Shamsudeen R S M, 2004, Insect fauna of shendurny wildlife sanctuary, Kerala, *Zoo's Print Journal*, Volume 19(1) pp 1321-1327.

XX. Pamungkas D W, Ruspendi E C A and Ani I L, 2015, Diversity and distribution of dragonflies (Odonata) in Bromo forest area, Central Java In: Exploration and Conservation of Biodiversity.

XXI. Ramar M, Mahendran M, Kamalakannan S, Jayakumar E, Anbalagan V, Murugan K, 2018, Biodiversity of insects and distribution pattern from Sirumallai hills, Eastern Ghats, Tamil Nadu, South India, *Journal of Biodiversity and Environmental Science*, volume 2(6) pp 495-498.

XXII. Roulston T A H, Smith S A and Brewster A L, 2007, A comparison of pan trap and intensive net sampling techniques for documenting a bee (Hymenoptera: Apiformes) fauna., *Journal of the Kansas Entomological Society*, Volume 80(2), pp 179-181.

XXIII. Samways M J, 1994, Insect Conservation, *EOLSS Publications.*

XXIV. Saunder M E and Luck G W, 2013, Pan trap catches of pollinators Insects vary with habit, *Australian Journal of Entomology*, 2013; 52:106-113.

XXV. Singh I J and Chib M, 2014, A preliminary checklist of butterflies (Lepidoptera: Rhopalocera) of Mendrelgang, Tsirang district, Bhutan. *Journal of Threatened Taxa*, Volume 6(5) pp 5755-5768.

XXVI. Spellerberg I F and Fedor P J, 2003, A tribute to Claude Shannon (1916- 2001) and a plea for more rigorous use of species richness, species diversity and the 'Shannon- Wiener' Index. *Global Ecology and Biogeography*, Volume 12 (3) pp 177-179.

XXVII. Thakkar B, Parmar S, Parikh P, 2015, Study on diversity of orthoptera fauna in South Gujarat, India, *International Journal of Pure and Applied Zoology*, Volume 3 (4) pp 368-374.

XXVIII. Tikader, 1986, Manual: Collection, Preservation and Identification of Insects and Mites of Economic Importance, pp 1-295.

XXIX. Usha A U I and Vimala K. John, 2015, A study on Insect diversity of a selected area in wadakkanchery district, Thrissur, Kerala. *The Journal of Zoological Studies*, Volume 2(3) pp 38-50.

XXX. Veenakumari, K., Mohanraj, P., and Bandyopadhyay, A. K. (1997). Insects herbivore and their natural enemies in mangals of the Andaman and Nicobar islands. *Journal of natural history* Volume 31 pp 1105-1226.