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The potential habitat for butterfly population dynamics was absorbed at Vasantham garden in the Bishop Heber College, Tiruchirappalli District, Tamil Nadu, India

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Abstract
The present study revelas that the Vasantham Garden, Bishop Heber College, Trichy, habitats were found to be the most suitable one for highly potential habitat for population dynamics of butterfly population and diversity throughout the study period. The different varieties of flowering plants, fruiting trees provide a wide range of nutrient-rich nectar, pollen, and palatable food plants to foliage-feeding, other leaves availability and the garden climatic conditions such as temperature, humidity, rainfall and wind velocity were the major and suitable factors throughout the year had influence on the distribution and diversity of population. In the Vasantham Garden among the 22,470 individuals observed, most of the members belong to the family Nymphalidae and was the most highly distributed family with a total number of 11,102 individuals. This was followed by Pieridae with 7,535 individuals, Papilionidae with 2,321 individuals, Lycaenidae with 1,249 individuals and Hesperiidae with only 263 individuals, respectively. The percentage contribution of the family Hesperiidae was 1.17%, Papilionidae was 10.33%, the contribution of Pieridae was 33.53%, the contribution of Lycaenidae was 5.56% and the contribution of Nymphalidae was 49.41% respectively. This study reveals the relationship between host plants and butterfly species richness and population density. The present study on butterflies emphasizes the role of variety of host plants, associated with various environmental factors on species richness of butterflies.

Keywords: butterfly, nymphalidae, hesperiidae, pieridae, papilionidae, lycaenidae

Introduction

Butterflies and moths (Order Lepidoptera) offer good opportunities for studies on population and community ecology (Pollard, 1991) [1]. Many species are strictly seasonal, preferring only a particular set of habitats (Gadgil, 1996) [2].The distribution of butterfly members in a population as a whole is basically the important aspect for diversity studies. The pattern of the butterfly population distributed in an ecosystem, the size of the area occupied by one butterfly species or one family group, the density of the species in the most favourable areas and the factors influencing their range of distribution are the other important aspects (Gunathilagaraj *et al.*, 1997) [3]. Butterflies require sugar, certain minerals and water for their survival. They obtain all these from the habitat by visiting flowers, bird droppings, and rotten fruits and from mud pudding in the suitable areas (Adler and Pearson, 1982) [4]. There are specialized indices for the computation and comparison of butterfly species, diversity, distributions and so on. Two important components, called species "richness" and "evenness", are vital for this study. Species richness provides an extremely useful measure of diversity when a complete catalogue of species in the community is obtained (Magurran, 1988) [5]. Diversity of species richness and evenness are calculated by Shannon index (Shannon, 1948) [6]. Hammond and Miller (1998) [7] conclude that the biodiversity of butterflies is linked to the ecosystem by influencing nutrient cycling, plant population and predator–prey population dynamics. Butterflies are also very sensitive to changes in temperature, humidity, and photo periodical parameters, which are often affected by habitat disturbance (Wood and Gillman, 1998) [8].

The population, which has been defined as a collective group of the same species occupying a particular space at a time has various characteristics. Some of the characteristics are density, natality, mortality, distribution, biotic potential, dispersion and growth form, and the others are genetic. Several papers on population dynamics of moths and butterflies of various ecosystems in different countries were published.

An alternative approach is to determine the relationship between habitat and the presence/absence and density of each species. This information can then be used to generate statistical models that predict species' distributions, based on more widely available data on the distributions of general vegetation types. This approach confers a range of benefits: models can be used to predict the likely effects of future changes in land use or to identify apparently suitable habitat that remains unoccupied (Lawton and Woodroe 1991; Rushton *et al.*, 2000; Smart *et al.*, 2000) [9-11]. A similar approach, using climate-based models, has been applied to predicting species' distributions under different climate scenarios (Brereton), Bennett and Mansergh, 1995 [12].

In butterflies, habitat quality depends on the distribution, amount, and quality of the different resources needed by each of the four developmental stages (i.e. eggs, caterpillars, pupae, and adults. There is accumulating evidence that hostplant quality is essential for caterpillars to achieve optimal growth and survival (Scriber, 2010) [13]. Boggs (2003) [14] analysed that survival and fecundity of butterflies are likely to depend on the quantity and quality of

adult food resource such as floral nectar, rotting fruits and so on, which may probably vary among different land-use patterns.
Butterflies and their caterpillars are dependent on specific host-plants for foliage, nectar and pollen as their food. Thus, butterfly diversity indirectly reflects overall plant diversity, especially that of herbs and shrubs, in the given area. Change in land-use pattern leads to landscape changes that can reflect change in butterfly diversity and distribution. In the Western Ghats, such changes in landscape are taking place at a large scale (Jha *et al.*, 2000) [15]. Hence, this type of study is essential in conservation and management of the Western Ghats biodiversity.

Materials and Methods

The research was conducted in the following locations

Geography and climate

This chapter includes different methods and techniques used both in the field as well as in the laboratory, for the completion of the present work, and these mainly involved field survey in the Vasantham garden habitat of Bishop Heber College Campus, collection, killing, preservation, rearing, slide preparation, drawings, field photography, collection of meteorological data, identification of host plants and statistical analysis pertaining to butterfly-fauna and their ecological and biological investigations. Tiruchirappalli, a centrally located inland district of Tamil Nadu without any sea-coastline, lies between 10°47'N 78°416'E and has an altitudinal gradient of 289 feet (88 meters). The district has an area of 4,404 square kilometers.

Bishop Heber College

Bishop Heber College is centrally situated in Trichy city. The 25 acre college campus has a rich and diverse butterfly fauna because of the availability of a wide range of habitats that provides ambient environment for foliage, nectar and pollen as their food for laying eggs to increase their population. Six locations were selected, which were visited every day of the study period.
The Vasantham Garden is man made in a 2 acre coverage, where more than 73 species of plants were identified, which included trees, shrubs, herbs, creepers grass, flowering plants, wild plants, orchids and floating plants. The abundance of relatively dense grass and flowers are the major attraction for the butterflies to this location.

Landscape: almost flat; attractive grassland with trees, creepers, plants and shrub bearing brightly coloured flowers; a small pond with many colorful fishes and water plants; the most green and eye-catching spot in the entire campus.

Soil: Red Sandy Soil, Black Soil (Soil is very rich in nutrients and organic matter)

Fig 1: Vasantham garden habitat

Aerial net

Since butterflies are aerial forms, an aerial net was used to collect them. The aerial net was made based on the guidelines given by Stefferud (1976) [16] and George *et al.* (1986) [17]. The net was made of a muslin net bag of 1m length tapering at the bottom and a strong aluminum handle of 1.5 m length. The bag was kept in hanging condition by sewing the net base to the rim on the handle. The bag was made long enough so that the tip may be flipped over the rim to form a pocket to prevent escape of the trapped butterfly. Butterflies were trapped inside the pocket of the net by

swinging it down backward towards the direction of flight. Thus trapped butterflies were carefully removed without damaging any of their body parts or scales and transferred to a jar.

Data collection and Statistical analyses

Field survey was made regularly for a period of twelve months from January 2017 to December 2018. The total number of each species observed was entered in the data sheet kept in the laboratory. The raw data were fed to a computer using special tool like SPSS. For population studies, the total number of butterflies censused was recorded and then released. The data collected were statistically analysed using the richness indices, evenness indices, diversity indices and population measures.

Results and Discussion

Plant phenology in Vasantham Garden

The Vasantham Garden habitat totally has 73 plant species belonging to 63 families including shrubs, herbs, small trees, trees, flowering plants and some ornamental and wild plants. Most of the permanent trees are fruiting trees, which includes the lime (*A. cinella),el*umichai (*C. lemon),*sapota (*P. sapota),* coconut tree (*C. nucifera),* star goose berry (*P. acidus),* cycas (*C. revolute),*curry leaf (*M. koengii),* teak (*T. grandis)* and so on. Flowering plants such as rose (*R. indica*), jasmine (*J. sambac*) and shoe flower (*H. rosa-sinensis*) are also seen here. Apart from this, there are other shrubs and herbs present in this habitat.

Table 1: Plant phenology of the Vasantham Garden

Sl. No	Botanical Name	Family	Vernacular Name	Habit
1	*Abutilon indicum* L.	Malvaceae	Thuthi	Tangled shrubs
2	*Acalypha indica* L.	Euphorbiaceae	Kuppaimeni	Herb
3	*Adathoda vasica.* Nees.	Acanthaceae	Aaduthoda ellai	Shrub
4	*Adeliari cinella* L.	Adelidae	Lime	Small tree
5	*Aerva lantana* L.Juss.	Amaranthaceae	Koolapoo	Under shrub
6	*Aloe vera* L.	Liliaceae	Chothu Kathalai	Tangled shrubs
7	*Andrographis echioides* L. Nees.	Acanthaceae	Gopuram tangi	Herb
8	*Artemisia absinthium* L.	Asteraceae	Nagathamani/asipathri	Tree
9	*Bambusa vulgaris* Schrad.	Poaceae	Moongil	A large grass
10	*Biden pilosa* L.	Asteraceae	Vettukaya poondu	Annual herbs
11	*Bougainvillea glabra* Choisy	Nyctaginaceae	Kagithapoo	Shrub
12	*Calotropis gigantean* L. W.T. Aiton	Asclepiadaceae	Eruku	Shrubs
13	*Canna hybrid* L.	Cannaceae	Canna lilly	Perennials shrub
14	*Casuarina equisetifolia* L.	Casuarinaceae	Sowku	Tree
15	*Catharanthus roseus* L. G.Don	Apocynaceae	Nithiya kalyani	A small erect herb
16	*Citrus lemon* L. Burm. f.	Rutaceae	Elumichai	Tree
17	*Clitoria ternatea* L.	Fabaceae	Sangu Kannikodi	Perennial herb
18	*Cocos nucifera* L.	Arecaceae	Thennai	Tree
19	*Crinum asiaticum* L.	Amaryllidaceae	Visamoongil	Herb
20	*Cycas circinalis* L.	Cycadaceae	Mathana kampoo	Evergreen palm like tree
21	*Cycas revolute* Thunb.	Cycadaceae	Madupannai (Cycas)	Tree
22	*Cymbopogon citrates* DC. Stapf.	Poaceae	Karppurappul	Grass
23	*Cynodon* dactylon L. Pers.	Poaceae	Arugampul	Grass
24	*Cyperus rotundus* L.	Cyperaceae	Karaikizhangu	Perennial grass-like plant Herb
25	*Desmodium triflorum* L. DC.	Fabaceae	Siru pulladi	Perennial herb
26	*Euphorbia masculata L.*	Euphorbiaceae	Mathill kalli	Creeper
27	*Eclipta prostrate* hass L.	Compositae	Karissalann kanni	Erect annual herb
28	*Euphorbia heterophylla* L.	Euphorbiaceae	Paulperuki	Herb
29	*Euphorbia hirta*L.	Euphorbiaceae	Amman Pacharisi	A small prostrate herb
30	*Ficus benjamia* L.	Moraceae	Aathimaram	Tree
31	*Ficus religiosa* L.	Moraceae	Arasa maram	A large deciduos tree
32	*Hibiscus cannabisnus* L.	Malvaceae	Pulicha keerai	Perennial herb
33	*Hibiscus rosa-sinensis* L.	Malvaceae	Semparuthi	Shrub
34	*Hybanthusennea spermus* L. F. Muell.	Violaceae	Oridazh thamarai	Erect shrub
35	*Ipomea quamolict* L.	Convolvulaceae	Mayilmannikkam	Herb/climber
36	*Ixora coccinea* L.	Rubiaceae	Idly poo	Shrub
37	*Jasminium auriculatum* Vahl.	Oleaceae	Mullai	Herb
38	*Jasminium sambac* L. Aiton	Oleaceae	Malligai	Shrubs
39	*Lantana camara*L.	Verbenaceae	Unnicheddy	Prostate herb
40	*Ipomea quamolict L.*	Convolvulaceae	Mayilmannikkam	Cardinal creeper
41	*Molinia caerulea* L. Moench.	Poaceae	Palanthootapull	Herb
42	*Murraya exotica* L.	Rutaceae	Kattu kariveppilai	Tree
43	*Murraya koengii* L. Sprengel.	Rutaceae	Kariveppilai	Climbing under shrub
44	*Nerium oleander* L.	Apocynaceae	Arali	Erect shrub
45	*Nymphea nouchali* Burm. F.	Nymphaeaceae	Karuneythal	aquatic plant
46	*Ocimum basilicum* L.	Lamiaceae	Thirunetrupachillai	Annual herb

47	*Ocimum grastissimum L.*	Lamiaceae	Ram Tulsi	Herb
48	*Oldenlandia corymbosa* L.	Rubiaceae	Kattuchaya ver	Herb
49	*Oldenlandia umbellate L.*	Rubiaceae	Chaaya ver	Tree
50	*Opuntia vulgaris* L.	Cactaceae	Chappathikalli	Shrub (or) vine
51	*Pandanus odoratissimus LF* L.f.	Pandanaceae	Thaalai	Spreading herb
52	*Pergularia daemia* L.	Apocynaceae	Uttamani	Climber
53	*Phalaris arundinaceous* L.	Poaceae	Nigandupull	Grass
54	*Phyllanthus acidus* L.	Euphorbiaceae	Arunelli	Small tree
55	*Phyllanthus emblica* L.	Euphorbiaceae	Nellii	Deciduous tree
56	*Phyllanthus maderaspatensis* L.	Euphorbiaceae	Shivappu nelli	Herb
57	*Phyllanthus niruri* L.	Euphorbiaceae	Keelanezhi	Erect herb
58	*Cissus quadrangularis* L.	Vitaceae	Pirandai	Climber
59	*Pisonia grandis* R.Br.	Nyctaginaceae	Leechi kottai keerai	Tree
60	*Pistia stratiotes* L.	Araceae-Arum family	Antarathamarai	Floating plant
61	*Plectranthus amboinicus* Lour.Spreng	Lamiaceae	Karpuravalli	Herb
62	*Portulaca grandiflora* hook.	Portulacaceae	Pathumanichedi	Herb
63	*Portulaca oleracea* L.	Portulacaceae	Parupu keera	Shrub
64	*Pouteria sapota* Jacq. H.E. Moore	Sapotaceae	Sapotta	Tree
65	*Quisqualis indica* L.	Combretaceae	Irangum malli	Creeper
66	*Rosa damascene* Mill.	Rosaceae	Pannirpushpam	Herb
67	*Rosa edword L.*	Rosaceace	Paneer rose	Herb
68	*Solanum trilobatum* L.	Solanaceae	Thoothuvalai	Annual herb
69	*Tabernaemontana divaricata* R.Br. ex Roem. & Schult.	Apocynaceae	Nandiar vattai	Evergreen shrub
70	*Tecoma stans* L. Juss ex Kunth	Bignoniaceae	Sonnapatti	Shrub
71	*Tectona grandis* L.f.	Verbenaceae	Thekku	Tree
72	*Tribulus terrestris* L.	Zygophyllaceae	Nerunji Mull	A large deciduos tree
73	*Zoysia tenuifolia* Wild.	Poaceae	Pampupullu	Grass

Source: Data obtained from Department of Botany, Bishop Heber College, Trichy [18].

Biodiversity and distribution of butterflies in the Vasantham Garden

A total number of 22,470 butterflies belonging to five families were observed and documented in the Vasantham Garden during the entire study period. The number of individuals photographed and collected, if necessary, for each family with their common name and scientific name, are given in table 2.

Hesperiidae

Eight species of Hesperiidae butterflies with 263 individuals were recorded during the entire study period (Table 2). They were

H1 - *Hasora chromus* C.
H2 - *Badamia exclamationis* F.
H3 - *Pseudoborbo bevani* M.
H4 - *Parnara bada* M.
H5 - *Udaspes folus C.*
H6 - *Suastus gremius* F.
H7 - *Pelopidas mathias* F.
H8 - *Borbo cinnara* W.

Among the eight species observed, the *B. cinnara* (H8) was the most highly distributed species with 74 individuals (28.14%) followed by *P. bada* (H4) with 56 individuals (22.29%), *H. chromus*(H1) with 51 individuals (19.39%), *B. exclamationis* (H2) with 27 individuals (10.27%), *P. mathias* (H7) with 18 individuals (6.84%), *P. bevani* (H3) with 15 individuals (5.70%)and *U. folus* (H5) with 12 individuals (4.56%), respectively. *Suastus gremius* (H6) was the least distributed species with only 10 individuals (3.80%).

Table 2: Family-wise list of butterflies documented in Vasantham Garden habitat, their Number and Percentage

Family	S.No	*Scientific Name*	Abbreviation	Common Name	Total	Percentage
Hesperiidae (H)	1	*Hasora chromus C.*	H1	Common banded awl	51	19.39
	2	*Badamia exclamationis F.*	H2	Brown awl	27	10.27
	3	*Pseudoborbo bevani M.*	H3	Bevan's swift	15	5.70
	4	*Parnara bada M.*	H4	Ceylon swift	56	21.29
	5	*Udaspes folus C.*	H5	Grass demon	12	4.56
	6	*Suastus gremius F.*	H6	Indian palm pob	10	3.80
	7	*Pelopidas mathias F.*	H7	Small branded swift	18	6.84
	8	*Borbo cinnara W.*	H8	Rice swift	74	28.14
Papilionidae (PA)	9	*Graphium doson C&R.Felder*	PA1	Common jay	290	12.49
	10	*Graphium Agamemnon L.*	PA2	Tailed jay	556	23.96
	11	*Papilio polymnestor C.*	PA3	Blue Mormon	11	0.47
	12	*Papilio polytes L.*	PA4	Common Mormon	811	34.94
	13	*Atrophaneura aristolochiae F.*	PA5	Common rose	319	13.74
	14	*Atrophaneura hector L.*	PA6	Crimson rose	172	7.41
	15	*Papilio demoleus L.*	PA7	Lime butterfly	162	6.98

Pieridae (P)	16	*Eurema hecabe L.*	P1	Common grass yellow	1303	17.29
	17	*Eurema brigitta C.*	P2	Small grass yellow	772	10.25
	18	*Eurema blanda B.*	P3	Three spotgrass yellow	1321	17.53
	19	*Eurema laeta B.*	P4	Spotless grass yellow	544	7.22
	20	*Catopsilia Pomona F.*	P5	Common emigrant	1366	18.13
	21	*Catopsilia pyranthe L.*	P6	Mottled emigrant	1446	19.19
Pieridae (P)	22	*Colias nilagiriensis C&R.Felder.*	P7	Nilgiri clouded yellow	6	0.08
	23	*Colotis amata F.*	P8	Small salmon arab	14	0.19
	24	*Colotis eucharis F.*	P9	Plain orange tip	8	0.11
	25	*Ixias marianne C.*	P10	White orange tip	11	0.15
	26	*Appias albina B.*	P11	Common albatross	20	0.27
	27	*Appias libythea F.*	P12	Western striped albatross	5	0.07
	28	*Cepora Nerissa F.*	P13	Common gull	101	1.34
	29	*Delias eucharis D.*	P14	Common jezebel	618	8.20
Lycaenidae (L)	30	*Curetis thesis D.*	L1	Indian sunbeam	225	18.01
	31	*Tarucus nara K.*	L2	Striped pierrot	21	1.68
	32	*Jamides bochus S.*	L3	Dark cerulean	30	2.40
	33	*Catochrysops Strabo F.*	L4	Forget – me – not	19	1.52
	34	*Pseuudozizeeria maha K.*	L5	Pale grass blue	134	10.73
	35	*Zizina otis F.*	L6	Lesser grass blue	104	8.33
	36	*Zizeeria karsandra M.*	L7	Dark grass blue	143	11.45
	37	*Zizula hylax F.*	L8	Tiny grass blue	160	12.81
	38	*Leptotes plinius F.*	L9	Zebra blue	12	0.96
	39	*Chilades lajus S.*	L10	Lime blue	130	10.41
	40	*Chilades putli K.*	L11	Eastern grass jewel	178	14.25
	41	*Everes lacturnus G.*	L12	Indian cupid	13	1.04
	42	*Chilades parr F.*	L13	Small cupid	80	6.41
Nymphalidae (N)	43	*Tirumala limniace C.*	N1	Blue tiger	753	6.78
	44	*Tirumala septentrionis B.*	N2	Dark blue tiger	528	4.76
	45	*Danaus genutia C.*	N3	Striped tiger	199	1.79
	46	*Danaus chrysippus L.*	N4	Plain tiger	1469	13.23
	47	*Parantica aglea S.*	N5	Glossy tiger	25	0.23
	48	*Euploea core C.*	N6	Common Indian crow	1383	12.46
	49	*Charaxes solons F.*	N7	Black rajah	21	0.19
	50	*Melanitis L.*	N8	Common evening brown	287	2.59
	51	*Mycalesis perseus F.*	N9	Common bush brown	408	3.68
	52	*Acraea violae F.*	N10	Tawny coster	1429	12.87
	53	*Phalanta phalantha D.*	N11	Common leopard	32	0.29
	54	*Euthalia aconthea C.*	N12	Common baron	119	1.07
	55	*Byblia ilithyia D.*	N13	Joker	779	7.02
	56	*Ariadne ariadne L.*	N14	Angled castor	496	4.47
	57	*Ariadne merione C.*	N15	Common castor	214	1.93
	58	*Junonia orithiya L.*	N16	Blue pansy	324	2.92
	59	*Junonia hierta F.*	N17	Yellow pansy	151	1.36
	60	*Junonia iphita C.*	N18	Chocolate pansy	523	4.71
	61	*Junonia lemonias L.*	N19	Lemon pansy	1423	12.82
	62	*Junonia almana L.*	N20	Peacock pansy	420	3.78
	63	*Hypolimnas bolina L.*	N21	Great egg fly	16	0.14
	64	*Hypolimnas misippus L.*	N22	Danaid egg fly	103	0.93
			Overall Total		22470	

Papilionidae

Seven species of Papilionidae butterflies with 2,321 individuals were recorded during the entire study period (Table 2). They were

PA1 - *Graphium doson* C& R. Felder.
PA2 - *Graphium Agamemnon* L.
PA3 - *Papilio polymnestor* C.
PA4 - *Papilio polytes* L.
PA5 - *Atrophaneura aristolochiae* F.
PA6 - *Atrophaneura hector* L.
PA7 - *Papilio demoleus* L.

Among the seven species observed, the *Papilio polytes* (PA4) was the most highly distributed species with 811 individuals (34.94%) followed by *G. Agamemnon* (PA2) with 556 individuals (23.96%), *A. aristolochiae* (PA5) with 319 individuals (13.74%), *G. doson* (PA1) with 290 individuals (12.49%), *A. hector* (PA6) with 172 individuals (7.41%) and *P. demoleus* (PA7) with 162 individuals (6.98%), respectively.
The species *Papilio polymnestor* (PA3) was the least distributed with 11 individuals only (Figure 2 & 3), and the contribtion of *P. polymnestor* was only 0.47%.

Pieridae

Fourteen species of Pieridae butterflies with 7,535 total individuals were recorded during the entire study period (Table 2). They were

P1 - *Eurema hecabe* L.
P2 - *Eurema brigitta* C.
P3 - *Eurema blanda* B.
P4 - *Eurema laeta* B.
P5 - *Catopsilia Pomona* F.
P6 - *Catopsilia pyranthe* L.
P7 - *Colias nilagiriensis* C& R. Felder.
P8 - *Colotis amata* F.
P9 - *Colotis eucharis* F.
P10 - *Ixias Marianne* C.
P11 - *Appias albina* B.
P12 - *Appias libythea F.*
P13 - *Cepora nerissa* F.
P14 - *Delias euchariss* D.

Among the fourteen species observed, the *C. pyranthe* (P6) was the most highly distributed species with 1,446 individuals (19.19%) followed by *C. Pomona* (P5) with 1,366 individuals (18.13%), *E. blanda* (P3) with 1,321 individuals (17.53%), *E. hecabe* (P1) with 1,303 individuals (17.29%), *E. brigitta* (P2) with 772 individuals (10.25%), *D. euchariss* (P14) with 618 individuals (8.20%), *E. laeta* (P4) with 544 individuals (7.22%), *C. nerissa* (P13) with 101 individuals (1.34%), *A. albina* (P11) with 20 individuals (0.27%), *C. amata* (P8) with 14 individuals (0.19%), *I. marianne* (P10) with 14 individuals (0.15%), *C. eucharis* (P9), with 8 individuals (0.11%) and *C. nilagiriensis* (P7) with 6 individuals (0.08%), respectively.
The species *A. libythea* (P12) was the least distributed one with only 5 individuals (Figure 2 & 3), and the contribution of *A. libythea* was only 0.07%.

Lycaenidae
Thirteen species of Lycaenidae butterflies with 7,535 total individuals were recorded during the entire study period (Table 2). They were
L1 - *Curetis thesis D.*
L2 - *Tarucus nara K.*
L3 - *Jamides bochus S.*
L4 - *Catochrysops strabo F.*
L5 - *Pseuudozizeeria maha K.*
L6 - *Zizina otis F.*
L7 - *Zizeeria karsandra M.*
L8 - *Zizula hylax F.*
L9 - *Leptotes plinius F.*
L10 - *Chilades lajus S.*
L11 - *Chilades putli K.*
L12 - *Everes lacturnus G.*
L13 - *Chilades parr F.*

Among the thirteen species observed, the *C. thesis* (L1) was the most highly distributed species with 225 individuals (18.01%) followed by *C. putli* (L11) with 178 individuals (14.25%), *Zizula hylax* (L8) with 160 individuals (12.81%), *Z. karsandra* (L7) with 143 individuals (11.45%), *P. maha* (L5) with 134 individuals (10.73%), *C. lajus* (L10) with 130 individuals (10.41%), *Z.otis* (L6) with 104 individuals (8.33%) *C. parr* (L13) with 80 individuals (6.41%), *J. bochus* (L3) with 30 individuals (2.40%), *T. nara* (L2) with 21 individuals (1.68%), *C. strabo* (L4) with 19 individuals (1.52%) and *E. lacturnus* (L12) with 13 individuals (1.04%), respectively
The species *L. plinius* (L9) was the least distributed one with only 12 individuals and the contribution of *A. libythea* was only 0.96%. (Figure 2 & 3).

Nymphalidae
Twenty one species of Nymphalidae butterflies with 11,102 individuals were recorded during the entire study period (Table 2). They were
N1 - *Tirumala limniace* C.
N2 - *Tirumala septentrionis* B.
N3 - *Danaus genutia* C.
N4 - *Danaus chrysippus* L.
N5 - *Parantica aglea* S.
N6 - *Euploea core* C.
N7 - *Charaxes solons F.*
N8- *Melanitis* L.
N9 - *Mycalesis perseus* F.
N10 - *Acraea violae* F.
N11 - *Phalanta phalantha* D.
N12 - *Euthalia aconthea* C.
N13 - *Byblia ilithyia* D.
N14 - *Ariadne ariadne* L.
N15 - *Ariadne merione* C.
N16 - *Junonia orithiya* L.
N17 - *Junonia hierta* F.
N18 - *Junonia iphita* C.
N19 - *Junonia lemonias* L.
N20 - *Junonia almanac* L.
N21 - *Hypolimnas bolina* L.
N22 - *Hypolimnas misippus* L.

Among the 21 species observed, the *D. chrysippus* (N4) was the most highly distributed species with 1469 individuals (13.23%) followed by *A. violae* (N10) with 1429 individuals (12.87%), *J. lemonias* (N19) with 1423 individuals (12.82%), *E. core* (N6) with 1383 individuals (12.46%), *B. ilithyia* (N13) with 779 individuals (7.02%), *T. limniace*(N1) with 753 individuals (6.78%), *T. septentrionis* (N2) with 528 individuals (4.76%), *J. iphita* (N18) with 523 individuals (4.71%), *A. ariadne* (N14) with 496 individuals (4.47%), *J. almanac* (N20) with 420 individuals (3.78%), *M. perseus* (N9) with 408 individuals (3.68%), *J. orithiya* (N16) with 324 individuals (2.92%), *Melanitis* (N8) with 287 individuals (2.59%), *A. merione* (N15) with 214 individuals (1.93%), *D. genutia* (N3) with 199 individuals (1.79%), *J. hierta* (N17) with 151 individuals (1.36%), *E.aconthea* (N12) with 119 individuals (1.07%), *H. misippus* (N22) with 103 individuals (0.93%), *P. phalantha* (N11) with 32 individuals (0.29%) *P. aglea* (N5) with 25 individuals (0.23%) and *C. solons* (N7) with 21 individuals (0.19%) respectively.
The species *H. misippus* (N21) was the least distributed species with only 16 individuals (0.14%) (Figure 2 & 3).

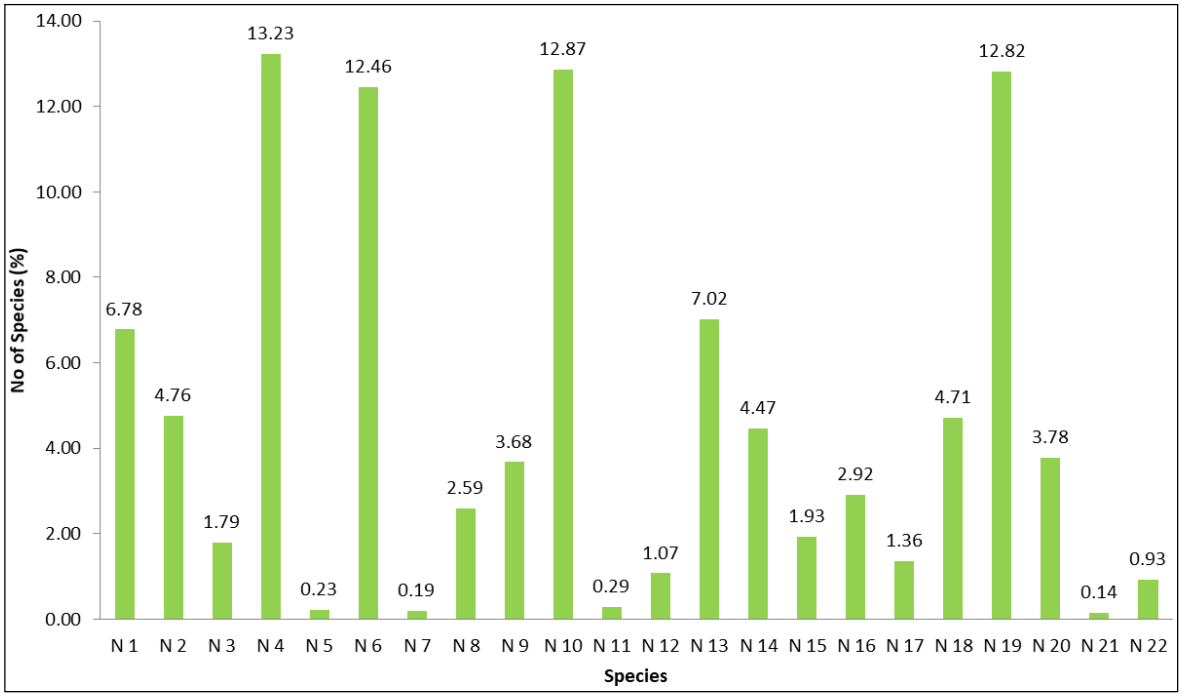

Fig 2: Percentage distribution of different species of Nymphalidae in the Vasantham Garden

In the Vasantham Garden among the 22,470 individuals observed, most of the members belong to the family Nymphalidae and was the most highly distributed family with a total number of 11,102 individuals. This was followed by Pieridae with 7,535 individuals, Papilionidae with 2,321 individuals, Lycaenidae with 1,249 individuals and Hesperiidae with only 263 individuals, respectively (Figure 2 & 3).

The percentage contribution of the family Hesperiidae was 1.17%, Papilionidae was 10.33%, the contribution of Pieridae was 33.53%, the contribution of Lycaenidae was 5.56% and the contribution of Nymphalidae was 49.41% respectively (Figure 2).

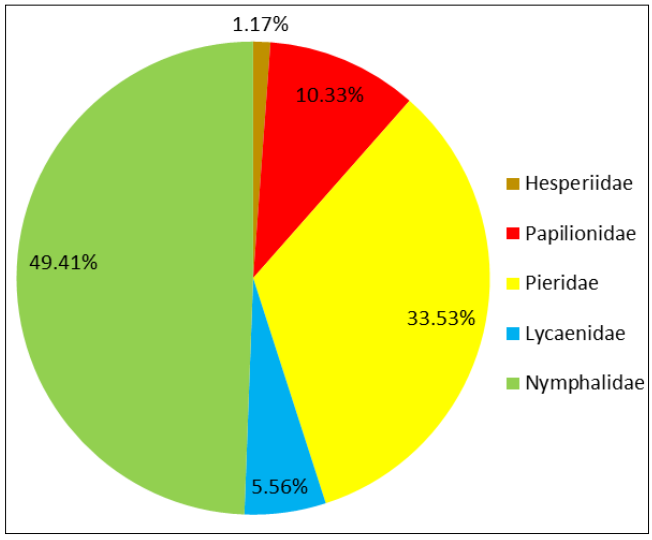

Fig 3: Percentage distribution of different families of butterflies in the Vasantham Garden

From the observed results, it was concluded that in the Vasantham Garden the family Nymphalidae was the most highly represented and densely distributed one with more number of individuals.

The result of the family-wise diversity indices analysis indicated (Table 3) in the Vasantham Garden, the family Nymphalidae was recorded as a rich family with 22 species (R1 = 2.225; R2 = 0.209) followed by the families Pieridae with 14 species (R1 = 1.456; R2 = 0.161), Lycaenidae with 13 species (R1 = 1.731; R2 = 0.406), Hesperiidae with 8 species (R1 = 1.256; R2 = 0.493) and Papilionidae with 7 species (R1 = 0.774; R2 = 0.145).

Table 3: Family-wise diversity indices of butterflies in the Vasantham Garden habitat

	Hesperiidae	**Papilionidae**	**Pieridae**	**Lycaenidae**	**Nymphalidae**
Richness					
NO	8	7	14	13	22
R1	1.256	0.774	1.456	1.731	2.225
R2	0.493	0.145	0.161	0.406	0.209
Diversity					
λ	0.184	0.224	0.152	0.117	0.087
H'	1.850	1.646	1.975	2.269	2.644
N1	6.359	5.188	7.213	9.678	14.074
N2	5.431	4.457	6.537	8.509	11.438
Evenness					
E1	0.889	0.846	0.748	0.884	0.855
E2	0.794	0.741	0.515	0.744	0.639
E3	0.765	0.698	0.477	0.723	0.622
E4	0.854	0.859	0.906	0.879	0.812
E5	0.826	0.825	0.891	0.865	0.798

The Hesperiidae family recorded the following values– Simpsons' index = 0.184; Shannon–Weiner index = 1.850; Hill's Diversity Number N1 = 6.359; N2 = 5.431; Evenness index E1 = 0.889; E2 = 0.794; E3 = 0.765; E4 = 0.854 and E5 = 0.826.

The family Papilionidae recorded the following values– Simpson's index 0.224; Shannon–Weiner index 1.646, Hill's

Diversity Number N1 = 5.188; N2 = 4.457; Evenness index: E1 = 0.846; E2 = 0.741; E3 = 0.698; E4 = 0.859 and E5 = 0.825.

The family Pieridae recorded the following values–Simpson's index 0.152; Shannon–Weiner index 1.975, Hill's Diversity Number N1 =7.213; N2 = 6.537; Evenness index: E1 = 0.748; E2 = 0.515; E3 = 0.477; E4 = 0.906 and E5 = 0.891.

The family Lycaenidae recorded the following values – Simpson's index 0.117; Shannon–Weiner index 2.269, Hill's Diversity Number N1 = 9.678; N2 = 8.509; Evenness index: E1 = 0.884; E2 = 0.744; E3 = 0.723; E4 = 0.879 and E5 = 0.865.

The family Nymphalidae recorded the following values– Simpson's index 0.087; Shannon–Weiner index 2.644, Hill's Diversity Number N1 = 14.074; N2 = 11.438; Evenness index: E1 = 0.855; E2 = 0.639; E3 = 0.622; E4 = 0.812 and E5 = 0.798.

In this landscape, the highly diversified family was Nymphalidae. The Shannon–Weiner diversity index for Vasantham Garden is well documented month-wise in Table 4. The family Hesperiidae showed moderate diversity index only over a very few months. A moderate diversity index was observed during the months of January, February and October (1.155,1.767,1.092), while over the remaining several months of the study period it showed the least index such as 0.150 during April, 0.450 August and 0.472 during October. Few month index showed only '0'. This indicated that among the five families studied, the members of the Hesperiidae showed the poorest diversity in the Vasantham Garden.

λ: Simpson's index

H': Shannon–Weiner index

The family Papilionidae showed moderate diversity index almost all the months studied except for a few months of 2012 and July 2013 during which the index was very low (0.552, 0.646). The highest diversity index was observed during the months of December and January (1.517, 1.743) while moderate index was observed during the months of September, October and November of (1.570, 1.412, 1.466) in the year of study period.

In the family Pieridae, the months with least diversity were February, May, June of 2012 (1.399, 1.416 and 1.460). The highest diversity index was observed during the months of July, August, November, October 2012 (1.918, 1.921, 1.872, 1.835) while a moderate index was observed in a few months in 2012 and 2013. The family Lycaenidae showed its highest diversity index during the months of April, May, June, October, November 2012 (2.154, 2.162, 2.208, 2.138, 2.097) and April, May, June, October, November 2013 (2.272, 2.163, 2.354, 2.227, 2.224, 2.170). Moderate diversity index was observed during the months of January to March 2012 (1.816, 1.868, 1.490), and December during 2013 (1.976). The family Nymphalidae showed its highest diversity index almost all the months studied except the months of June and July 2012 during which the index was very least (1.841, 1.823). The highest diversity index was observed during the months of October and November of (2.588, 2.641) during the entire year of study.

Season-wise Shannon–Weiner Index (Table 5) of Vasantham Garden indicated that the diversity of butterfly population was very high during monsoon (Hesperiidae = 1.130 Papilionidae = 1.470, Pieridae = 1.870, Lycaenidae = 2.030 and Nymphalidae = 2.520) and post-monsoon (Hesperiidae = 1.446, Papilionidae = 1.680, Pieridae = 1.691, Lycaenidae = 1.799 and Nymphalidae = 2.331) periods, while it showed moderate levels during the summer season (Hesperiidae = 0.547, Papilionidae = 1.547, Pieridae = 1.757, Lycaenidae = 2.256 and Nymphalidae = 2.138) and very poor diversity during pre-monsoon (Hesperiidae = 0.763, Papilionidae = 1.074, Pieridae = 1.882, Lycaenidae = 1.991, and Nymphalidae = 1.847). Gradually, the population diversity picked up from pre-monsoon onwards in almost all families studied, and it reached its peak during monsoon and then faced a declining trend from post-monsoon onwards.

Among the five families studied, the family Nymphalidae showed the best representation in almost all seasons. It also showed the best richness (R1 = 2.225), diversity (H = 2.644, N1 = 14.074, N2 = 11.438) and evenness (E1 = 0.855, E2 =0.639, E3 = 0.622, E4 = 0.812 and E5 = 0.798) (Table 3), while the family Pieridae showed the least representation during all the seasons.

Table 4: Month-wise Shannon–Weiner index computed for Butterflies in the Vasantham Garden

Families	Hesperiidae	Papilionidae	Pieridae	Lycaenidae	Nymphalidae
Jan-17	1.155	1.767	1.743	1.816	2.059
Feb-17	0.895	1.631	1.599	1.868	2.478
Mar-17	0.666	0.751	1.627	1.490	2.499
Apr-17	0.150	0.000	1.644	2.154	2.277
May-17	0.472	0.552	1.789	2.162	2.192
Jun-17	0.000	0.000	1.851	2.208	1.821
Jul-17	0.000	0.000	1.918	1.903	1.823
Aug-17	0.450	0.000	1.921	2.138	2.397
Sep-17	0.485	0.000	1.707	1.491	1.399
Oct-17	0.750	1.092	1.905	2.097	2.482
Nov-17	0.000	0.868	1.872	2.121	2.588
Dec-17	0.000	0.000	1.835	2.058	2.323
Jan-18	1.767	1.554	1.487	1.806	2.040
Feb-18	1.631	1.422	1.399	2.074	2.318
Mar-18	0.751	1.511	1.508	1.655	2.342
Apr-18	0.000	1.653	1.610	2.272	1.926
May-18	0.552	1.515	1.416	2.163	2.171
Jun-18	0.000	1.581	1.460	2.354	1.981
Jul-18	0.000	1.040	1.683	2.227	1.729
Aug-18	0.000	0.646	1.659	2.224	2.255
Sep-18	0.000	1.570	1.614	1.496	1.351
Oct-18	1.092	1.412	1.550	2.170	2.471
Nov-18	0.868	1.466	1.638	2.059	2.641
Dec-18	0.000	1.517	1.631	1.976	2.389

Table 5: Mean of season-wise observation of Shannon Index in Vasantham Garden

Family	Summer (Apr-Jun)	Pre-monsoon (Jul-Sep)	Monsoon (Oct-Dec)	Post-monsoon (Jan-Mar)
Hesperiidae	0.547 ± 0.54	0.763 ± 0.69	1.13±0.4	1.446 ± 0.41
Papilionidae	1.547 ± 0.13	1.074 ± 0.50	1.47±0.07	1.680 ± 0.05
Pieridae	1.757 ± 0.05	1.882 ± 0.14	1.87±0.03	1.691 ± 0.05
Lycaenidae	2.256 ± 0.08	1.991 ± 0.40	2.03±0.15	1.799 ± 0.16
Nymphalidae	2.138 ± 0.18	1.847 ± 0.50	2.52±0.13	2.331 ± 0.21

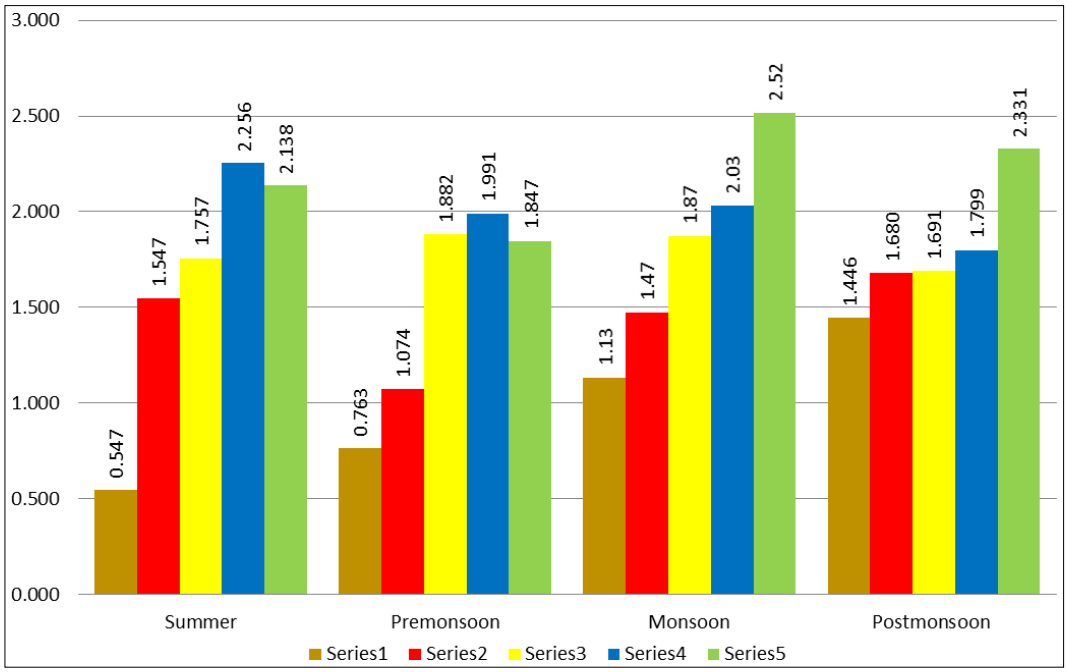

Fig 4: Season-wise distribution of butterfly population in Vasantham Garden

Error bar of Mean Abundance - 2017

Table 6: Mean Abundance of butterflies in Vasantham Garden

Family	Mean	Std. Error	Error Bar Mean ±.S.E
PA	175.83	50.863	175.83±50.863
PI	544.67	77.613	544.67±77.613
L	53.62	11.726	53.62±11.726
N	381.64	92.171	381.64±92.171

The table 6 provided, wherein the mean abundance (544.67) of the butterfly species Pieridae is high in the habitat Vasantham Garden followed by Nymphalidae (381.64) and the intervals of the error bars (Mean ±.S.E) are displayed which explain the sample.

Moreover, it approximates 95% confidence interval error bars and gives the variations of abundance from species to species in the habitat Vasantham Garden.

Error bar of Mean Abundance – 2018

Table 7: Mean Abundance of butterflies in Vasantham Garden

Family	Mean	Std. Error	Error Bar Mean ±.S.E
PA	209.17	55.161	209.17±55.161
PI	593.00	67.650	593.00±67.650
L	50.25	10.544	50.25±10.544
N	392.64	81.917	392.64±81.917

The table 7 provided, wherein the mean abundance (593.00) of the butterfly species Pieridae is high in the habitat Vasantham Garden followed by Nymphalidae (392.64) and the intervals of the error bars (Mean ±.S.E) are displayed which explain the sample.

Moreover, it approximates 95% confidence interval error bars and gives the variations of abundance from species to species in the habitat Vasantham Garden.

Population dynamics of butterflies in the Vasantham Garden

In the Vasantham Garden all the butterflies belonging to the five families studied were at the maximum numbers during the post rainy season. Fluctuations in their number in most of the families largely coincided with the late winter and summer seasons only. Low population density was exhibited by most of the families during May to July of both the years (2017 and 2018) during which the environmental conditions prevailed was not favourable for them. Butler and (Wang C 2000) [19] indicated that population shift may be directly related to weather conditions or indirectly to the effects of temperature or rainfall pattern or natural enemies or foliage chemistry or other factors. However the indirect effects of environmental stresses on host plant density or natural enemies, which thereby affect butterfly dynamics, may not be explained very easily in the artificial manmade garden such as the Vasantham Garden in the Bishop Heber College Campus.

Butterflies use host plants as a source of diverse chemical substances, which are employed in defense, mating, synthesis of wing and body pigments and other special life functions (Brower and Fink, 1985) [20]. *Ixora coccinea* is the host plants for *D. chrysippus* (N4) and *Nerium oleander* the host plants for *Euploea core* (N6) and *Ixora coccinea* which are found in abundance in this ecosystem. A number of shrubs such as *Tridax procumbens* and the wild grasses and herbs are the host plants for *C. pyranthe* (P6) and *E. blanda* (P3) and Zinnia. Apart from nourishing, the trees, shrubs and herbs present in the Vasantham Garden largely used as roosting, resting, basking, mating location and shelter. A dominant proportion of the population adopts shrub areas in cooler cloudy and windy weather (Dennis and Dennis, 2006) [21]. With quantitative data gathered on butterfly populations, the present study also analysed the biodiversity and seasonal patterns in butterfly populations and interactions. The vegetation types and levels of disturbance in the six habitats chosen were documented. During the survey, a large number of butterflies were found to use shrubs and herbs as roosting places, especially

the *Papilio demoleus*, which preferred lemon plants, *Danaus chrysippus* preferred Ixora, and *Euploea core* preferred Nerium plants. Papilionids such as *Papilio demoleus, P. polytes, A. aristolochiae*, Nymphlidae such as *H.misippus, D. chrysippus,* and Pieridae like *C. pyranthe, E. blanda, Ehecabe, E. brigitta* and few others were observed as predominant species of this ecosystem. Although they exhibited seasonal or periodical peaks, they occurred almost in all the months.

Conclusion

Biodiversity is one of the important cornerstones of sustainable development, and it represents the biological wealth of a given nation. Insects and plants are becoming extinct because of habitat loss, over-exploitation, pollution, over-population and the threat of global climatic changes. Biodiversity monitoring programs are used for a variety of purposes, including species distribution, population, habitat models, red list assessments, detection of spatial and temporal trends, tropical insect diversification, evaluation of environmental impacts, and habitat management, ecological, evolutional and conservational aspects. Many species are strictly seasonal and prefer only particular set of habitats, as they are good indicators of habitat quality. Among insects, butterflies are treated as indicators of the ecosystem, important herbivore pollinators, they serve as food and host for multiple other organisms at higher trophic levels. And also considered as important mega-specifics. Living organisms are not uniformly distributed all over the habitats, but are limited to those areas, where they are species-specific. This is one of the major factors governing distribution of animals in various habitat types. This research reveals a relationship between butterfly species diversity and population density. The study results revealed that the population dynamics of butterflies in the Vasantham Garden habitats was extraordinarily high due to huge- and small-sized trees and luxurious growth of flowers, herbs, shrubs and grasses. Overall, the current butterfly study emphasizes the impact of a diverse range of host plants, as well as varying environmental circumstances, on butterfly species diversity were censured and documented.

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