International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 1549-1557

Received: 18-11-2020
Accepted: 27-12-2020

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Biodiversity of Lepidoptera fauna in horticultural ecosystem in RVSAC-Usilampatti, Thanjavur

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DOI: https://doi.org/10.22271/chemi.2021.v9.i1v.11445

Abstract
Biodiversity is a function of the number of the any taxon present, the evenness with which the taxons are distributed (species evenness or family evenness) and the interaction component of richness and evenness. The present investigation was carried out to study the arthropod biodiversity in Horticulture ecosystem at RVS Agricultural College, Thanjavur, India. The farm lies between 10.6796° N latitude and 78.9194° E longitude with an altitude of 426.7M above MSL. The insect collections were done in both Agri-Horticultural crops (Maize, Castor, Thenai, Cotton, Mango, Sapota, Coconut, Guava and some weeds). In the study, a total of 39 fauna species (butterflies) were recorded in horticultural ecosystem under 39 genera, 14 families and 1 order were observed in the horticultural ecosystem. Among the insect families, the family Nymphalidae consists of many species followed by Noctuidae. It was also recorded a total of 11 species under the family Nymphalidae followed by Noctuidae (10 species). Among the different functional groups, a diversity of a herbivores and tourist was maximum and comprised of 27 species under herbivores and 13 species under tourists. Species richness and diversity index were calculated for comparison within weekly collection and to know the variance between lepidopteron species. It was concluded that the species richness of herbivores and tourist were found to be abundant during winter 2018 and summer 2019.

Keywords: Lepidoptera, relative abundance, diversity index and species richness

Introduction
Insects have important role in the ecosystems as herbivores, pollinators, nutrient cyclers, regulating populations of other organisms and feeding on or serving as food for other species (Losey *et al.*, 2006) [1]. The tropical regions are known for their richness of species diversity (Mathew *et al.*, 1993) [2].

Lepidoptera (butterflies and moths) is one of the most prevalent terrestrial orders, and perform essential ecosystem services such as decomposition, nutrient cycling, pollination and providing prey for passerine birds (Jaroensutasinee *et al.*, 2011) [3].

Butterflies are monophyletic groups but moths are paraphyletic groups within the Lepidoptera. The diversity of Lepidoptera depends on the adaptability of a species to a particular habitat as the most significant biological elements of an ecosystem are through the dimension, diversity of species and population size (Kumar, 2013) [4].

The role of insects in the maintenance of essential life support systems in natural habitats is well recognized. The role of insect in the maintenance of essential life support systems in natural habitats is well recognized (Wells *et al.*, 1983).

At present about 80 percent of the world's known animals are insects, and lepidopterans account s for 1,12,000 species, which include both butterflies and moths (Gunathilagaraj *et al.*, 1998) [6]. Lepidopteran insects are of diversified nature and they occur both as crop pests and pollinators.

Review of Literature
Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure (Beals, 1999) [7].

Varshney (1983) [8] reported that a list of 1,150 butterfly species with their common and scientific names. He assembled all known common names of butterflies as well as shown their present valid scientific names along with family names.

Kumar (2011) [9] worked on butterfly's abundances Bundelkhand. Nine hundred and forty eight individuals of butterflies collected from various study sites, which include 29 genera and 38 identified species belonging in six families Nymphalidae-Brush-footed Butterfly family was the most dominant with 11 species followed by Pieridae-White and yellows (10), Lycaenidae-Blues (6), Danaidae-The tigers (4), Hespiridae-Skippers (4), Papilionidae-Swallotails (3).

Reddy *et al*. (1990) [10] Studied pollination of *Celerodendrum infortunatum* (Verbenacae) by butterflies. This plant flowers from February to April and during 06.00 to 07.00 hr they offer nectar and pollen to insects. A total 17 species of insects are found foraging at the flowers diurnally. Of these three were bees, 13 butterflies and one hawk moth. Authors studied the nectar volume of flowers and proboscis length of butterflies.

Materials and Methods

Biodiversity of lepidoptera fauna in Horticultural ecosystem

The present investigation was carried out to study the Lepidoptera biodiversity in horticultural ecosystem at RVS Agricultural college-Thanjavur, India. The various methodologies followed for collection, preservation, identification of lepidoptera, diversity analysis are presented in this chapter.

Experimental details

The farm lies between 10.6796° N latitude and 78.9194° E longitude with an altitude of 426.7M above MSL. The insect collections were done in Horticultural crops (Maize, Castor, Thenai, Cotton, Mango, Sapota, Coconut, Guava and some major weeds).

Mode of assessment

Method of sampling of lepidoptera species

The Arthropod fauna species were collected in the early hours of the day in the main field (8 -10 hrs) at weekly intervals by using different methods of collection *viz.*, insitu and net sweeping (Hassan *et al.*, 1995) [11] and the details are presented as below.

Net sweeping method

Above ground lepidoptera pests and predator species were trapped in sweep net (32 cm diameter and 70 cm height) and were monitored. Sampling was done by net sweeping method in zig zag manner at the rate of five sweepings. The data was used to calculate the inventory of fauna Lepidoptera community.

Preservation of lepidoptera fauna

The collected insects were killed by chilling injury and these specimens were sorted, pinned, labelled and mounted in wooden boxes (Uniyal and Mathur, 1998) [12]. The method described by Tikader and Bal (1981) [13] was followed for the preservation of the field collected soft bodied insects. The lepidoptera collected by various methods were brought to the laboratory and killed by chilling injury.

Diversity analysis

1. *Shannon-Wiener function (H)*

A function devised to determine the amount of information in a code or signal, and defined:

$$H = -\sum_{i=1}^{S_{obs}} p_i \log_e p$$

where pi = the proportion of individuals in the ith species; or in terms of species abundance:

$$H = \log_e N - \frac{1}{N}\sum_{i=1}^{\infty}(p_i \log_e p_i)n_i$$

where ni = the number of species with i individuals. The information measure is nits for base e and bits per individual for base 2 logarithms.

2. Simpson index (D)

A diversity index proposed by Simpson (1949) [15] to describe the probability that a second individual drawn from a population should be of the same species as the first. A similar type of index had a few years earlier been proposed by G. Yule to compare an author's characteristic vocabulary (frequency of different words in his writings). The statistic, C *(or Y)* is given by:

$$C = \sum_{i}^{S_{obs}} {p_i}^2 \quad {p_i}^2 = \frac{N_i(N_i - 1)}{N_T(N_T - 1)}$$

where Ni is the number of individuals in the ith species and NT the total individuals in the sample.

3. Margalef D

$$D = \frac{(S-1)}{\ln N},$$

where S is species number and N the total number of individuals in the sample.

4. Fisher's

This is a parametric index of diversity that assumes that the abundance of species follows the log series distribution:

$$\alpha x, \frac{\alpha x^2}{2}, \frac{\alpha x^3}{3}, \ldots\ldots \frac{\alpha x^n}{n}$$

where each term gives the number of species predicted to have 1,2,3,….n individuals in the sample. This is a useful index, which has been widely used. To test if a log series distribution is appropriate see 'Fitting distributions' below.α is estimated by an iterative procedure that may take an appreciable amount of time with large data sets.

5. Whittaker's

$$\beta_w = S/\alpha - 1,$$

where S = the total number of species and α the average species richness of the samples. All samples must have the same size (or sampling effort).

6. Cody's

$$\beta_c = \frac{g(H) + l(H)}{2},$$

where g(H) is the number of species gained and l(H) the number lost moving along the transect.

7. Routledge's br

$$\beta_R = \frac{S^2}{2r + S} - 1,$$

where S is the total species number for the transect and r the number of species pairs with overlapping distributions.

8. Routledge's bi

$$\beta_I = \log(T) - \left[\left(\frac{1}{T}\right)\sum e_i \log(e_i)\right] - \left[\left(\frac{1}{T}\right)\sum \alpha_i \log(\alpha_i)\right],$$

where ei is the number of samples along the transect in which species i is present and α the species richness of sample i and T is ei.

9. Routledge's be

$$\beta_E = \exp(\beta_I) - 1.$$

10. Wilson and Schimida's

$$\beta_T = \frac{[g(H) + l(H)]}{2\alpha},$$

5. Relative abundance

It measures the percentage of individuals over all the species. It was measured by the formula,

$$R = \frac{a}{N} X\ 100$$

Singh and Rai, 2000) [23]

Where,
R = Relative abundance
a = Total population of a particular species/taxon
N = Total population of all the species/taxon

Statistical analysis

The number of butterfly species (S), the number of individuals for each species (N), α- and β-diversity indexes were calculated. The α-diversity was calculated from various indices including the Shannon-Wiener diversity index (H) (Shannon, 1948) [14] that measures the species diversity within the community of an ecosystem (Sagar and Sharma, 2012) [24], Margalef index (d) that provides a measure of species richness, and Simpson index (D) that gives the species dominance. As the D index increases, the diversity decreases and for this reason we also calculated the form 1-D. In addition, as a measure of Fisher alpha index and species richness was calculated and all these indexes were calculated using "Species diversity & Richness" software developed by Dr. R. M. H. Seaby and Dr. P.A. Henderson (2006) [26] - Pisces Conservation Ltd-2001 Version 2.65 available at web link http://www.irchouse.demon.co.uk/

Results and Discussion

Inventory of lepidoptera fauna in Horticultural ecosystem

Lepidopteran insects were collected (Butterflies and moths) at weekly intervals during winter 2018 and summer 2019 from Horticultural ecosystem were identified to the extent of possible taxons and are presented in table 1 and Plate 1. Total of 39 fauna species (butterflies) were recorded in horticultural ecosystem under 29 genera, 14 families and 1 order were observed in the horticultural ecosystem. Among the insect families, the family Nymphalidae consists of many species followed by Noctuidae. It was also recorded a total of 11 species under the family Nymphalidae followed by Noctuidae (10 species). Among the different functional groups, a diversity of an herbivores and tourist was maximum and comprised of 27 species under herbivores and 13 species under tourists.

Relative abundance

The weekly collection and inventory of lepidoptera fauna in agricultural land horticultural ecosystem was given in table 3. Survey was conducted from 1st week and continued up to 8th week. A total number of 39 individual species were recorded in horticultural ecosystem respectively comprising 13 species as tourist and 27 species as herbivores. It was found that the relative abundance of *Achraea violae* was more (27.9%) followed by *Delias eucharis* (12.29%) while a lower relative abundance was recorded in *Danaus sp., Junonia almona, J.lemonias, Papilio polytes, Delias eucharis, Hebomia sp., Hippotion celerio, Achaea janata, Achaea sp., Rajendra irregularis, Eudioptes indica, Amata cyssea, Semiothisa pervolgata* (0.72% each). Biodiversity of lepidoptera fauna in horticultural ecosystem In the horticultural ecosystem, the biodiversity of lepidoptera fauna is in similar trend as in agricultural ecosystem. Many other species were also recorded in agricultural and horticultural ecosystem which aid in pollination and contributes towards an increased yield in different ecosystem. The results are in accordance with *Nair et al*., (2014) [27], Arya *et al*., (2014) [28], Rajagopal *et al*., (2011) [29]. It was concluded that in RVSAC, the butterfly fauna especially *Achraea violae, Delias eucharis, Eurma hecabe, Pachiliopta aristolochia, Pachiliopta hectar and* were found to be dominant in agricultural and horticultural ecosystem. Considering all the lepidoptera species in each category, relative abundance of herbivores were found to be predominant over tourists.

Table 1: Weekly collection of lepidoptera fauna in Horticulture ecosystem

Sl. No	Family / Scientific Name	Population in Numbers								
		1 week	2 week	3 week	4 week	5 week	6 week	7 week	8 week	Total
Nymphalidae										
1	*Danaus chrysippus*	0	0	1	0	0	0	0	1	2
2	*Danaus jenutia*	O	0	0	1	0	1	0	0	2
3	*Teliervo limniace*	4	0	2	1	0	1	1	2	11
4	*Achraea violae*	7	14	6	9	16	2	8	12	84
5	*Junonia lemonias*	1	0	3	0	1	5	0	2	12
6	*Junonia almona*	0	1	0	0	0	0	1	0	2
7	*Junonia orithya*	2	0	1	0	2	1	0	1	7
8	*Junonia hierta*	0	1	0	0	0	0	1	0	2
9	*Ergolis merione*	0	2	0	0	0	0	0	0	2
10	*Euploea core*	2	0	2	0	1	1	0	2	8
11	*Hypolimnas miscipes*	1	0	0	1	0	0	2	0	4
Papilionidae										
12	*Pachiliopta hectar*	0	6	0	4	0	2	0	0	12
13	*Pachiliopta aristolochia*	3	3	5	4	0	2	0	1	18
14	*Papilio demoleus*	1	0	0	1	1	0	0	1	4
15	*Papilio polytes*	1	0	0	0	0	0	0	0	1
Pieridae										
16	*Catopsilia pyranthe*	0	0	0	2	0	0	3	0	8
17	*Eurema hecabe*	2	6	2	1	6	2	3	5	27
18	*Delias eucharis*	10	9	13	0	0	5	0	0	37
19	*Hebomia sp.*	1	0	3	1	0	1	0	2	8
Hesperiidae										
20	*Pelopidas mathias*	1	0	4	2	0	0	1	2	10
Sphingidae										
21	*Hippotion Celerio*	1	1	0	0	3	0	1	0	6
Satyridae										
22	*Melanitis leda ismene*	0	1	0	0	0	1	0	0	2
Geometriidae										
23	*Semiothisa pervolgata*	1	0	0	0	0	0	0	0	1
Noctuidae										
24	*Othreis ancilla*	0	0	1	1	0	0	1	0	3
25	*Achaea Janata*	0	0	0	0	1	0	0	0	1
26	*Spiroma spp.*	1	1	1	0	0	0	2	0	5
27	*Dysgonia algira*	1	0	0	0	1	1	2	0	5
28	*Mythimna sp*	1	0	0	0	0	0	0	0	1
29	*Spodoptera litura*	0	0	0	0	0	0	0	1	1
30	*Chrysodeixi serisoma*	0	0	1	0	0	0	0	1	2
31	*Earias vittella*	0	0	1	0	0	1	0	0	2
Arctiidae										
32	*Rajendra irregularis*	0	0	0	0	0	0	1	1	2
Erebidae										
33	*Pyrrharctia Isabella*	0	1	0	0	0	1	0	0	2
34	*Amata cyssea*	1	0	0	0	0	0	0	0	1
Lycaenidae										
35	*Lampides boeticus*	0	2	0	0	2	0	0	0	4
36	*Euchrysops cnejus*	0	0	0	0	1	0	0	0	1
Pyralidae										
37	*Sylepta derogata*	0	0	1	0	0	1	0	0	2
Amatidae										
38	*Syntomis thoracica*	1	0	2	0	0	0	1	0	4
Hypsidae										
39	*Hypsa ficus*	0	0	0	0	0	1	0	0	1
40	Unknown	1	0	1	1	1	1	1	1	7
	Total	44	48	50	29	36	30	29	35	301

Table 2: Alpha diversity indices

Alpha diversity indices						
Species collections in *Weeks*	Shannon wiener index		Simpsons D	Margalef J	Fishers alpha	Species Richnesss
	H	Variance H				
Week 1	2.5556	0.02496	11.038	4.8158	13.371	19
Week 2	2.1151	0.018664	6.963	3.0998	5.8616	13
Week 3	2.5155	0.019002	10.294	4.3456	10.086	18
Week 4	2.3116	0.027577	9.3585	3.751	9.4903	14
Week 5	1.8841	0.038061	4.5	3.0696	6.3026	12

Week 6	2.6337	0.023372	17.4	4.7042	16.259	17
Week 7	2.5058	0.027547	12.237	4.3681	13.296	16
Week 8	2.3391	0.033648	7.7778	4.1858	11.037	16

Table 3: Beta diversity indices

S. No	Index	Beta Diversity
i)	Whitaker Bw	1.304
ii)	Cody Bc	18.5
iii)	Routledge Br	0.35282
iv)	Routledge Bi	0.67263
v)	Routledge Be	1.9594
vi)	Wilson & Shimda Bt	1.184

Saurav *et al*., (2017) [30] concluded that out of 75 genera and 6 families, Nymphalidae was to found to be the most dominant in nature at Howrah district, west Bengal, India. The present findings are in conformity with the above observations.

Ashish Triple (2018) [31] stated that 35 species in Nymphalidae, 34 Lycaenidae species, 18 Hesperiidae and 18 Pieridae species were recorded in Wasdha district area (Central India), Maharashtra. The present findings are found to support the earlier findings.

Research periods are classified as winter and summer, So, first 4 week of collections were under Winter period and 5 to 8 week of collections were under summer days of 2019. Shannon wiener (H) index (Table 2) shows higher index in 6th week of collection, followed by 1st week of collection and lowest index was calculated in 5th week of collection. The variance H of Shannon wiener index was calculated, which has higher variance in 5th week of collection followed by 8th week of collection and lowest variance was calculated in 2nd week of collection whereas in Simpson (D) index (Table 2), higher index was calculated in 7th week of collection followed by 1st week of collection and lowest index was calculated in 5th week of collection.

Margalef (J) index (Table 2) shows higher index in 1st week of collection followed by 6th week of collection and lowest index was calculated in 5th week of collection whereas Shannon wiener index, higher index was calculated in 6th week of collection followed by 1st week of collection and lowest index was calculated in 5th week of collection and in Fisher alpha index (Table 2), higher index was calculated in 6th week of collection followed by 1st week of collection and lowest index was calculated in 2nd week of collection. Finally higher species diversity was calculated in 1st week of collection followed by 3rd week of collection and lowest species diversity was calculated in 5th week of collection which proves low numbers of species were collected in fifth week of summer 2019.

Kumar *et al*. (2008) [32] also observed the highest diversity and evenness of lepidoptera in spring and least in winter. In Fisher alpha index, higher index was calculated in 6th week (Summer-2019) of collection and lowest index was calculated in 2nd week (Winter-2019) of collection. The present findings are found to support the earlier findings

In 39 species were collected in both winter and summer of 2018 and 2019 around 8 weeks and The highest Beta index (Table 3) was calculated in Cody Bc index, followed by Routledge Be and lowest index was calculated in Routledge Br and their values are 18.5, 1.96 and 0.35 respectively.

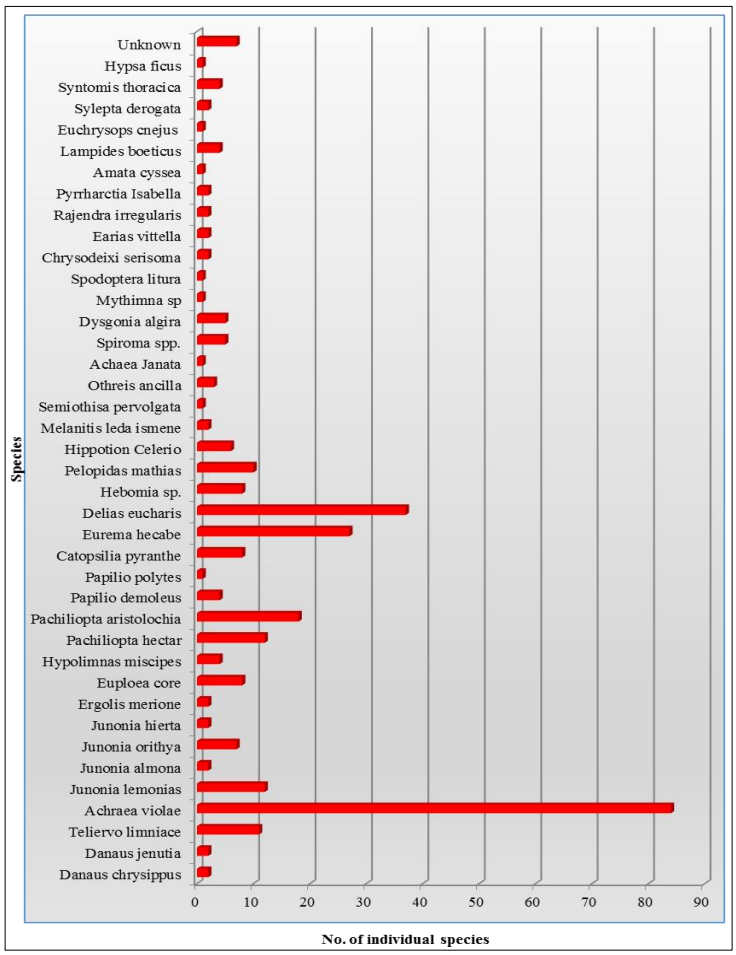

Fig 1: Biodiversity of lepidoptera fauna in RVSAC-Thanjavur

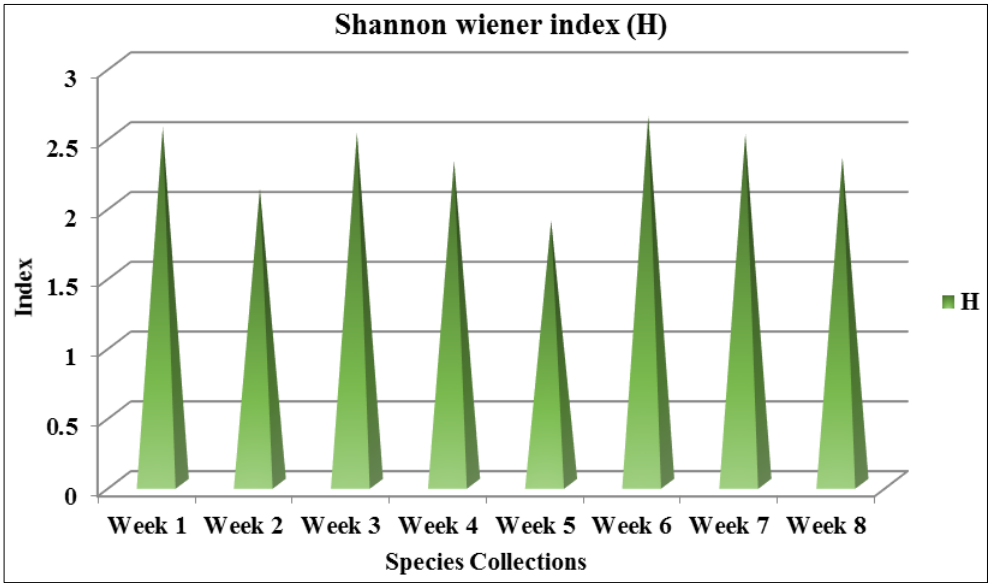

Fig 2: Alpha diversity index – Shannon wiener index (H)

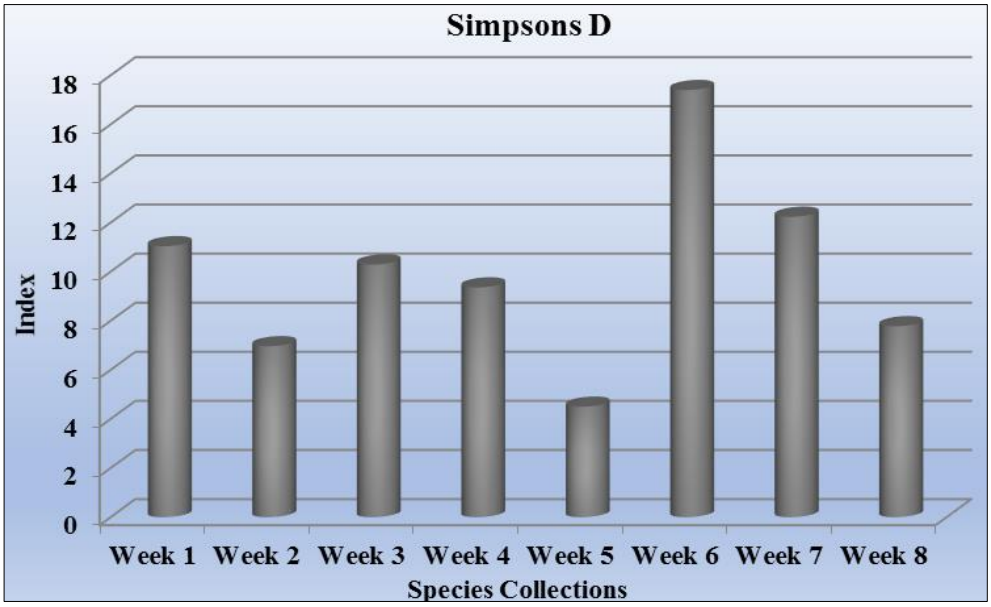

Fig 3: Alpha diversity index – Simpson index (D)

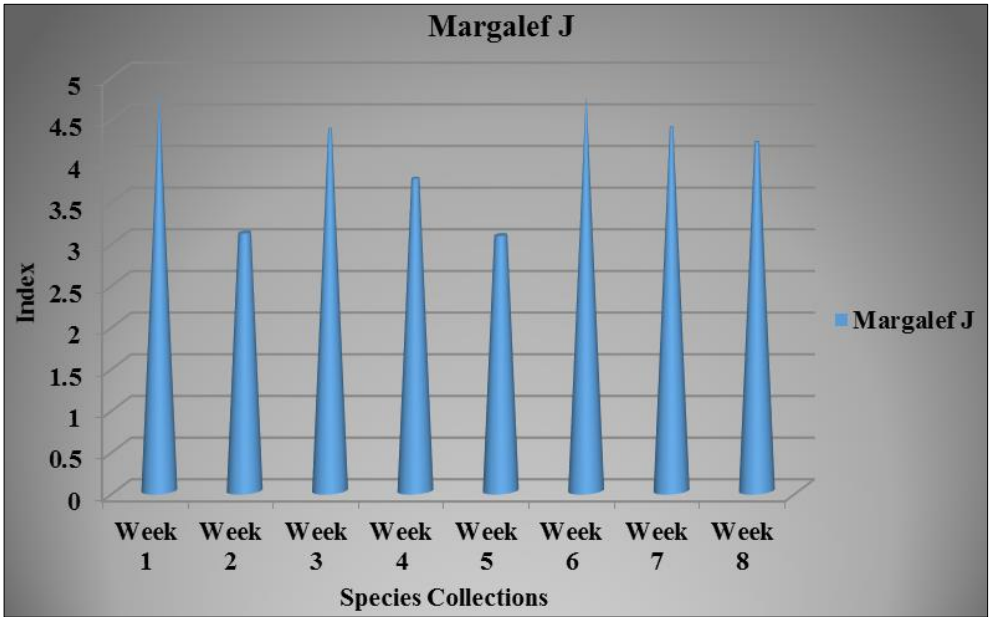

Fig 4: Alpha diversity index – Margalef index (J)

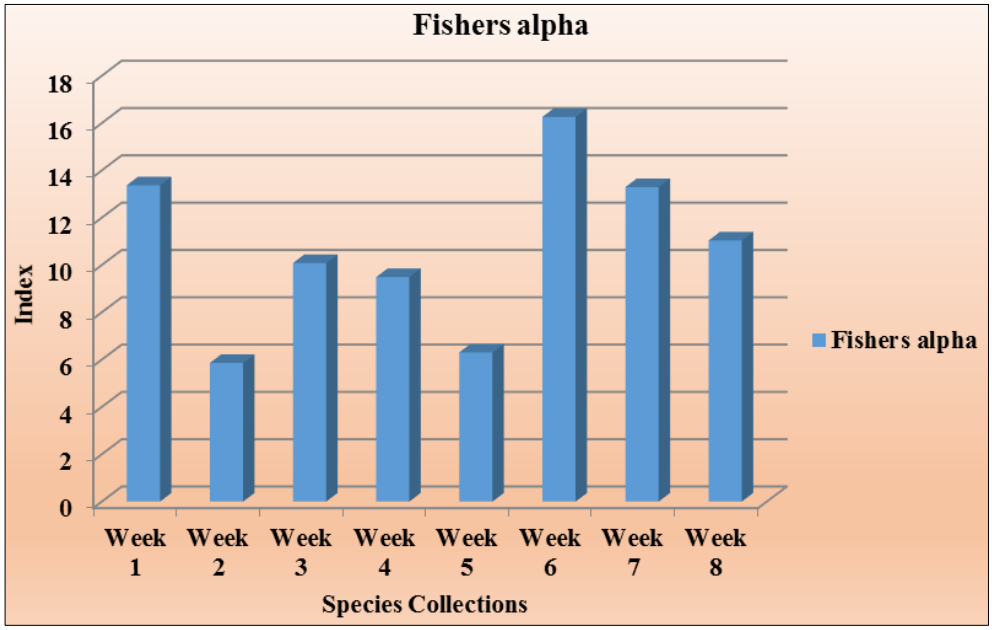

Fig 5: Alpha diversity index – Fishers alpha index

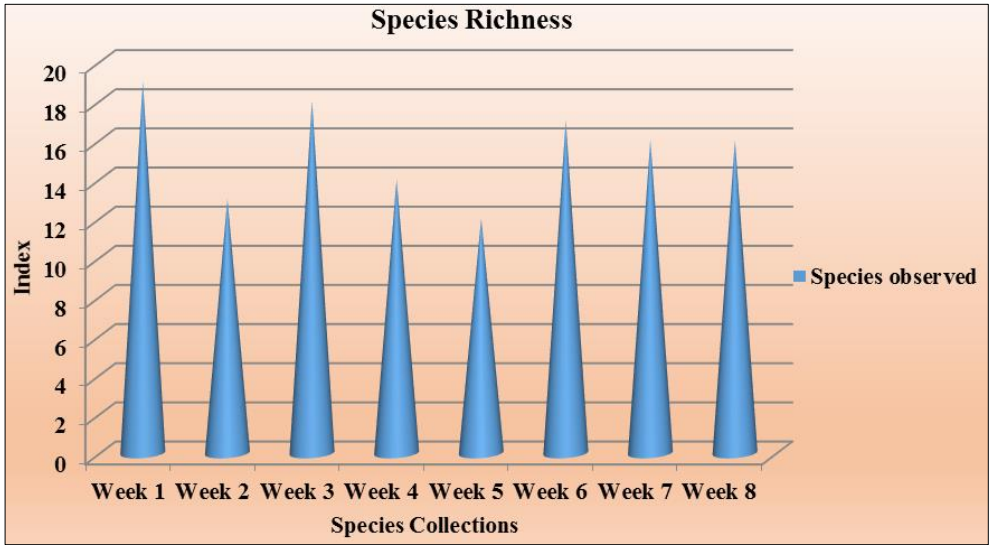

Fig 6: Alpha diversity index – Species Richness

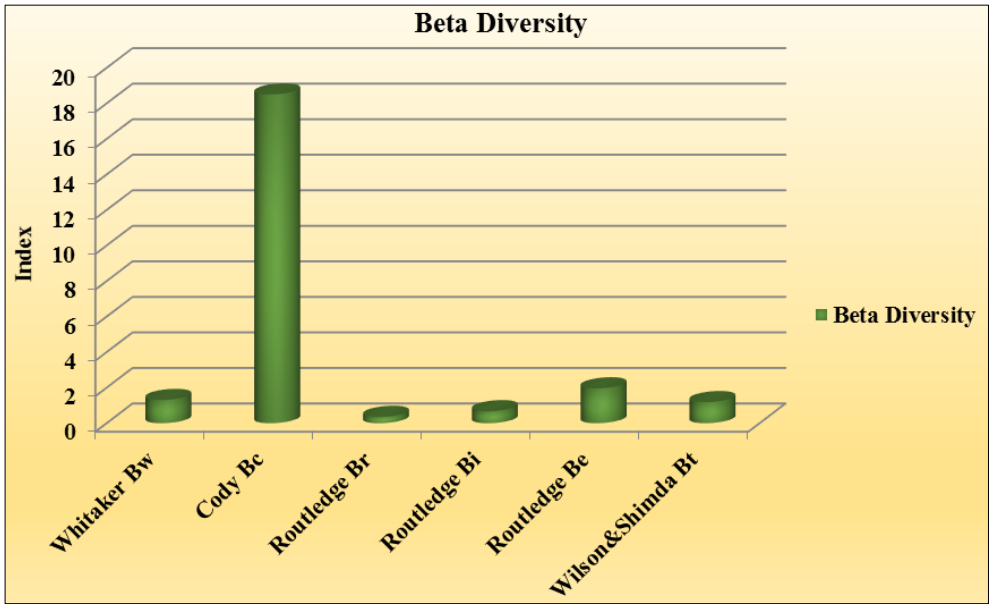

Fig 7: Beta diversity index – Whitaker BW index, Cody Bc index, Routledge Br, Bi & Be index and Wilson & Shimda Bt index

Summary
A total of 39 fauna species (butterflies) were recorded in agricultural and horticultural ecosystem under 33 genera, 14 families and 1 order was observed in the agricultural and horticultural ecosystem. Among the insect families, the family Nymphalidae was the most diversed with 11 species followed by Noctuidae (10 species). A total of 39 species were recorded under the order lepidoptera which include the family Nymphalidae (11 species), Noctuidae (10 species) and Papilionidae and Pieridae each 4 species. Among the different functional groups, a diversity of a herbivores comprised of 27 species followed by tourists consisting of 13 species.
A total number of 138 and 119 individuals were recorded in agricultural and horticultural ecosystem respectively comprising of 27 species of herbivores and 13 species of tourists (Fig. 1).
In horticultural ecosystem, the Species richness of the following species *Achraea violae* (84 Numbers) is higher followed by *Delias eucharis* (37 Numbers), *Eurema hecabe (*27 Numbers) and lowest was in *Papilio polytes, Semiothisa pervolgata, Achaea Janata, Mythimna sp, Spodoptera litura, Amata cyssea, Euchrysops cnejus, Hypsa ficus*(1 numbers each)
In Alpha diversity indices, Shannon wiener (H) index (Fig. 2) shows higher index in 6th week of collection, followed by 1st week of collection and lowest index was calculated in 5th week of collection. In Simpson (D) index (Fig. 3), higher index was calculated in 7th week of collection followed by 1st week of collection and lowest index was calculated in 5th week of collection. In Margalef (J) index (Fig. 4), higher index was calculated in 1st week of collection followed by 6th week of collection and lowest index was calculated in 5th week of collection. In Shannon wiener index, higher index was calculated in 6th week of collection followed by 1st week of collection and lowest index was calculated in 5th week of collection. In Fisher alpha index (Fig. 5), higher index was calculated in 6th week of collection followed by 1st week of collection and lowest index was calculated in 2nd week of collection. In species richness (Fig. 6), higher species diversity was calculated in 1st week of collection followed by 3rd week of collection and lowest species diversity was calculated in 5th week of collection.
The highest Beta index (Fig. 7) was calculated in Cody Bc index, followed by Routledge Be and lowest was calculated in Routledge Br and their values are 18.5, 1.96 and 0.35 respectively. Present findings concludes that *Achraea violae* is the dominant species in this research area which should be control before it reaches the pest level in the cropping area of RVSAC and Thanjavur district in future.

References
1. Losey JE, Vaughan M. The economic value of ecological services provided by insects. Bioscience 2006;56(4):311-323.
2. Mathew GEORGE, Rahamathulla VK. Studies on the butterflies of silent valley national park. Entomon 1993;18(3):185-192.
3. Jaroensutasinee M, Pheera W, Ninlaeard R, Jaroensutasinee K, Choldumrongkul S. Weather Affecting Macro-Moth Diversity at Khao Nan National Park, Thailand. Walailak Journal of Science and Technology (WJST) 2011;8(1):21-31.
4. Kumar A. Butterfly (Lepidoptera: insecta) diversity from different sites of Jhagadia, Ankleshwar, district-Bharuch, Gujarat. Octa Journal of Environmental Research 2013, 1(1).
5. Wells H, Hill PS, Wells PH. Nectarivore foraging ecology: rewards differing in sugar types. Ecological Entomology 1992;17(3):280-288.
6. Gunathilagaraj K, Perumal TNA, Jayaraman K, Ganesh Kumar M. Some south indian butterflies, Publ: Nilgiris Wild and International Association, Udagamandalam 1998, 32-36.
7. Beals MLG, Harnell S. Diversity indices: Simpson's D and E 1999. www.tiem.utk.edu/ gross/bioed/bealsmodules/simpsonDI.html pp. 3.
8. Varshney RK. Revised nomenclature for taxa in Wynter-Blyth's book on the butterflies on Indian region. J Bombay nat. Hist. Sco 1985;82(2):309-321.
9. Kumar P, Wanganeo A, Wanganeo R, Sonaullah F. Seasonal variations in zooplankton diversity of railway pond, Sasaram, Bihar. International Journal of Environmental Sciences 2011;2(2):1007-1016.
10. Reddy TB, Aruna C. Pollination ecology *Ofalangium lamarkii* (Alangiaceae) 1990.
11. Hassan S, Jensen JM, Graybill RB, Lynch WD, Sabin W. Apparatus and methods for including codes in audio signals and decoding. U.S. Patent. Nielsen Audio Inc 1995;5:450-490.
12. Uniyal VP, Mathur PK. Diversity of butterflies in the Great Himalayan National Park, Western Himalaya. Indian Journal of Forestry 1998;21:150-151.
13. Tikader Pal. The Fauna of India, butterfly: lepidoptera. Zool. Surv. India, Calcutta 1981;II(1):533.
14. Shannon CE. A mathematical theory of communication. Bell System tech. J 1948;27:37-423, 623-656.
15. Simpson EH. Measurement of diversity. Nature 1949;163(4148):688.
16. Margalef. The Margalef's index (DMg) supposes a functional relation between the number of species and the total number of individuals 1974.
17. Fisher RA, Corbet AS, Williams CB. The relation between the number of species and the number of individuals in a random sample of an animal population. J Anim. Ecol 1943;12:42-58.
18. Whittaker R. Evolution and measurement of species diversity. Taxon 1972;21:213-251.
19. Cody LM. Bird diversity components within and between habitats in Australia, In R.E. Ricklefs & D. Schluter (eds.). Species diversity in ecological communities. Historical and geographical perspectives. University of Chicago, Chicago, Illinois, USA 1993, 147-158.
20. Routledge RD. On Whittaker's components of diversity. Ecology 1977;58:1120-1127.
21. Routledge RD. Diversity indices: which ones are admissible? Theoret. Biol., n 1979;76:503-515.
22. Wilson MV, Shmida A. Measuring beta diversity with presence-absence data. J Ecol 1984;72:1055-1064.
23. Singh NN, Rai Sanjeev. Relative abundance of different coccinellids in mustard ecosystem. Indian Journal of Entomology 1984;62(4)(2000):422-426.
24. Sagar R, Sharma GP. Measurement of alpha diversity using Simpson index (1/Lamda): the jeopardy. Environmental Skeptics and Critics 2012;1(1):23.
25. Sagar R, Singh JS. Species diversity and its measurement. The Botanica 1999;49:9-16.
26. Seaby RM, Henderson PA. Species diversity and richness version 4. Pisces Conservation Ltd., Lymington, England 2006, 123.

27. Nair R, Teo WS, Mittal V, Swarbrick A. ID proteins regulate diverse aspects of cancer progression and provide novel therapeutic opportunities. Molecular Therapy 2014;22(8):1407-1415.
28. Arya MK, Dayakrishna CR. Species richness and diversity of Butterflies in and around Kumaun University, Nainital, Uttarakhand, India. Journal of Entomology and Zoology studies 2014;2(3):153-159.
29. Rajagopal T, Sekar M, Manimozhi A, Baskar N, Archunan G. Diversity and community structure of butterfly of Arignar Anna Zoological Park, Chennai, Tamil Nadu. Journal of environmental biology 2011;32(2):201-207.
30. Saurav D, Amal KM, Subhadeep C. Diversity of butterflies (Lepidoptera: Rhopalocera) of Howrah district, West Bengal, India. Journal of Entomology and Zoology Studies 2017;5(6):815-828.
31. Ashish Tiple. Butterflies (Lepidoptera Rhopalocera) of the Bor Wildlife Sanctuary, Wardha, Maharashtra, Central India. Biodiversity Journal 2018;9(3):171-180.
32. Kumar M, Kumar P. Valuation of ecosystem services: A psychocultural perspective. Ecological Economics 2008;64:808-819.
33. Kumar P. Valuation of ecosystem services: An assessment of conceptual underpinnings. In Koizumi T, Okabe K, Thompson I[D], Sugimora K, Toma T, Fujita K, eds. The Role of Forest Biodiversity in the Sustainable Use of Ecosystem Goods and Services in Agro-forestry, Fisheries, and Forestry: Proceedings of International Symposium for the Convention on Biological Diversity, Tokyo, Japan. Forest and Forest Products Research Institute 2010, 29-35.