Original Research Article

Diversity and Abundance of Butterflies (Lepidoptera: Rhopalocera) in Sethu Bhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, South India

ABSTRACT

Butterflies play a vital role in the ecosystem, acting as pollinators, pollution indicators, pests, predators, weed killers, a good source of food and being of aesthetic, economic and ecological importance. World-wide butterfly populations are on the decline due to habitat destruction and deforestation. This study was taken with the prime objective of preparing the checklist of butterflies at SethuBhaskara Agricultural College and Research Foundation, Karaikudi, Tamil Nadu, from April 2023 to July 2023. A total of 976 individuals of 76 species belonging to 5 families have been recorded in the survey. For this study, the college was mapped into four different habitats: botanical garden area, agricultural field area, horticultural field area and grassland area. Results revealed that the family Nymphalidae showed the maximum number of species (22.0 species) from 12 genera (29.0%), followed by Lycaenidae (20.0 species) from 17 genera (26.5%), Pieridae (18.0 species) from 9 genera (24.0%), Hesperiidae (12.0 species) from 11 genera (16.0%) and the least being Papilionidae (4.0 species) from 2 genera (5.5%). Among the four sites, the botanical garden area ranks first with the highest number of butterflies (140 species, N = 280), followed by the horticultural field area (129 species, N = 258), the agricultural field area (115 species, N = 230) and the grassland area (104 species, N = 208). According to the monthly distribution of butterflies, the maximum number of species and abundance were recorded in the months of July (307 species, N = 332), followed by June (141 species, N = 282), April (112 species, N = 224) and least in May (69 species, N = 138). The overall Shannon-Weiner diversity index was H = 1.50, Pielou's evenness index was E = 0.60 and Margalef's index was R = 13.30. This study illustrated useful information on butterfly diversity in the study region, which serves as a baseline for future monitoring programs.

Keywords: Butterfly, Conservation, Diversity, Ecosystem, Nymphalidae

1. INTRODUCTION

Butterflies (Lepidoptera: Rhopalocera) are fascinating, colorful and the most studied insects in the world [1]. Butterflies occupy a vital position in the ecosystem as keystone species that act as valuable pollinators and help more than 50 economically important crops in the pollination process and the food chain and food

web [2, 3, 4], biological and pollution indicators of terrestrial ecosystem [5], nutrient recycling (N, P, K) and decomposition [6], biological pest control [7], good source of food and have aesthetic, economic and ecological importance [8, 9, 10]**.** Butterflies can be used as a good biological indicator for vegetative structure, habitat quality [11, 12], climate change, environmental health and degradation [7],and the impact of different threats due to anthropogenic disturbances [13]. Approximately 28,000 species of butterflies are recorded in the world [14]. Of these, 1504 species of butterflies are recorded in the Indian subcontinent, which is about 8.74% of the total butterfly species in the world and constitutes 65.0% of the total Indian fauna [14, 15]. The number of Indian butterflies amounts to one-fifth of the world's species [16, 17]. Among which, Tami Nadu hosts about 323 species of butterflies [18, 19]. Butterflies are classified into two superfamilies, *viz.,* Hesperioidea and Papilionoidea. Hesperioidea consists of a single family of Hesperiidae (Skippers), whereas Papilionoidea consists of the rest of the butterfly families, *viz.,* Papilionidae (Swallowtails), Pieridae (Whites and Sulphurs), Nymphalidae (Brush-footed butterflies) and Lycaenidae (Blues) [20]**.** The recent worldwide trend is that anthropogenic disturbances like urbanization, deforestation, habitat destruction, industrialization, and climate change, along with agricultural intensification like the use of pesticides and herbicides, cause migration or local extinction of butterflies [21, 22, 23, 24]**.** In the last 40 years, there has been a dramatic decline of about 35.0% in butterfly abundance across the globe [25] and due to anthropogenic drivers of defaunation, many species (about 40.0%) may face extinction in the next few decades [26]. Studies on the diversity of butterflies in any area help understand the status of an ecosystem [27]. Studies related to butterfly diversity are necessary to prevent extinction and further decline, particularly in urban regions and educational institutional campuses, where they are very rare [28] and extremely necessary for effective and proper conservation of butterflies [29]. However, no previous study has been carried out on the butterflies' diversity at SethuBhaskara Agricultural College and Research Foundation (SBAC & RF), Karaikudi, Sivagangai district. Hence, the present study was the first preliminary attempt to document the species diversity and abundance of butterflies in SBAC and RF, Karaikudi. The result of the survey will be helpful in making a butterfly checklist and conservation plan for the study area.

2. MATERIAL AND METHODS

2.1. STUDY AREA

The study was conducted at SethuBhaskara Agricultural College and Research Foundation, Karaikudi, Sivagangai district, Tamil Nadu, India (Fig. 1). The college is situated between 9°51'13.3" N latitude and 78°44'44.6' N longitude, with average rainfall and temperature ranging from 603–800 mm and 29°C–41°C. The study area occupies an area of 234 acres. The study area is predominantly covered by agricultural, horticultural and agroforestry ecosystems. For the purpose of the butterfly survey, the entire campus was mapped into

four different habitats: botanical garden area, agricultural field area, horticultural field area and grassland area.

Fig. 1. Map showing the study location

2.1.1. Habitat 1 (Botanical garden area): The botanical garden area comprises a lot of flowering plant species, *i.e*., Ixora, Hibiscus, Jasmine, Plumeria, Yellow Elder, Paper Flower, Pin Wheel Flower, Water Lily, Cosmos, Table Rose, Rose, and Nerium and is beautifully maintained.

2.1.2. Habitat 2 (Agricultural field area): The agricultural field areas mainly produce Paddy, Ragi, Maize, Pulses (Black gram and Green gram), Groundnut, Gingelly, Sorghum and Daincha. In addition, the area includes organic farming areas, traditional paddy cultivation fields and medicinal plant gardens.

2.1.3. Habitat 3 (Horticultural field area): The horticultural field area supports a variety of crops, *i.e.,* Chilli, Brinjal, Bhendi, Tomato, Mango, Guava, Sapota, Citrus, Marigold, Banana, Curry leaf, Grape, Watermelon, Castor and Water apple.

2.1.4. Habitat 4 (Grassland area): The grassland area is occupied by mixed vegetation, mainly grasses, climbers, creepers and shrubs, *i.e.,* Country mallow, Indian jointvetch, Water leaf, Milk weed, Giradol, Tick weed, Butterfly pea, Three-leaved caper, Wild poinsettia, Puncture vine, Morning glory, Rosy milk weed vine, Red pea egg plant, Prosopis, Coat buttons, Acacia, Desert horsepurslane, Bamboo and Lantana. Some common trees that are grown on the campuses *are* Neem, Pungam, Rain tree, Jamun tree, Foxtail palm, Traveler's palm, Royal palm, Cutch tree, Trumphet tree, Gulmohar, Copper pod tree, Golden Shower tree, Giger tree, Singapore Cherry, Acacia, Marudham and Nuna tree. Artificial canals, fish ponds and standing water are additional specialties in the study area.

2.2. BUTTERFLY SURVEY

The survey and documentation of the butterfly were conducted for a period of four months, from April 2023 to July 2023. The standard modified Pollard walk method was used for field surveys with necessary modifications [30, 31]. The butterflies were observed within 2.5 meters on the left and right sides and five meters in front of the observer. Field observations were taken twice a day, from early morning (8.0 am–10.0 am) to evening (3.0 pm–5.0 pm) during good weather conditions (no heavy rain or strong winds) to ensure maximum

detection of butterflies on all working days. Photography was taken during the field visit using Canon DSLR cameras (77 and 80 D, 135-250 mm). Species identification was done with the help of field guides and books, *viz*., 'South Indian Butterfly: Field Guide [32],Butterflies of India [33],Butterflies of Tamil Nadu' [19]and other available literature [34]. Identification was also done with the help of consultation with experts and the online website I-Found-Butterflies (Indian Foundation for Butterflies) (http://www.ifoundbutterflies.org/). No specimens were collected or killed during the study period. On the basis of occurrence, the butterflies' species were classified as abundant (80–100%), common (60–80%), occasional (40–60%), rare (20–40%) and very rare (below 20%) [35]. Recorded species were categorized under the IUCN Red List [36] and their status in the Wildlife Protection Act (WPA) 1972 of India [37].

2. 3. DATA ANALYSIS

Shannon-Wiener was calculated for butterfly diversity [38]. Species evenness was calculated by Pielou's evenness [39] and species richness was calculated by Margalef's index [40, 41]. Also, a dominance index or relative diversity was calculated to compare the species abundance. Relative diversity is also known as percentage occurrence. The overall mean monthly sighting was calculated by the Seasonal Index [42]. All the data were pooled and analyzed using Microsoft Office Excel 2007.

2.3.1. Shannon-Wiener Index (H'):

$H' = -\sum (P_i) (\ln P_i)$

Where, P_i = Proportion of each species

ln = Natural logarithm

2.3.2. Pielou's Evenness Index (E):

$E = H'/\ln(S)$

Where, S = Number of species

2.3.3. Margalef's index (R):

$R = (S-1)/\ln N$

Where, S = Total number of species

N = Total number of individuals in the sample

ln = Natural logarithm

2.3.4. Dominance Index (Ds):

$Ds = ni \times 100/ N$

Where,ni = number of butterflies in the family

N **=** Total number of butterflies in all the family

2.3.5. Seasonal Index (SI)

SI = Month-wise mean/Overall mean ×100

Where, month-wise mean is the mean number of butterflies sighted during the study period and overall mean is the mean of all month-wise means.

3. RESULTS AND DISCUSSION

3.1. Family wise composition of butterflies

The study revealed that a total of 976 individuals of 76 species belonging to 51 genera and 5 families of butterflies (Nymphalidae, Lycaenidae, Pieridae, Hesperiidae, and Papilionidae) were recorded in this study **(Table 1–5).** Photographs of each species categorized into their respective families were represented **(Plate 1–5).** The highest number of species and

highest abundance have been observed in Nymphalidae (22 species from 12 genera, 29.0%, N = 321), followed by Lycaenidae (20 species from 17 genera, 26.5%, N = 285), Pieridae (18 species from 9 genera, 24.0%, N = 185), Hesperiidae (12 species from 11 genera, 16.0%, N = 125) and the lowest number of species and abundance in Papilionidae(four species from 2 genera, 5.5%, N = 60), as illustrated **(Table 6)**.The study shows the highest species-to-genus ratio (S/G ratio) for Pieridae and Papilionidae compared to the other three families.The species-to-genus ratio (S/G) that determines species distribution among genera was 1.8, 1.2, 2.0, 1.1, and 2.0 for Nymphalidae, Lycaenidae, Pieridae, Hesperiidae, and Papilionidae, respectively **(Table 6).** Among the total recorded species, their relative abundance indicates that 33.0% are common (25 species), followed by abundant (32.0%, 24 species), occasional (18.0%, 14 species), rare (13%, 10 species) and very rare (3.0%, 2 species) **(Fig. 2; Table 1-5).**

Table 1. Checklist of butterfly species belonging to the family Nymphalidaerecorded **in the study area**

S. No.	Common Name	Scientific Name	IUCN Status	Abundance
1	Lemon Pansy	*Junonialemonias* (Linnaeus, 1758)	NE	A
2	Blue Pansy	*Junoniaorithiya* (Linnaeus, 1758)	NE	R
3	Peacock Pansy	*Junoniaalmana*(Linnaeus, 1758)	LC	O
4	Grey Pansy	*Junoniaatlites* (Linnaeus, 1763)	NE	C
5	Yellow Pansy	*Junoniahierta*(Fabricius, 1798)	LC	O
6	Chocolate Pansy	*Junoniaiphita*(Cramer, 1779)	NE	O
7	Plain Tiger (Male)	*Danauschrysippus*(Linnaeus, 1758)	LC	A
8	Striped Tiger (Male)	*Danausgenutia*(Cramer, 1779)	NE	A
9	Angled Castor	*Ariadne ariadne* (Moore, 1884)	NE	C
10	Common Castor	*Ariadne merione* (Cramer, 1777)	NE	C
11	Danaid Egg Fly (Female)#	*Hypolimnasmisippus* (Linnaeus, 1764)	LC	R
12	Great Egg Fly	*Hypolimusbolina* (Linnaeus, 1758)	NE	R
13	Common Four Ring	*Ypthimahuebneri* (Kirby, 1871)	NE	C
14	White Four Ring	*Ypthimaceylonica* (Hewitson, 1865)	LC	R
15	Common Bush Brown	*Mycalesisperseus*(Fabricius, 1775)	NE	C
16	Glade Eye Bush Brown	*Mycalesis patina* (Moore, 1857)	NE	C
17	Joker	*Bybliailithyia*(Drury, 1773)	NE	C
18	Common Indian Crow****	*Euploea core* (Cramer, 1780)	LC	C

19	Tawny Costor	*Acraeaviolae*(Linnaeus, 1758)	NE	C
20	Common Evening Brown	*Melanitisleda*(Linnaeus, 1758)	NE	A
21	Blue Tiger	*Tirumalalimniace*(Cramer,1775)	NE	A
22	Common Sailor	*Neptishylas*(Linnaeus, 1758)	NE	C

IUCN Status: NE-Not evaluated; LC-Least concern
Abundance: A-Abundant, C-Common, O-Occasional, R-Rare
Wildlife Protection Act-1972: ****Schedule IV, #Schedule I & II

Table 2. Checklist of butterfly species belonging to the family Lycaenidae recorded **in the study area**

S. No.	Common Name	Scientific Name	IUCN Status	Abundance
1	Small Grass Jewel	*Freyeriaputli*(Kollar, 1844)	NE	A
2	Grass Jewel	*Freyeriatrochylus*(Freyer, 1845)	NE	A
3	Plain Cupid	*Chiladespanadava*(Horsefield, 1829)	NE	C
4	Lime Blue	*Chiladeslajus*(Stoll, 1780)	NE	A
5	Gram Blue**	*Euchrysopscnejus*(Fabricius, 1798)	NE	A
6	Common Smoky Blue	*Euchrysopsmalathana*(Boisduval, 1833)	NE	C
7	Dull Babul Blue	*Azanusuranus*(Butler, 1886)	NE	C
8	Forest Pierrot	*Tarakahamada*(Druce, 1875)	NE	C
9	Common Pierrot##	*Castaliusrosimon*(Fabricius, 1775)	NE	C
10	Indian Cupid	*Evereslacturnus*(Godart, 1824)	NE	C
11	Rounded Pierrot	*Tarucusnara*(Kollar, 1848)	NE	VR
12	Zebra Blue	*Leptotesplinius*(Fabricius, 1793)	NE	A
13	Common Silverline	*Spindasisvulcanus*(Fabricius, 1775)	NE	A
14	Common Cerulean	*Jamidesceleno* (Cramer, 1775)	NE	A
15	Lesser Grass Blue	*Zizinaotis*(Fabricius, 1787)	NE	A
16	Tiny Grass Blue	*Zizulahylax*(Fabricius, 1775)	NE	A
17	Tamil Large Guava Blue	*Virachola Isocrates* (Fabricius, 1793)	NE	O
18	Tawny Silver Line	*Cigaritisacamas*(Klug, 1834)	NE	C
19	Forget-Me-Not	*Catochrysopsstrabo*(Fabricius, 1793)	NE	A
20	Ceraunus Blue	*Hemiargusceraunus*(Fabricius, 1793)	NE	O

IUCN Status: NE-Not evaluated
Abundance: A-Abundant, C-Common, O-Occasional, VR-Very Rare
Wildlife Protection Act-1972: **Schedule II (Part II), ## Schedule I & IV

Table 3. Checklist of butterfly species belonging to the family Pieridae recorded **in the study area**

S. No.	Common Name	Scientific Name	IUCN Status	Abundance
1	Small Grass Yellow	*Euremabrigitta* (Stoll,1780)	LC	C
2	One Spot Grass yellow	*Euremaandersoni*(Moore, 1886)	LC	A
3	Common Grass Yellow	*Euremahecabe* (Linnaeus, 1758)	NE	A
4	Small Orange Tip (Female)	*Colotisetrida*(Boisduval, 1836)	NE	C
5	Crimson Tip (Male)	*Colotisdanae*(Fabricius, 1775)	NE	R
6	Plain Orange Tip	*Colotis aurora* (Cramer, 1780)	NE	O
7	Desert Orange Tip	*Colotisevagore* (Klug, 1829)	NE	O
8	Large Salmon Arab	*Colotisfausta*(Oliver, 1804)	NE	R
9	Common Albatross**	*Appias albino* (Boisduval, 1836)	NE	C
10	Striped Albatross***	*Appiaslibythea*(Fabricius, 1775)	NE	R
11	Mottled Emigrant	*Catopsillapyranthe* (Linnaeus, 1758)	NE	A
12	Oriental Lemon/Common Emigrant	*Catopsilia Pomona* (Fabricius, 1775)	NE	C
13	African Migrant	*Catopsiliaflorella*(Fabricius, 1775)	NE	C
14	Pioneer	*Belenoisaurota*(Fabricius, 1793)	LC	A
15	Common Gull**	*Ceporanerissa*(Fabricius, 1775)	NE	A
16	Psyche	*Leptosianina*(Fabricius, 1793)	NE	O
17	Andaman Great Orange Tip	*Hebomoiaroepstorfii* (Wood-Mason, 1880)	NE	O
18	White Orange Tip	*Ixias marianne* (Cramer, 1779)	NE	C

IUCN Status: NE-Not evaluated; LC-Least concern
Abundance: A-Abundant, C-Common, O-Occasional, R-Rare,
Wildlife Protection Act-1972: **Schedule II (Part II), ***Schedule III

Table 4. Checklist of butterfly species belonging to the family Hesperiidae recorded **in the study area**

S. No.	Common Name	Scientific Name	IUCN Status	Abundance

1	Common Grass Dart	*Taractroceramaevius*(Fabricius, 1793)	NE	O
2	Tamil Grass Dart	*Taractroceraceramas*(Hewitson, 1868)	NE	VR
3	African Marbled Skipper	*Gomaliaelma*(Trimen, 1862)	NE	R
4	Chinese Swift	*Pelopodassinensis*(Mabille, 1877)	NE	R
5	Rice Swift	*Borbocinnara*(Wallace, 1866)	NE	A
6	Indian Palm Bob	*Suastusgremius*(Fabricius, 1798)	NE	C
7	Brown Awl	*Badamiaexclamationis*(Fabricius, 1775)	LC	A
8	Grass Demon	*Udaspesfolus*(Cramer, 1775)	NE	O
9	Grizzled Skipper	*Pyrgusmalvae* (Linnaeus, 1758)	NE	O
10	Acacia Skipper	*Cogiahippalus*(Edwards, 1882)	NE	C
11	Manfreda Giant Skipper	*Stallingsiamaculosus* (Freeman, 1955)	NE	O
12	Common Bush Hopper	*Ampittiadioscorides*(Fabricius, 1793)	NE	R

IUCN Status: NE-Not evaluated; LC-Least concern
Abundance: A-Abundant, C-Common, O-Occasional, R-Rare, VR-Very Rare

Table 5. Checklist of butterfly species belonging to the family Papilionidae recorded **in the study area**

S. No.	Common Name	Scientific Name	IUCN Status	Abundance
1	Common Lime	*Papiliodemoleus*(Linnaeus, 1758)	NE	A
2	Common Mormon	*Papiliopolytes*(Linnaeus, 1758)	NE	A
3	Common Rose	*Pachlioptaaristolochiae*(Fabricius, 1775)	LC	C
4	Crimson Rose*****	*Pachliopta hector* (Linnaeus, 1758)	LC	O

IUCN Status: NE-Not evaluated; LC-Least concern
Abundance: A-Abundant, C-Common, O-Occasional
Wildlife Protection Act-1972: *Schedule I (Part IV)

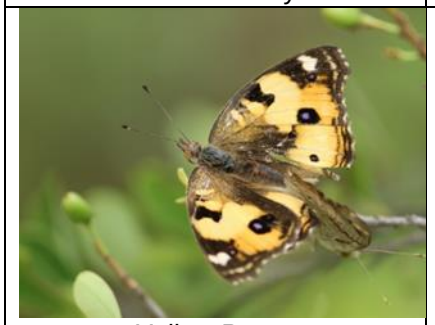
Plate 1. Photographs of butterfly species belonging to the family Nymphalidae recorded **in the study area**


Lemon Pansy


Blue Pansy


Peacock Pansy


Striped Tiger


Yellow Pansy


Chocolate Pansy


Plain Tiger


Great Egg Fly


Angled Castor


Common Castor


Danaid Egg Fly


Common Evening Brown

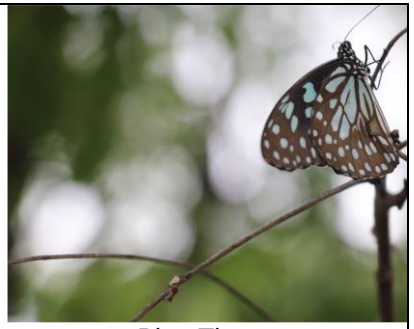
 Common Four Ring	 White Four Ring	 Common Bush Brown	 Blue Tiger
 Joker	 Common Indian Crow	 Tawny Costor	 Common Sailor

Plate 2. Photographs of butterfly species belonging to the family Lycaenidae recorded **in the study area**

 Small Grass Jewel	 Grass Jewel	 Plain Cupid	 Lime Blue
 Gram Blue	 Common Smoky blue	 Dull Babul Blue	 Forest Pierrot

 Common Pierrot	 Indian Cupid	 Rounded Pierrot	 Zebra Blue
 Common Silverline	 Common Cerulean	 Lesser Grass Blue	 Tiny Grass Blue
 Tamil Large Guava Blue			

Plate 3. Photographs of butterfly species belonging to the family Pieridae recorded **in the study area**


Small Grass Yellow


One Spot Grass yellow


Common Grass Yellow


Small Orange Tip


Crimson Tip


Plain Orange Tip


White Orange Tip


Large Salmon Arab


Common Albatross


Common Gull


Mottled Emigrant


Oriental Lemon/Common

			Emigrant
 Psyche	 Pioneer		

Plate 4. Photographs of butterfly species belonging to the family Hesperiidae recorded **in the study area**

 Common Grass Dart	 Tamil Grass Dart	 African Marbled Skipper	 Chinese Swift


Rice Swift


Indian Palm Bob


Brown Awl


Grass Demon

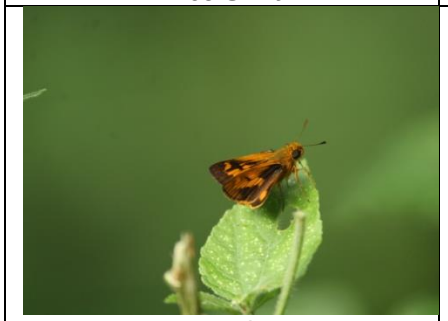

Common Bush Hopper

Plate 5. Photographs of butterfly species belonging to the family Papilionidae recorded **in the study area**


Common Lime


Common Mormon


Common Rose


Crimson Rose

UNDER PEER REVIEW

Table 6. Family wise composition, species to genus ratio and diversity indices of butterflies in the study area

S. No.	Family	Number of Species (S)	Number of Genus (G)	S/G	N	H	E	R	D (%)
1	Nymphalidae	22	12	1.8	321	0.36	0.12	3.64	29.0
2	Lycaenidae	20	17	1.2	285	0.35	0.12	3.36	26.5
3	Pieridae	18	9	2.0	185	0.34	0.12	3.26	24.0
4	Hesperiidae	12	11	1.1	125	0.29	0.12	2.28	16.0
5	Papilionidae	4	2	2.0	60	0.15	0.11	0.73	5.5
6	Total	76	51	-	976	1.50	0.60	13.30	100

S/G-Species to Genus Ratio; N-Number of individuals, H- Shannon-Wiener Index, E- Pielou's Evenness, R- Margalef's index, D- Dominance Index

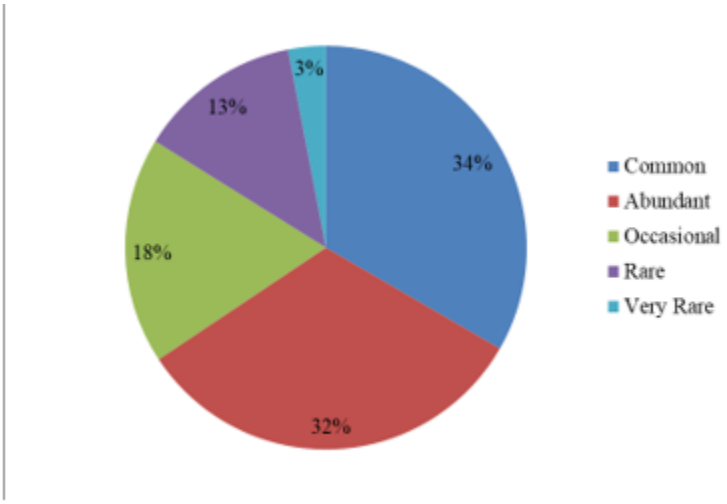


Fig. 2. Local status of recorded butterflies in the studyarea

Butterflies are important bioindicators of the ecosystem. Potent pollinators and ecological indicators like butterflies are important for estimating the general health of an ecosystem. Butterflies play a pivotal role in ecosystem restoration as pollinators. An increase in butterfly populations may indicate an increase in plant diversity in the area [43].The present study, for the first time ever, aims at evaluating butterflies on our campus. The results accumulated so far clearly indicate that the overall diversity of butterflies on our campus is quite good. Nymphalidae represented the highest number of species in the present study (22.0 species from 12 genera, 29.0%), while the Hesperiidae (12.0 species from 11 genera, 16.0%) and Papilionidae (4.0 species from 2 genera, 5.5%) families represented the lowest number of species. Similarly, a high number of species from Nymphalidae were observed by [44, 45, 46, 47, 48] in their studies. The highest species richness and abundance might be due to the presence of host plants suitable for Nymphalidae [49], high dispersal ability, ecological adaptation, being polyfag characteristic and strong or active flight, enabling them to search for resources in large geographical areas [6, 50, 51, 52, 53].This is consistent withNymphalidae being the largest butterfly family, accounting for one-third of all known

species worldwide [14]. According to [54] this phenomenon could be due to the large number of species in the family as well as their wide variety of food selection, including flowers, fruits, honey dew, tree sap, rotten materials and decomposing carcasses.The reason for the abundance of Lycaenidae and Pieridae butterflies in the study area can be attributed to the dominance of their food plants belonging to the genus *Cassia, Albizia* and *Bauhinia* in the study region [13, 55].However, in the present study, Hesperiidae and Papilionidae were poorly represented in the study area, which reported members of Papilionidae to be the least represented. One of the possible reasons for this difference could be due to the difficulties in observing Hesperiidae butterflies because of the limited monitoring time (8.0–10.0 am and 3.0–5.0 pm), their dull color and their crepuscular habit, *i.e., that*they are active in the early morning and to a lesser extent in the evening. This probably indicates that the climate, vegetation type and availability of host plants in the present study area may not be suitable for members of the Hesperiidae family. The availability of host plants determines butterfly abundance [56]. Butterflies solely depend on plants and their diversity highly depends on plant species diversity [23, 57].This, however, needs to be confirmed by further extensive surveys in this region. It is not unlikely that a few butterfly species may have escaped notice and will be added in the future.

3.2. Butterfly community, composition in different habitats

The maximum number of species and abundance were observed in the garden area (140 species, N = 280), followed by the horticultural field area (129 species, N = 258), the agricultural field area (115 species, N = 230) and the minimum in the grassland area (104 species, N = 208) **(Fig.3; Table 7).**

Table 7. Butterflies species composition in different months and habitats in the study area

S. No.	Months	Garden area		Agricultural Field Area		Horticultural Field Area		Grassland Area		Total		Seasonal Index (SI)
		S	N	S	N	S	N	S	N	S	N	%
1	April	31	62	27	54	33	66	21	42	112	224	23.0
2	May	14	28	21	42	18	36	16	32	69	138	14.0
3	June	42	84	31	62	36	72	32	64	141	282	29.0
4	July	53	106	36	72	42	84	35	70	307	332	34.0
5	Total	140	280	115	230	129	258	104	208	629	976	100

S= Number of species; N = Number of individuals

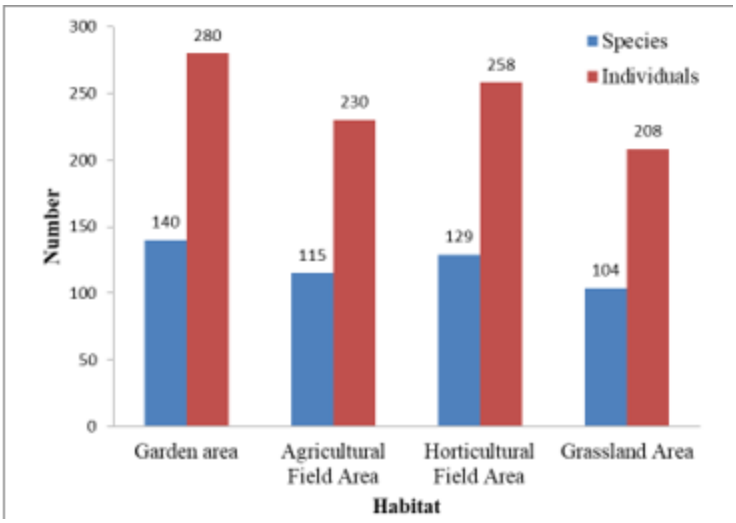


Fig. 3. Species number and individual number of butterflies in different habitat in the study area

The highest number of species with the highest abundance in the botanical garden area compared to agricultural, horticultural and grassland areas may be due to the high diversity of host plants, rich nectar resources and variety of flowers, *viz*., Ixora, Hibiscus, Jasmine, Plumeria, Yellow Elder, Paper Flower, Pin Wheel Flower, Water Lily, Cosmos, Table Rose, Rose, Nerium, Lantana and Golden Shower Tree [58] and undisturbed habitats compared to other areas. The artificially created site, like a botanical garden, mainly contains cultivated plants, especially nectar-rich flowering plants, which host several butterfly species and hence report high diversity compared to the natural areas.Agricultural field areas have low plant diversity. Lower butterfly diversity in agricultural lands might be due to agricultural intensification, chemical fertilizers and the usage of pesticides and herbicides [59, 60, 61].The lowest number of butterfly species recorded in the grassland area might be due to continuous anthropogenic activities and the limited availability of plants. Another reason for the low abundance of butterfly species in grassland areas could be the absence of shade in these areas. Anthropogenic disturbance around grassland areas affects butterfly communities [62, 63]. The agricultural expansion and intensification, overgrazing by cattle in grassland areas, construction of buildings leading to habitat destruction and movement of heavy vehicles may cause a shift in the relative abundance and diversity of butterflies in the study area. These disturbances are degrading habitat quality and adversely affecting the food resources of butterflies, which in turn have the potential to accelerate declines in their abundance and diversity. Hence, conservation of butterflies is necessary to maintain biodiversity and prevent extinction. The primary goal of conservation is to identify the different areas or hot spots that support the butterfly population and their survival [64].

3.3. Butterfly species composition in different months

Themaximum number of butterfly species and abundance was recorded in July (307 species, N = 332), followed by June (141 species, N = 282), April (112 species, N = 224) and the minimum in May (69 species, N = 138) **(Fig. 4; Table 7).** Similarly, the Seasonal Index (SI)alsorecorded themaximum number of butterfly species in July (34.1%), followed by June (29.5%), April (24.0%), and the minimum in May (14.2%).

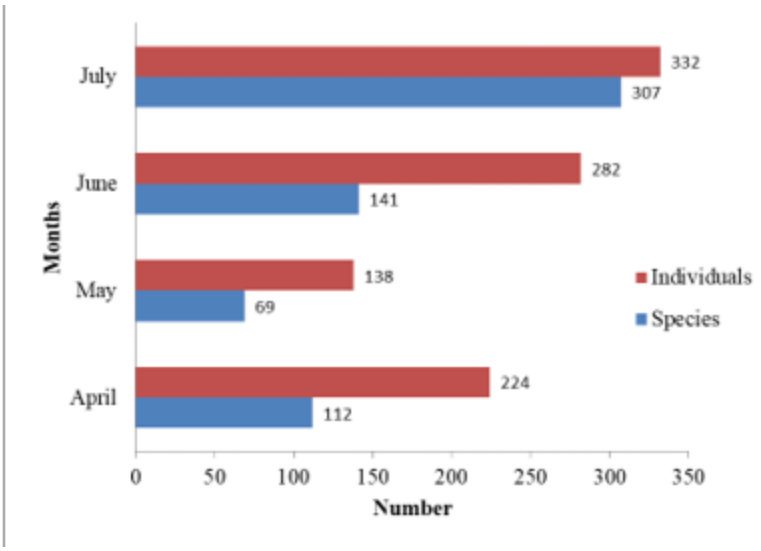


Fig.4. Month-wise distribution of recorded butterflies in the study area

The highest number of butterflies was seen in the month of July, followed by June and the least in the dry seasons (May and April). The butterflies tend to avoid dry habitats and prefer moist places [65].The butterfly population rapidly declined during the period from April to May. Usually, in southern India, these months are very hot and dry. Moreover, factors such as scarcity of water, poor nectar butterfly pasture and dry vegetation result in lower butterfly abundance and lower survival abilities for most species. Seasonal fluctuations of butterflies are often influenced by climatic and ecological conditions such as temperature, photoperiod, rainfall, humidity, variation in the availability of food resources, vegetation cover such as herbs and shrubs and the presence of natural enemies [66, 67, 68, 69]. Low rainfall, high temperatures, and high wind speeds were recorded from April to May and the disappearance of green vegetation was witnessed during this period. When the summer heat is high, they tend to go into hiding inside the bushes and temperature highly affects the activity of butterflies, their distribution, growth and breeding. High air temperatures cause a decrease in the volume of nectar secretion in flowers [70]. Accordingly, the abundance of butterflies was low during this period.The distribution and diversity of butterflies vary depending on the season. They are abundant in some months and absent during other months [71]. When the distribution of families over four months was compared, we noted an increase in the number of butterflies towards the monsoon period (July). [72] reported that rainfall conditions greatly influence butterfly numbers and species distributions. In southern India, the monsoons promote an increase in foliage cover and density and have a profound effect on the seasonal occurrence of butterflies. The young, tender leaves in ample quantity stimulated by high rainfall provide better quality food for larvae and thus result in peak abundance of butterflies during monsoons [73].

3.4. Diversity indices, WPA, 1972 and IUCN Status of recorded butterflies in the study area

Diversity indices of recorded species indicated that Nymphalidae was the most diverse and species-rich family (H = 0.36, E = 0.12, R = 3.64), while the family Papilionidae was the least diverse and least species-rich (H = 0.15, E = 0.11, R = 0.73) **(Table 6)**. The overall Shannon-Weiner diversity index was H = 1.50, Pielou's evenness index was E = 0.60 and Margalef's index was R = 13.30. Out of the total 76 species, twelve were categorized under the least concern (LC) status as per the IUCN Red List (IUCN, 2022). The remaining sixty-

fourspecies were marked as not evaluated (NE). Eight species were legally protected in India under the Wildlife Protection Act of 1972 under Schedules I, II, III, and IV of the act **(Table 1–5)**. A total of eight species of butterflies from the study area are designated under the Wildlife Protection Act (WPA, 1972) while describing their status and justifying their inclusion in the scheduled list, suggesting the need for strict conservation measures.

4. CONCLUSION

The present study demonstrated that 976 individuals of butterflies of 76 species belonging to 51 genera and five families were recorded. More butterfly species and abundance were recorded in the study area during the month of July, as well as in the habitat of the garden area. The study area is rich in butterflies. Although the study area supports a good number of butterfly species, it requires detailed further study throughout the year. The present list is not conclusive and exploration is needed to update this checklist. This information will help in future research on butterflies and conserve them by establishing a butterfly park and garden and by creating awareness among school and college students.

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