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Entomofaunal diversity of Lepidoptera in different ecosystems of South India

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ABSTRACT
Insect biodiversity is a type of biodiversity that solely focus on insect percentage because they are the most species-diverse group on Earth and play an important role in Ecosystem. This study documents Entomofaunal Biodiversity of Lepidoptera in different Ecosystem in Southern district of Tamilnadu. Insects collecting were carried out once in every fortnight from microhabitats such as arboreal litter, aerial, bark and boulder bed microhabitats using the collection tools, sweep net, beating sheets and light traps. More than a different species of insects in different ecosystems of Tamilnadu. A total 16739 individuals insects were collected by three ecosystems. Udangudi agro ecosystem (AES) represented with highest number of insects individuals 7238 followed by Keela vallanadu Scrub jungle ecosystem with 5428 number of insect individuals and Pudukottai Semi-arid ecosystem with 4073 number of insects individuals. A total 17 families and 45 species are identified. With this different ecosystems studied and analyzed with Dominance Index, Simpson Index, Shannon Index, Menhinick Index and Margalef Richness Index. This will ensures sustainable entomological diversity of increasing the role of biological control in pest management systems.
AES – Agro Ecosystem
SAES – Semi-Arid Ecosystem
SJES – Scrub-Jungle Ecosystem

Keywords: Entomofauna, biodiversity, distribution, agroecosystem, scrub jungle ecosystem, semi-arid ecosystem, Diversity Indices.

INTRODUCTION

Insects are relatively the largest number of species in the animal kingdom. They are the world’s most successful and diverse group of organisms. About 30 million insect species have been so far reported as known species of insects on earth. Insects are known to be the most diverse and successful animals on earth. Owing to their environmental plasticity to survive in different environments, insets are superior in abundance than any other fauna or flora.

With the copious diversity, insects are the warp and weft in the functioning and sustenance of many ecosystem (Cock et al., 2012). They facilities pollination, nutrient recycling as herbivores, pollinators, scavengers, predators and parasites (Weisser and Siemann, 2008) (Oerke and Dehne, 2004), (Losey and Vaughan, 2008), (Cranston, 2010) and (Clock et al., 2012) and are important sources of food for many fauna (Hallmann et al., 2014).

Considering the importance of the insects in different ecosystem it imperative to study the community structure of the insects fauna across globe. The Western Ghat of India is well known for its wide diversity and endemicity of flora and fauna and is one of the important hotspot of biodiversity in India (Myers et al., 2000). Presently, Western Ghat is one of the most densely populated biodiversity hotspot in the world sustaining 400 million people (Molur et al., 2011). Insect faunal documentation in the Western Ghats is well represented in the Fauna of British India series of the early part of the 1900s, after which there has been “taxonomic inertia” (Dubois, 2013) in India in comparison to the documentation made earlier.

The tropical scrub jungles are mostly dry and thorny forest regions. These forests are very common in dry areas of Southern India. There are about 4,294 such thorny forests graded as scrub ecosystem in India. More than 230 of them are found in Tamil Nadu State (Agarwal, 1990).

The survival of semiarid insects depends largely on their selection of suitable microhabitats. Most of semiarid insects are nocturnal. They confine their activities to the hours of darkness and pass the day under litter or boulder or in other sheltered places like barks and burrows. On the other hand, some carabid beetles can be seen wandering around in hot day light. They posses adaptations such as warning colouration, tastelessness to the predators etc. and thus they are not compelled to be nocturnal (Cloudsley-Thompson, 1979).

The day active insects also leave the sand when the temperature reaches about 38^{o}C or above in order escape excessive heat. Some insects climb on the grass, some dive into holes while others fly about the ground level. There are only a few grasshopers and beetles which are active throughout the day even during summer.
The present investigation is aimed at understanding certain lepitoptera diversity in different ecosystems in South India. The main objectives of the investigation were to determine diversity indices. The study way carried out in the biodiversity of lepitoptera in different ecosystems during the study of period from January 2022 to December 2022.

Materials and Methods
Study area
The study area includes three different ecosystems: agroecosystem, semiarid ecosystem and scrub jungle ecosystem all located in Thoothukudi District of Tamil Nadu State, India. The first two ecosystems are located within the Thoothukudi District limit the third one is positioned at the border of Thoothukudi and the adjacent to Tirunelveli District. A study was carried out to understand the distribution pattern of assemblages, abundance and diversity of different entomofauna of agriculture fields, semiarid zone and scrub jungle ecosystem.
The agroecosystem is located at Udangudi 56 km South-East region of Tuticorin (8^{o} $69^{,}$ N and 78^{o} $03^{,}$ E). It is a vast stretch (3 acres) of well managed agricultural, horticultural and fruit cultivating practices are going on in full swing. A part of this land is used for grazing dairy cattle. The soil type is red and sandy. But chosen sectors have been converted into loamy type. However, the basement soil is red. Both the red and the loamy soils are rich with minerals and the entire area is highly fertile.
A wide range of crops are cultivated. Fruit trees such as (Lemon, Sapota, Mango, Seetha, Banana) are the perennial plants. Vegetables such as (Murungai, Ladies finger, Tomato, Brinjal) are also cultivated. Trees such as Coconut, Palm trees, Karuvelam tree *(Prosopis juliflora)* etc.
The semiarid ecosystem is located at Pudukotai, about 24 km West of Tuticorin (8^{o} $82^{,}$ N and 78^{o} $01^{,}$ E). It has no human dwelling. It extends 8 km North –South and 17 km East-West, bordering the Tuticorin-Tirunelveli state high way.
The scrub jungle ecosystem is located at Keela Vallanadu, about 37 km West of Tuticorin. But the forest range is distributed between Tuticorin and Tirunelveli Districts. The hill range is positioned at 8^{o} $65^{,}$ N 77^{o} $87^{,}$ E. The total length of the forest boundary line is 30 km. The altitude is 210 m MSL. The entire range is composed of four mounds, named after the villages surrounding them from the northern end as **Keela Vllanadu. Kodiparambu, Karungallodai and Manakkarai.**

Assessment
The collection method adopted in the three ecosystems were more or less similar. In each ecosystems, six plots (100 x 100 m., each) were chosen at six different sectors. Each plot was further subdivided into six subplots of the about 50 x 30m = $1500m^2$, each. Inset collections were carried out once in every fortnight between 6.00 a.m. and 6.00 p.m., in almost all the accessible microhabitats such as aerial, arboreal, litter, boulder bed etc. A light trap was also set in place of function from 6.00 p.m to 6.00 a.m. on the stipulated days of collections. The study was carried out from January 2022 to December 2022. The number of insects collected was multiplied by the total number of subplots and divided y the number of plots observed to get the total number of insects available in the ecosystem at one time. Insects collected live were killed and processed based on the reference of Stefferud (1976) and George et al., (1986).
The statistical analyses on parameter such a Richness, Diversity Indices etc. were computed based on the recomendations of Southwood and Henderson (2000). The collection made are kept stored in the insectaries of the Department of Zoology and Research Centre, Aditanar College of Arts and Science, Tiruchendur, Tamil Nadu, South India.

Results
Entomofaunal Biodiversity of lepitoptera in different ecosystems
The composition of total order Lepidoptera was different in all three ecosystem i.e Agro-ecosystem (AES), Scrub Jungle Ecosystems (SJES), Semi-Arid Ecosystems (SAES). A total of 16739 number of individuals of Lepidoptera were recorded which belongs to 17 families i.e Pyraustidae, Pyralidae, Asotidae, Amatidae, Arctiidae, Noctuidae, Sphingidae, Iymantriidae, Eupterotidae, Geometridae, Hesperiidae, Papilionidae, Danaidae, Satyridae, Nymphalidae, Pieridae, Lycaenidae. The agro ecosystem dominated with 7238 number of individuals followed Scrub jungle ecosystems with 5428 individuals and 4073 number ofindividuals were collected from ecosystems. (Table 1.1 and Figure 1.1)

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Table 1: Distribution and composition of Lepidoptera in different ecosystemsduring the study of period from January 2022 to December 2022.

		ECOSYSTEMS			
S. No	**FAMILY**	**Udangudi Agro Ecosystem (AES)**	**Keelavallandu Scrub-Jungle Ecosystem (SJES)**	**Pudukottai Semi- arid Ecosystems (SAES)**	**TOTAL SPECIES**
1	Pyraustidae	416	322	196	934
2	Pyralidae	621	432	319	1372
3	Asotidae	321	362	281	964
4	Amatidae	515	418	321	1254
5	Arctiidae	617	218	319	1154
6	Noctuidae	455	314	298	1067
7	Sphingidae	333	241	118	692
8	Lymantriidae	461	372	269	1102
9	Eupterotidae	512	255	168	935
10	Geometridae	298	312	118	728
11	Hesperiidae	417	252	181	850
12	Papilionidae	341	281	172	794
13	Danaidae	365	241	372	978
14	Satyridae	417	321	348	1086
15	Nymphalidae	505	414	321	1240
16	Pieridae	383	492	98	973
17	Lycaenidae	261	181	174	616
	TOTAL	**7238**	**5428**	**4073**	**16739**

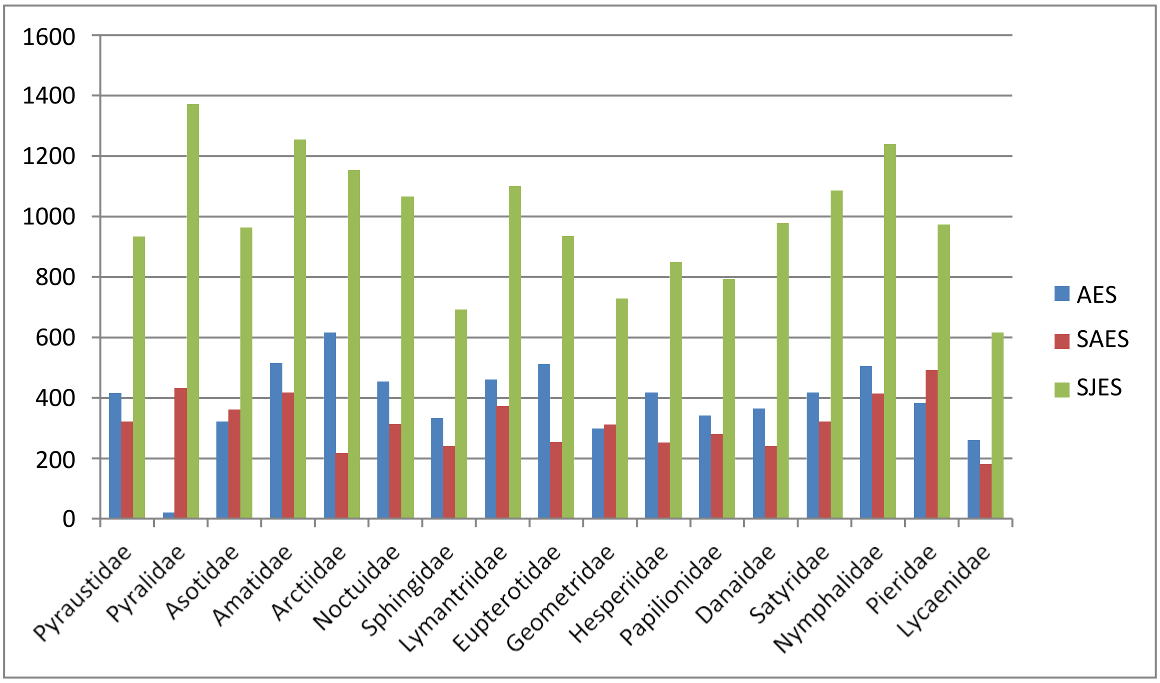

Figure 1: Distribution and abundance of Lepideptera – Family wise in three different ecosystems during the study of period from January 2022 to December 2022.

Diversity of Order Lepidoptera

A total of 45 species belonging to 24 genera and 17 families were recorded during entire sampling period. It was observed that the family with highest number of total species was sphingidae with 8 species, followed by Noctuidae 5 species, Pyraustidae 3 species, Pyralidae 3 species, Asotidae 3 species, Arctiidae 3 species, Eupterotidae 3 species, Papilionidae 3 species, Nymphalidae 3 species, Amatidae 2 species, Lymantriidae 1 species, Geometridae 1 species, Hesperiidae 1 species, Satyridae 1 species, Pieridae 1 species, Lycaenidae 1 species (Table 2 and Figure 2)

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Table 2: Total number of Lepidoptera species during the study of period fromJanuary 2022 to December 2022.

S.No	FAMILY	NO OF SPECIES
1	Pyraustidae	3
2	Pyralidae	3
3	Asotidae	3
4	Amatidae	2
5	Arctiidae	3
6	Noctuidae	5
7	Sphingidae	8
8	Lymantriidae	1
9	Eupterotidae	3
10	Geometridae	1
11	Hesperiidae	1
12	Papilionidae	3
13	Danaidae	3
14	Satyridae	1
15	Nymphalidae	3
16	Pieridae	1
17	Caenidae	1
	TOTAL	45

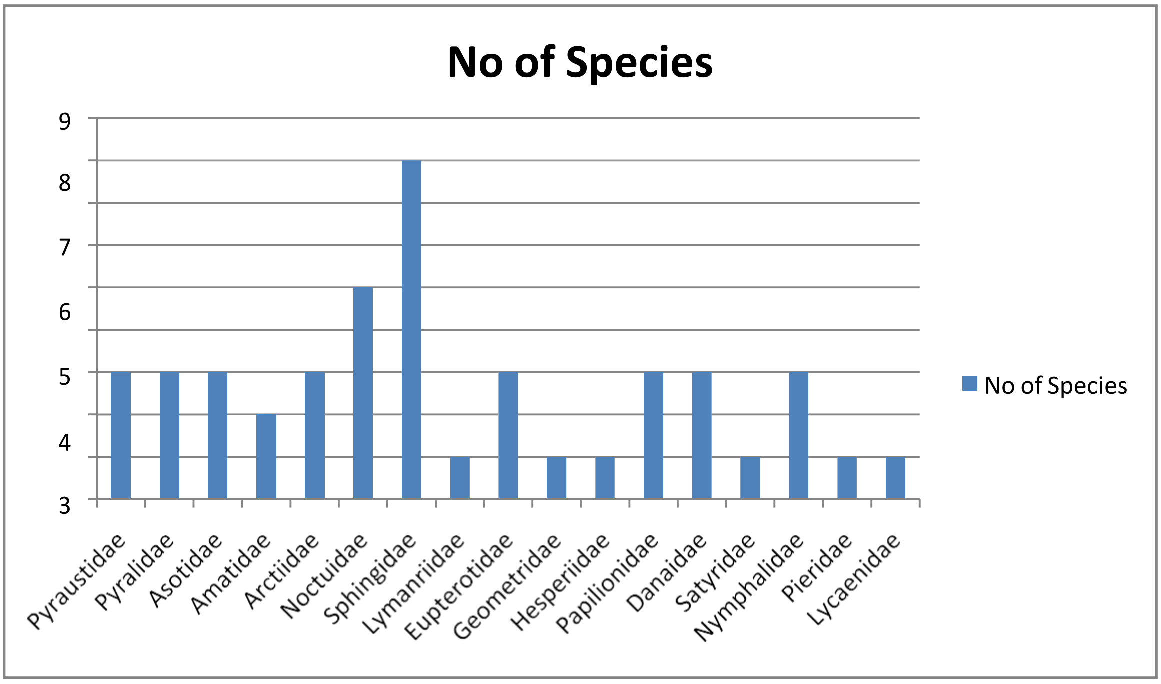

Figure 2: Distribution of Lepidoptera species during the study of period from January 2022 to December 2022

Checklist and Abundance of order Lepidoptera

The total 45 species belongs to order lepidoptera which is recorded with 17 families 45 genera. Among 45 species of lepidoptera 45 are identified species is represented in the (Table 3)

Table 3: Checklist and Abundance of Lepidoptera in three different ecosystem during the study of period from January 2022 to December 2022

ORDER LEPIDOPTERA						
S.No	**FAMILY**	**S.No**	**GENUS / SPECIES**	**AES**	**SJES**	**SAES**
1	Pyraustidae	1	Hymenia *(Hymenia recurvalis)*	172	98	72
		2	Cnaphalocrocis *(Cnaphalocrocis medinalis)*	123	134	92
		3	Cnaphalocrocis *(Cnaphalocrocis poeyalis)*	121	90	32
2	Pyralidae	4	Scirpophaga *(Scirpophaga incertulas)*	214	141	101
		5	Scirpophaga *(Scirpophaga nivella)*	197	130	128
		6	Scirpophaga *(Scirpophaga innotata)*	210	161	90
3	Asotidae	7	Asota *(Asota Caricae)*	89	111	87
		8	Asota *(Asota Heliconia)*	134	123	98
		9	Asota *(Asota Plaginota)*	98	128	96
4	Amatidae	10	Amata *(Amata Passalis)*	261	125	148
		11	Amata *(Amata huebneri)*	254	293	173
5	Arctiidae	12	Creatonotos *gangis)* *(Creatonotos*	222	97	117
		13	Amsacta *(Amsacta Albistriga)*	198	86	81
		14	Utetheisa *(Utetheisapulchella)*	197	35	121
6	Noctuidae	15	Ophiusa *(Ophiusa tirhaca)*	98	67	41
		16	Ophiusa *(Ophiusa Coronata)*	72	32	23
		17	Ophiusa *(Ophiusa disjungens)*	111	81	72
		18	Achaea *(Achaea Janata)*	89	72	62
		19	Achaea *(Achaea serva)*	85	62	100
7	Sphingidae	20	Theretra *(Theretra nessus)*	42	31	19
		21	Theretra *(Theretra gnoma)*	31	28	17
		22	Acherontia *(Acherontia styx)*	62	32	8
		23	Acherontia *(Acherontia lachesis)*	28	17	21
		24	Psilogramma *(Psilogramma vates)*	19	23	6
		25	Psilogramma *(Psilogramma increta)*	21	41	4
		26	Psilogramma *(Psilogramma menephron)*	16	21	19
		27	Hyles *(Hyles lineata)*	114	48	24
8	Lymantriidae	28	Euproctis *(Euproctis lutea)*	461	372	269
9	Eupterotidae	29	Eupterote *(Eupterote mollifera)*	118	81	72
		30	Eupterote *(Eupterote undata)*	132	134	90
		31	Eupterote *(Eupterote lineosa)*	262	40	6
10	Geometridae	32	Thalassodes *(Thalassodes quadraria)*	298	312	118
11	Hesperiidae	33	Spialia *(Spialia galba)*	417	252	181
12	Papilionidae	34	Papilio *(Papilio demoleus)*	86	62	46
		35	Papilio *(Papilio polytes)*	132	98	62
		36	Papilio *(Papilio memnon)*	123	121	64
13	Danaidae	37	Danaus *(Danaus Chrysippus)*	111	87	98
		38	Danaus *(Danaus plexippus)*	86	98	120
		39	Danaus *(Danaus genutia)*	168	56	154
14	Satyridae	40	Mycalesis *(Mycalesis mineus)*	417	321	348
15	Nymphalidae	41	Precis *(Precis almana)*	135	111	98
		42	Precis *(Precis orithya)*	162	132	141
		43	Precis *(Precis hierta)*	208	171	82
16	Pieridae	44	Colotis *(Colotis danae)*	383	492	98
17	Lycaenidae	45	Lampides *(Lambides boeticus)*	261	181	174
			TOTAL	**7238**	**5428**	**4073**

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Pooled diversity indices of Lepitoptera

The diversity indices is calculated from the pooled data of order Lepidoptera from every ecosystems during the study of period from January 2022 to December 2022. The Dominance Index was recorded highest in AES with the value of 0.9679 and lowest in SJES with the value of 0.9628. The Simpson Index was recorded highest in SJES with the value of 0.0372 and lowest in AES with the value of 0.0320. The Shannon Index was recorded highest in AES with the value of 3.591 and lowest in SJES with the value of 3.525. The Menhinick Index was recorded highest in SAES with the value of 0.7051 and lowest in AES with the value of 0.5289. (Table 4).

Table 4: Pooled diversity indices of Lepidoptera during January 2022 to December 2022

DIVERISTY OF LEPIDOPTERA			
ECOSYSTEMS	**AES**	**SJES**	**SAES**
Taxa_S Genus/Species	45		
Individuals	7238	5428	4073
Dominance Index	0.9679	0.9628	0.9657
Simpson Index	0.0320	0.0372	0.0343
Shannon Index	3.591	3.525	3.541
Menhinick Index	0.5289	0.6108	0.7051
Margalef Richness Index	4.951	5.117	5.293

Seasonal Abundance of Lepidoptera: January 2022 to December 2022

The Seasonal variation of order Lepidoptera was recorded from different ecosystems during the year January 2022 to December 2022. Among 17 families of lepidoptera was recorded during the year January 2022 to December 2022. In agro ecosystem the highest number of individuals was recorded with 2648 individuals during the postmonsoon season and lowest was recorded with 2278 individuals during the monsoon season in (SJES) the highest number of individuals was recorded during the postmonsoon season with 1885 individuals and lowest was recorded during the premonsoon season with 1675 individuals. In semi-arid ecosystem the monsoon season recorded highest number of 1474 individuals and lowest was recorded during the postmonsoon season with 1142 individuals. (Table 5 and Figure 3)

Table 5: Seasonal Abundance of Lepidoptera in different ecosystem during the year January 2022 to December 2022.

LEPIDOPTERA		**January 2022 to December 2022**								
		Udangudi Agro-Ecosystem (AES)			**Keela Vallanadu Scrub-Jungle Ecosystem (SJES)**			**Pudukottai Semi-arid Ecosystem(SAES)**		
S.No	**FAMILY**	**PM**	**M**	**POM**	**PM**	**M**	**POM**	**PM**	**M**	**POM**
1	Pyraustidae	172	123	121	98	134	90	72	92	32
2	Pyralidae	214	197	210	141	130	161	101	128	90
3	Asotidae	89	134	98	111	123	128	87	98	96
4	Amatidae	171	142	202	113	148	157	98	142	81
5	Arctiidae	222	198	197	97	86	35	117	81	121
6	Noctuidae	141	171	143	98	127	89	99	119	80
7	Sphingidae	138	99	96	81	93	67	62	35	21
8	Lymantriidae	182	161	118	121	123	128	97	112	60
9	Eupterotidae	118	132	262	81	134	40	72	90	6
10	Geometridae	102	87	109	86	117	109	62	35	21
11	Hesperiidae	123	122	172	79	40	133	91	18	72
12	Papilionidae	86	132	123	62	98	121	46	62	64
13	Danaidae	111	86	168	87	98	56	98	120	154
14	Satyridae	123	120	174	141	82	98	161	85	102
15	Nymphalidae	135	162	208	111	132	171	98	141	82
16	Pieridae	94	132	157	123	141	228	35	41	22
17	Lycaenidae	91	80	90	45	62	74	61	75	38
	TOTAL	**2312**	**2278**	**2648**	**1675**	**1868**	**1885**	**1457**	**1474**	**1142**

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1) $$\text{Dominance Index} = 1 - \left(\frac{\Sigma ini(ni-1)}{N(N-1)}\right)$$

2) $$\text{Simpson Index} = \frac{\Sigma ini(ni-1)}{N(N-1)}$$

3) $$\text{Shannon Index} = -\Sigma\left(\frac{ni}{N} - 1n\left(\frac{ni}{N}\right)\right)$$

4) $$\text{Menhinick Index} = \frac{s}{\sqrt{\Sigma ini}}$$

5) $$\text{Margalef Richness index} = \frac{s-1}{1nN}$$

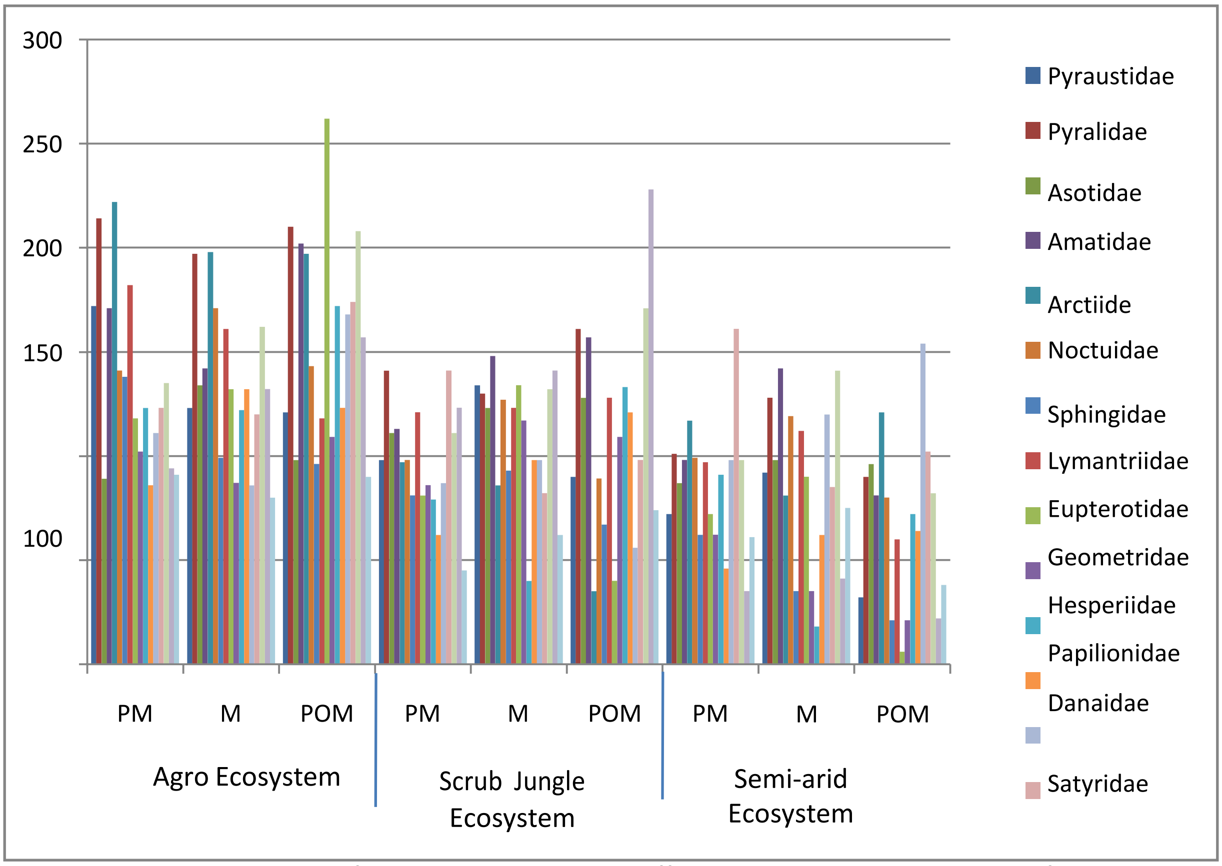

Figure 3: Seasonal variation and of Lepidoptera across three different ecosystemsduring the period from January 2022 to December 2022.

Seasonal Diversity of Order Lepidoptera January 2022 to December 2022

During the year 2022 Lepitoptera is represented by 17 families. The Dominance Index was recorded highest in SJES during the premonsoon season with 0.9379 and lowest in SAES during the postmonsoon season with 0.9222. The Simpson Index was recorded highest in SAES during the postmonsoon season with 0.0778 and lowest in SJES during the premonsoon season with 0.0620. The Shannon Index was recorded highest in AES during the monsoon season with 2.8 and lowest in SAES during the postmonsoon season with 2.65. The Menhinick Index was recorded highest in SAES during the postmonsoon season with 0.5031 and lowest in AES during the postmonsoon season with 0.3304. The Margalef Richness index was recorded highest in SAES during the postmonsoon season with 2.273 and lowest in AES during the postmonsoon season with 2.03 (Table 6).

Table 6: Seasonal diversity Indices of Lepidoptera of three different ecosystemduring the from January 2022 to December 2022.

LEPIDOPTERA	**January 2022 to December 2022**								
ECOSYSTEMS	**Udangudi Agro- Ecosystem (AES)**			**Keela Vallanadu Scrub-Jungle Ecosystem (SJES)**			**Pudukottai Semi- arid Ecosystem (SAES)**		
DIVERSITY	**PM**	**M**	**POM**	**PM**	**M**	**POM**	**PM**	**M**	**POM**
Taxa_S Family	17								
Individuals	10	34	55	5	23	41	0	13	22
Dominance Index	0.9361	0.9377	0.936	0.9379	0.9376	0.93	0.9353	0.9309	0.9222
Simpson Index	0.0638	0.0622	0.0640	0.0620	0.0624	0.0699	0.0647	0.0690	0.0778
Shannon Index	2.789	2.8	2.787	2.799	2.794	2.733	2.778	2.729	2.65
Menhinick Index	0.3536	0.3562	0.3304	0.4154	0.3933	0.3916	0.4454	0.4428	0.5031
Margalef Richness Index	2.066	2.07	2.03	2.155	2.124	2.122	2.197	2.193	2.273

Discussion

In this pioneer study carried out in three diverse ecosystems of South India, agro ecosystem showed high Species Richness and Diversity followed by the SAES zone and the SJES. It was obvious that agroecosystem, even through it was a man made modified farmland, reported to have a rich variety of entomofauna. In addition, the ecosystem showed a high level of homogeneity of distribution for most of the insects as pointed out by Muralirangan et al. (1993). This efficiency was further enhanced by the occurance of domesticated gardens and a pond nearby.

The rich number of species available in the agroecosystem was mainly because of the availability of varieties of crop plants and microhabitats. At the same time, decrease in host plant availability or nutrient-poor host plants which was observed in the semiarid zone and the (SJES) was found as the main factor for poor distribution and diversity in those areas. It was also noted that although pesticides were applied, nitrogen-rich fertilizers were able to soothe insects such as carabids in their microhabitats.

Humification of litter was observed in the agroecosystem which was not possible in dry habitats like the scrub jungle and SAES. Marginal vegetation which includes milk weed plants and shrubs was large in size around the ecosystem. But it was poor in the semiarid zone and almost nil in SJES. This vegetation was found to harbour many larvae of butterflies. All these observation were supported by Hammond and Miller (1998) who found out that shrubs, herbs and grasses supported high level of species richness for Lepidoptera.

In the present study, the Scarabaeidae were numerous both the semi-arid and the SJES, owing to the availability of dung. Mico et al (1998) in their study clearly indicated that scarabs were dominant in the brush-wood ecosystem than the wetland the ecosystem was the constant cool interior climate. On the other hand, the SAES and SJES differed greatly in this respect since aerial and arboreal climate was hot and very hot respectively for the two ecosystems. Boulder bed and bark microhabitats were not found in the agroecosystem but the latter was more in the SAES and the former in the SJES. The predatory reduviids were numerous in trap and litter of the semiarid zone. Ambrose (1996) authenticated presence of more number of reduviids in various ecosystems of Indian sub continent.

CONCLUSION

From this study concluded that the Udangudi Agroecosystem stood first with high individuals of collected insects order lepidoptera. Through it is obvious fact that insects contribute much to the ecological welfare and insect conservation world in view of their critical role in conservation of ecosystem, the insect distribution and diversity in two natural ecosystems were far below than the man made agroecosystem. Moreover, the conservation efforts towards entomofaunna remains meager compared to that the mammals and birds. In this context, the authors advocate the conservation of natural ecosystems that enriches the entomofauna to maintain ecological balance to sustain the very existence of human beings.

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