



Seasonal Diversity of Butterflies in the Fragmented Habitats of Waghai Botanical Garden of The Dangs - Gujarat

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Abstract

Background: The world is currently undergoing a very rapid loss of butterfly biodiversity comparable with the great mass extinction events that have previously occurred only five or six times in the Earth's history. This is an alarming call of these tiny scraps of biodiversity which now have scarce appearance surrounding the huge human kingdom.

Objective: The richness of biodiversity depends on the climatic conditions and area of the region. The present research work focuses on studying butterflies diversity, their habitat preferences and seasonal distribution in structured plots of Waghai Botanical Garden.

Method: For carrying out systematic study, Waghai Botanical Garden was fragmented into five sub habitats i.e. Dry & Moist Deciduous plot, Evergreen plot, Bamboo plot & Dang plot, Scrub Thorn Forest & Medicinal & Taxonomy plot. Intra-individual comparative abundance study for observed butterfly species within fragmented plots of Waghai botanical garden was carried out graphically to study the butterfly's preference in the plots of botanical garden.

Results: Out of 70 species, the maximum number of species i.e. 27 species were observed from family Nymphalidae, followed by 18 species from Lycaenidae, 15 species from Pieridae, Papilionidae with 7 species and 3 species from Hesperidae.

Conclusion: During post-monsoon season, highest total average rainfall of around 850 mm was observed in Waghai during monsoon, which provided excellent quality and quantity of larval food plants for the caterpillars and nectar rich flower source for adult butterflies in post-monsoon months. Thus maximum numbers of butterflies' species were observed during the months of October & November.

Keywords: Butterflies; Botanical Garden; Gujarat; Habitat Preference; Seasonal Diversity.

1. Introduction

The diversity of life is one of the most striking aspects of our planet; hence knowing how many species inhabit Earth is among the most fundamental questions in science (Mora et al., 2011). Today, there is an urgent need of not only the in-depth research on diversity but also to induce it for conservation. Diversity studies leads to the destined path of conservation. Biodiversity is the variety of different types of life found on the Earth and the variations within species. It is a measure of the variety of organisms present in different ecosystems.

The richness of biodiversity depends on the climatic conditions and area of the region. Waghai is about 32 km north from the district headquarters of Ahwa, and about 52 km south of the hill station of Saputara in the Dangs district. Also known as the Cherapunji of the state, average rainfall of 2000 mm, which is spread over 90 days makes Dang a paradise. With lush green forest, bamboo breaks and waterfall, the entire hilly terrain of Dangs harbour an amazing variety of plants, butterflies and birds. Temperature varies from minimum of 10°C in January to maximum of 36 °C in June. The Dangs forest tract falls between the parallels of latitude 20.33'53" and 21.3'52" and the meridians of longitude 73.27'58"

and 73.56'36". The Dangs forest tract starts from the rugged mountain chains of Sahyadri in the east and descends on the western side extending to the edge of plains of Gujarat. The hills are mostly low and flat topped. In the Dangs, Waghai Botanical Garden is a large (24-hectare) garden with 1,400 varieties of plants from all over India. The amateur nature lover can marvel at different varieties of bamboo like the Chinese Bamboo, Golden Bamboo, Beer Bottle Bamboo, etc. and enjoy strolling along the beautiful walkways each lined with different species of tree.

General lepidopteran studies have already been carried out in Gujarat with respect to protected areas (Aldrich 1946, Mosse 1929, Shull 1964) and wildlife sanctuaries (Sharma & Ahmed 2013, Bhalodia et al. 2002) and fragmented habitats of urban residential & agriculture landscapes (Mali et al. 2014, Gandhi & Kumar 2015). But no work has been focused on fragmented habitats like botanical garden. Apart from that, earlier lepidopteran diversity studies were least combined with their seasonal occurrence or their habitat preferences. Thus, the present research work focuses on studying rhopalocerans, their habitat preferences and seasonal distribution in selected fragmented plots of Waghai Botanical Garden at Gujarat, India.

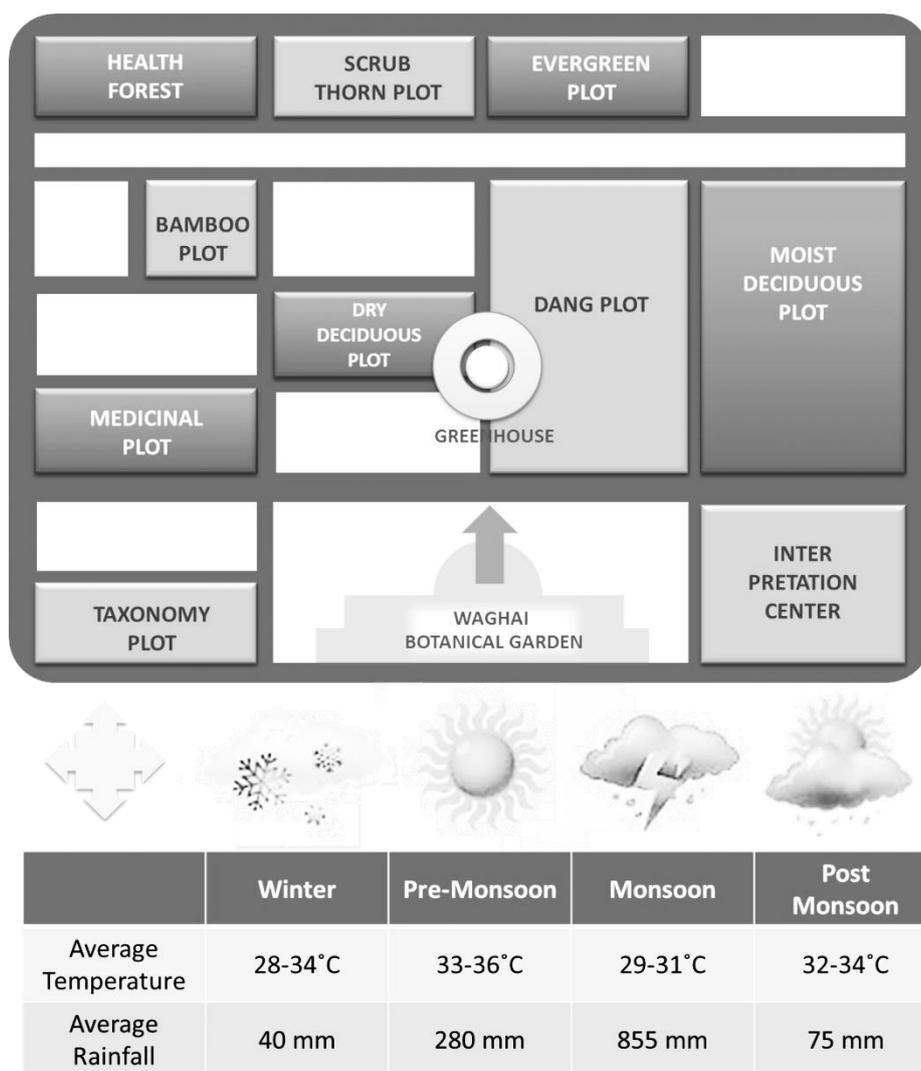


Fig. 1: Schematic Representation of Waghai Botanical Garden with Associated Seasonal Factors

2. Materials & methods

2.1. Sampling Protocol – Pollard Walk method

Systematic approach was followed to monitor the rhopalocerans. During the entire study of three consecutive years from 2012 to 2015, Pollard Walk method was utilized to document the butterflies though with modification (Pollard & Yates 1993). Pollard Walk method states that each fixed path is walked along a fixed duration time. In the present study, selected path visits were made during the morning time i.e. 900-1200 hours and later at 1500-1800 hours.

Each path is walked upon for a period of 2-3 hours and the visibility of 10 meters was kept at both the sides of the path as represented in scheme of Waghai Botanical Garden in Figure 1. Visual encounters were made during the entire study period. Rhopaloceran collection was made whenever butterflies were unidentified on field sessions. Butterflies were observed on both the sides of the paths within botanical garden.

2.2. Collection of Data

Studies on rhopaloceran diversity was conducted from 2012 to 2015, i.e for a period of three years. Utilizing the Pollard Walk Method, required observations were made in the morning & evening hours. Majority of the rhopalocerans were identified characteristically on the field using standard references.

On- field essentials were carried during all the field visits. This includes well-featured camera, butterfly net, storage vials and identification keys (picture guides). Visual observations and butterfly net method was used to monitor and identify butterflies. Butterflies were identified on the field site itself and if not identified were collected using butterfly net. Adult butterflies were usually collected with the help of butterfly net (Kunte, 2000). Depending on the number of sightings, abundance of butterfly species were categorised into Very Common (>25 sightings during the entire study period), Common (10-25 sightings) and Rare (1-5 sightings).

2.3. Rendering Habitat Preference

Table 1: Sub- Habitats of Waghai Botanical Garden in The Dangs

Sr No	Fragmented Habitat	Description of Zone
1	Dry & Moist Deciduous Plot	Dry & Moist tree or shrub species shedding its leaves annually
2	Evergreen Plot	Plants retaining green leaves through out the year
3	Bamboo & Dang Plot	A plot having giant woody grass which is grown chiefly in the tropics.
4	Scrub Thorn Forest	Consists primarily of small, tall, thorny trees that shed their leaves seasonally
5	Medicinal& Taxonomy Plot	General & Specific systemic arrangement of trees and plants

Waghai botanical garden of the Dangs was selected as a model fragmented habitat to study the abundance of butterfly species in botanical garden. For carrying out organized study, Waghai Botanical Garden was fragmented into five sub habitats as mentioned in Table 1 i.e. (i) Dry & Moist Deciduous plot, (ii) Evergreen plot, (iii) Bamboo plot & Dang plot, (iv) Scrub Thorn Forest & (v) Medicinal & Taxonomy plot. Dry tree or shrub shedding its leaves annually forms Dry Deciduous Plot & Moist tree or shrub shedding its leaves annually forms Moist Deciduous Plot; while plants retaining green leaves throughout the year forms the evergreen plot. Bamboo & Dang plot covers giant woody grass which is grown chiefly in the tropics. Scrub Thorn Forest consists primarily of small, tall, thorny trees that shed their leaves seasonally. Medicinal & Taxonomy Plot comprises of general & specific systemic arrangement of trees and plants which are medically important. Intra-individual comparative abundance study for observed butterfly species within fragmented plots of Waghai botanical garden was carried out graphically to study the butterfly's preference for the fragmented habitats of botanical garden.

2.4. Rendering Seasonal Variations

Table 2: Climatological Seasons of India with respect to months

Sr No	Climatological Season	Months
1	Winter	December, January, February, March
2	Pre Monsoon (Summer)	April, May, June
3	Monsoon (Rainy)	July, August, September
4	Post Monsoon (Autumn)	October, November

To study the effect of different seasons on the diversity of butterflies, seasonal monthly visits were made to the selected fragmented habitats of Waghai Botanical Garden. The months were divided into winter, pre-monsoon, monsoon and post monsoon seasons as depicted in Table 2. December, January, February and March forms winter season, the months April, May and June are considered as the pre-monsoon months; whereas July, August and September months form the monsoon season. October and November form the post monsoon season.

During the visit to the selected fragmented habitats, the maximum temperature and rainfall data was obtained. Hence, the average maximum temperature and average monthly rainfall details of three years i.e. from 2012 -2015 were utilized for monthly comparative study with respect to the observed number of butterfly species.

2.5. Photographing Butterflies

One of the most pleasant aspects of studying butterflies is capturing them digitally garnishing with some patience. Rhopaloceran photography was done using Sony Cybershot DSC- W220 with 12.1 megapixels and 4X optical zoom.

Along with that, Lumix Panasonic DMC-FZ 60 with 16.1 megapixels and 24X Optical Zoom was also utilized for photographing small sized butterflies. Required editing of photographs was done using essential softwares.

2.6. Taxonomical Identification of Rhopalocerans

Taxonomic identification of the rhopalocerans using the multiple pictorial field guides as on-field identification manuals and standard reference books for their systematic identification. Pictorial guides of (Kunte, 2000), (Kehimkar, 2008) and (Parasharya & Jani, 2007) were helpful during field visits. Standard works of (Evans, 1932) and (Wynter Blyth, 1957) were utilized to confirm the on field identification. Expert advice was taken as and when required for the confirm identification of species.

Concerned identification of host plants or nectar resources was done by the faculty members of Department of Botany, Faculty of Science, The Maharaja Sayajirao University of Baroda, Vadodara.

2.7. Statistical Analysis of Species Diversity

Alpha diversity indices were utilized to analyse the butterfly diversity using the statistical software PAST version 2.17c:

Shannon Weiner Diversity Index: This typical diversity index states the number of species within site with the relative abundance of each species.

It is defined as:

$H' = \sum p_i \ln p_i$ (where p_i = proportion of the i^{th} species in the total sample)

Pielou's Evenness Index: This index states the distribution of the relative abundance of species in a site.

It is defined as:

$J = H' / \ln S$ (where S = number of species present in the site)

The value of J ranges from 0 to 1. Less is the variation in communities between the species, the higher the value of J .

3. Results & Discussion

A total of 70 butterfly species belonging to 5 families and 49 genera were observed during the entire study period. Of which, maximum number of species were observed from family Nymphalidae i.e. 27 species, followed by 18 species from family Lycaenidae, followed by 15 species from family Pieridae, followed by 7 species of family Papilionidae and 3 species belonging to family Hesperidae as represented in Table 4. Some of the captured photographs of some documented butterfly species in Waghai Botanical Garden were collectively represented in Figure 3.

3.1. Rendering Sub-habitat Preference

Table 3: Habitat Preference of Documented Species of Butterflies in Sub-Habitats of Botanical Garden - Waghai Botanical Garden in The Dangs District, Gujarat, India

Sr. No	Area	No. of Butterfly Species observed
1	Dry & Moist Deciduous Plot	27
2	Evergreen Plot	32
3	Dang & Bamboo Plot	19
4	Scrub Thorn & Health Forest	13
5	Medicinal & Taxonomy Plot	44

Waghai Botanical Garden comprises of multiple plots like dry and moist deciduous plots, evergreen plot, Dang and Bamboo Plot, Scrub thorn and health forest, Medicinal and taxonomy plot. Medicinal and taxonomy plot showed the maximum number of species i.e. 44 species, followed by evergreen plot with 32 butterfly species, followed by dry and moist deciduous plots with 27 butterfly species. Total 19 butterfly species were observed from Dang and Bamboo plot whereas 13 species was observed from scrub thorn and health forest (Table 3). Graphical comparison between numbers of butterfly species observed is depicted from Figure 2.

As compared to other plots, highest numbers of butterfly species i.e. 44 were found in the systematically developed Medicinal & Taxonomy plot, due to availability of systematically developed plots having significant number of nectar rich sources & larval food source plants.

Considerable numbers of butterfly species were found in the dry & moist deciduous plots of botanical garden due to availability of considerable number of larval food source plants which shed their leaves annually & in the evergreen plots which remains evergreen forever. Due to lack of nectar rich flower source plants in the tall woody bamboo plots & Scrub thorn forest, least numbers of butterfly species were observed among all other fragments.

Botanical garden is devoid of any anthropological interference i.e. pesticide or weedicides application. Hence, keeping it at its nature's purity, such habitats harbor good butterfly diversity.

Diversity indices were calculated to study the species diversity in the Waghai botanical garden. Within Waghai Botanical Garden, Shannon Weiner Diversity & Pielou's Evenness Index were found to be 3.99 & 0.77 respectively.

Typical Shannon Weiner Diversity values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the habitat increase.

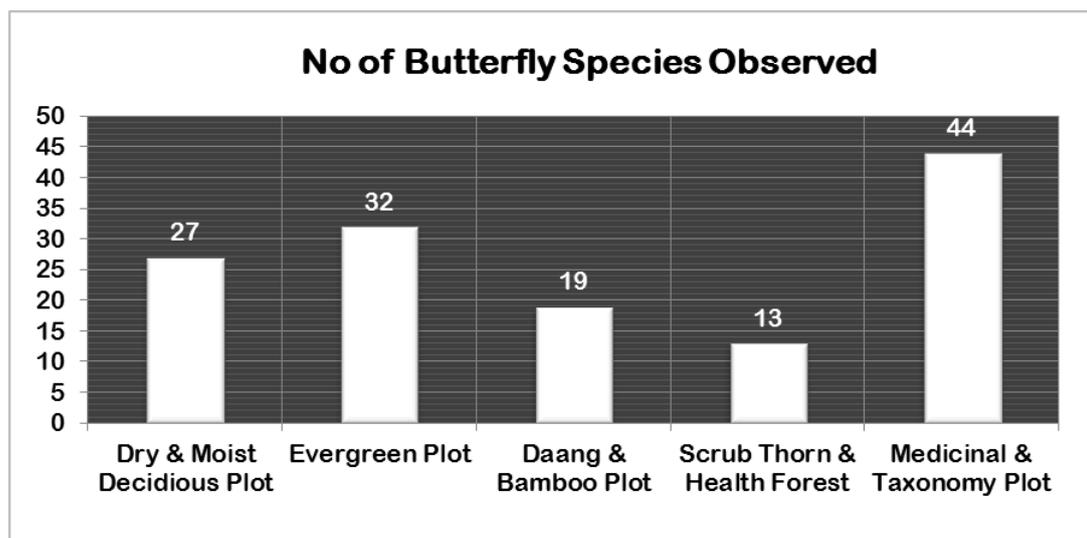


Fig. 2: Habitat Preference of Documented Species of Butterflies in Sub- Habitats of Botanical Garden - Waghai Botanical Garden in The Dangs

Table 4: Butterfly Species Abundance in Waghai Botanical Garden in the Dangs District (VC = Very Common, C=Common, R=Rare)

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	<i>Graphium agamemnon</i> Linnaeus, 1758	VC
2	Common Jay	<i>Graphium doson</i> Felder & Felder, 1864	VC
3	Spot Swordtail	<i>Graphium nomius</i> Esper, 1785	C
4	Common Rose	<i>Pachliopta aristolochiae</i> Fabricius, 1775	C
5	Crimson Rose	<i>Pachliopta hector</i> Linnaeus, 1758	C
6	Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	VC
7	Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	C
Family Pieridae			
8	Western Striped Albatross	<i>Appias libythea</i> Fabricius, 1775	R
9	Pioneer	<i>Belenois aurota</i> Fabricius, 1793	C
10	Common Emigrant	<i>Catopsilia pomona</i> Fabricius, 1775	C
11	Mottled Emigrant	<i>Catopsilia pyranthe</i> Linnaeus, 1758	C
12	Common Gull	<i>Cepora nerissa</i> Fabricius, 1775	C
13	Small Salmon Arab	<i>Colotis amata</i> Fabricius, 1775	R
14	Crimson Tip	<i>Colotis danae</i> Fabricius, 1775	C
15	Small Orange Tip	<i>Colotis etrida</i> Boisduval, 1836	C
16	Common Jezebel	<i>Delias eucharis</i> Drury, 1773	C
17	Small Grass Yellow	<i>Eurema brigitta</i> Stoll, 1780	VC
18	Common Grass Yellow	<i>Eurema hecabe</i> Linnaeus, 1758	VC
19	White Orange Tip	<i>Ixias marianne</i> Cramer, 1779	C
20	Yellow Orange Tip	<i>Ixias pyrene</i> Linnaeus, 1764	C
21	Psyche	<i>Leptosia nina</i> Fabricius, 1793	C
22	Common Wanderer	<i>Pareronia hippia</i> Fabricius, 1787	R
Family Nymphalidae			
23	Tawny Coster	<i>Acraea terpsicore</i> Linnaeus, 1758	C
24	Angled Castor	<i>Ariadne ariadne</i> Linnaeus, 1763	R
25	Common Castor	<i>Ariadne merione</i> Cramer, 1777	C
26	Common Nawab	<i>Charaxes athamas</i> Drury, 1770	R
27	Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	R
28	Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	R
29	Plain Tiger	<i>Danaus chrysippus</i> Linnaeus, 1758	VC
30	Striped Tiger	<i>Danaus genutia</i> Cramer, 1779	VC
31	Common Indian Crow	<i>Euploea core</i> Cramer, 1780	VC
32	Common Baron	<i>Euthalia aconthea</i> Cramer, 1777	R
33	Great Eggfly	<i>Hypolimnas bolina</i> Linnaeus, 1758	C
34	Danaid Eggfly	<i>Hypolimnas misippus</i> Linnaeus, 1764	C
35	Peacock Pansy	<i>Junonia almana</i> Linnaeus, 1758	C
36	Grey Pansy	<i>Junonia atlites</i> Linnaeus, 1763	C
37	Yellow Pansy	<i>Junonia hierta</i> Fabricius, 1798	C
38	Chocolate Pansy	<i>Junonia iphita</i> Cramer, 1779	C
39	Lemon Pansy	<i>Junonia lemonias</i> Linnaeus, 1758	VC
40	Blue Pansy	<i>Junonia orithya</i> Linnaeus, 1758	C
41	Common Evening Brown	<i>Melanitis leda</i> Linnaeus, 1758	VC
42	Common Bushbrown	<i>Mycalis perseus</i> Fabricius, 1775	VC
43	Common Sailer	<i>Neptis hylas</i> Linnaeus, 1758	C
44	Glassy Tiger	<i>Parantica aglea</i> Stoll, 1782	VC
45	Common Leopard	<i>Phalanta phalantha</i> Drury, 1773	C

Sr.no	Common name	Scientific Name	Abundance
46	Baronet	<i>Symphaedra nais</i> Forster, 1771	C
47	Blue Tiger	<i>Tirumala limniace</i> Cramer, 1775	VC
48	Common Five-ring	<i>Ypthima baldus</i> Fabricius, 1775	C
49	Common Four-ring	<i>Ypthima huebneri</i> Kirby, 1871	C
Family Lycaenidae			
50	Plum Judy	<i>Abisara echerius</i> Stoll, 1790	R
51	Angled Pierrot	<i>Caleta decidia</i> Hewitson, 1876	C
52	Common Pierrot	<i>Castalius rosimon</i> Fabricius, 1775	C
53	Forget-Me-Not	<i>Catochrysops strabo</i> Fabricius, 1793	C
54	Lime Blue	<i>Chilades lajus</i> Stoll, 1780	C
55	Plains Cupid	<i>Chilades pandava</i> Horsfield, 1829	C
56	Angled Sunbeam	<i>Curetis dentate</i> Moore, 1879	R
57	Indian Sunbeam	<i>Curetis thetis</i> Drury, 1773	C
58	Gram Blue	<i>Euchrysops cnejus</i> Fabricius, 1798	C
59	Indian Cupid	<i>Everes lacturnus</i> Godart, 1824	C
60	Common Cerulean	<i>Jamides celeno</i> Cramer, 1775	R
61	Zebra Blue	<i>Leptotes plinius</i> Fabricius, 1793	C
62	Pale Grass Blue	<i>Pseudozizeeria maha</i> Kollar, 1848	C
63	Red Pierrot	<i>Talicerca nyseus</i> Guerin-Meneville, 1843	C
64	Stripped Pierrot	<i>Tarucus nara</i> Kollar, 1848	C
65	Dark Grass Blue	<i>Zizeeria karsandra</i> Moore, 1865	C
66	Lesser Grass Blue	<i>Zizina otis</i> Fabricius, 1787	C
67	Tiny Grass Blue	<i>Zizula hylax</i> Fabricius, 1775	C
Family Hesperidae			
68	Brown Awl	<i>Badamia exclamationis</i> Fabricius, 1775	R
69	Rice Swift	<i>Borbo cinnara</i> Wallace, 1866	R
70	Dark Palm Dart	<i>Telicota bambusae</i> Moore, 1878	R

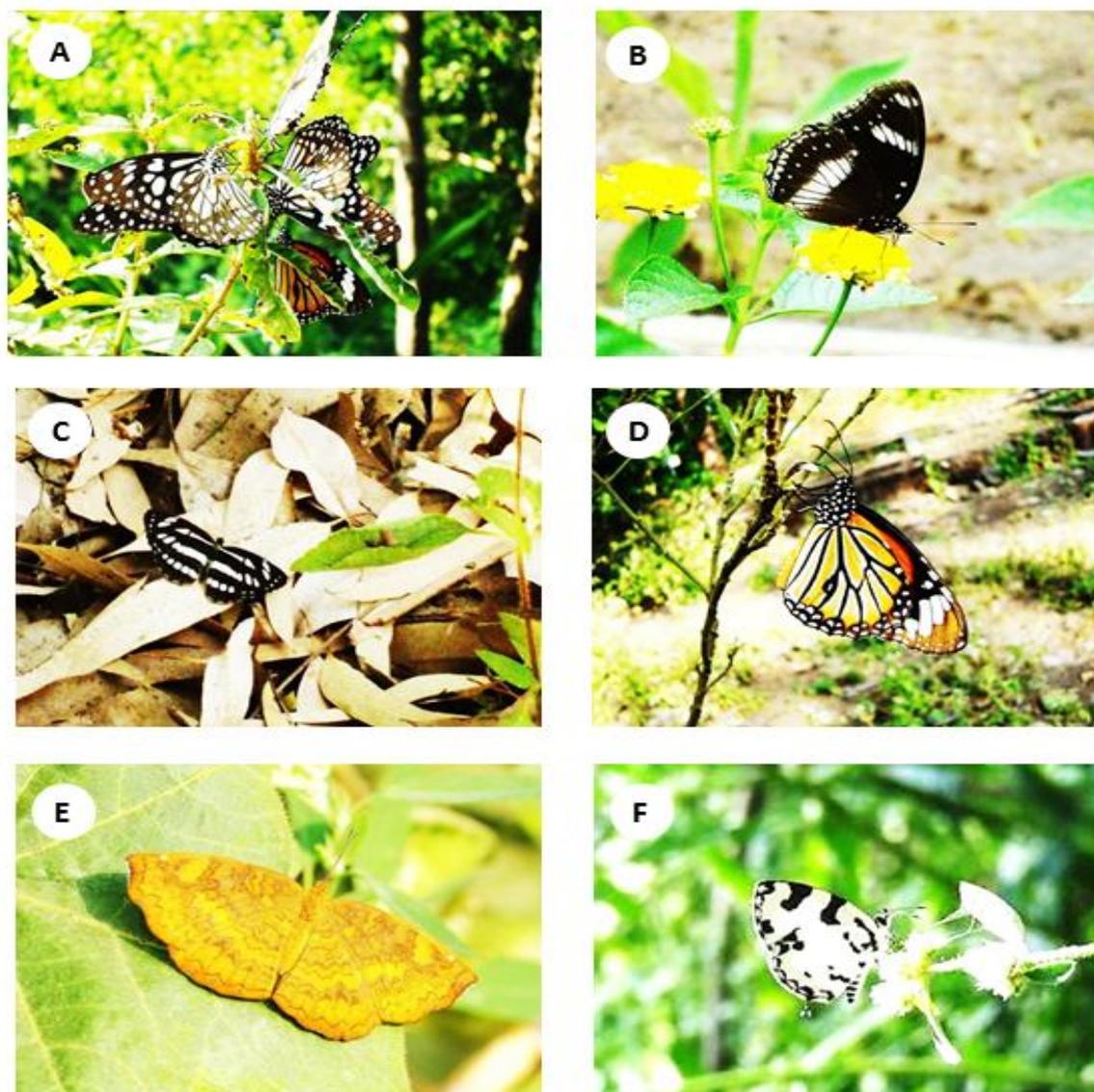


Fig. 3: Some of the Documented Butterfly Species from Waghai Botanical Garden, The Dangs, Gujarat, India (A) Group of Nymphalids Sucking Plant Sap (B) Great Eggfly *Hypolimnas bolina* Linnaeus, 1758 (C) Common Sailer *Neptis hylax* Linnaeus, 1758 (D) Stripped Tiger *Danaus genutia* Cramer, 1779 (E) Common Castor *Ariadne merione* Cramer, 1777 (F) Angled Pierrot *Caleta decidia* Hewitson, 1876.

3.2. Rendering Seasonal Diversity

Table 5: Seasonal Distribution of Documented Species of Butterflies from Waghai Botanical Garden of The Dangs District

Season	Month	No. of Species Observed	Maximum Average Temperature (°C)	Average Monthly Rainfall (mm)
Pre Monsoon	Apr	34	36	10
	May	27	35	30
	Jun	40	33	240
Monsoon	Jul	37	30	430
	Aug	26	29	285
	Sep	41	31	140
Post monsoon	Oct	55	34	60
	Nov	63	32	15
Winter	Dec	48	30	0
	Jan	36	28	30
	Feb	30	31	0
	Mar	45	34	10

The Dangs form the northern most part of the Western Ghats region, which is considered to be one of the most diverse regions of India. The Dangs receives maximum rainfall in Gujarat. Seasonal distribution of butterfly species was also observed at Waghai Botanical Garden of The Dangs along with documentation of 70 species of butterflies. Monthly number of documented butterfly species observed with corresponding maximum average temperature and average monthly rainfall is provided in Table 5.

Along with the list, graphical representation of monthly distribution of documented butterfly species observed with respect to maximum average temperature and average monthly rainfall in Waghai is also depicted by 2D double Y-axis plot in Figure 4. Detailed seasonal occurrence of individual butterfly species within Waghai botanical garden is provided in Table 6.

Table 6: Seasonal Distribution of Documented Species of Butterflies from Waghai Botanical Garden of The Dangs

Sr.no	Family	Common Name	Scientific Name	Pre Monsoon	Monsoon	Post Monsoon
1	Papilionidae	Tailed Jay	<i>Graphium agamemnon</i> Linnaeus, 1758	√	√	√
2		Common Jay	<i>Graphium doson</i> Felder & Felder, 1864	√	√	√
3		Spot Swordtail	<i>Graphium nomius</i> Esper, 1785	√	-	-
4		Common Rose	<i>Pachliopta aristolochiae</i> Fabricius, 1775	-	-	√
5		Crimson Rose	<i>Pachliopta hector</i> Linnaeus, 1758	-	-	√
6		Lime Butterfly	<i>Papilio demoleus</i> Linnaeus, 1758	√	√	√
7		Common Mormon	<i>Papilio polytes</i> Linnaeus, 1758	-	-	√
8	Pieridae	Western Striped Albatross	<i>Appias libythea</i> Fabricius, 1775	√	-	√
9		Pioneer	<i>Belenois aurota</i> Fabricius, 1793	√	√	√
10		Common Emigrant	<i>Catopsilia pomona</i> Fabricius, 1775	√	√	√
11		Mottled Emigrant	<i>Catopsilia pyranthe</i> Linnaeus, 1758	√	√	√
12		Common Gull	<i>Cepora nerissa</i> Fabricius, 1775	√	-	√
13		Small Salmon Arab	<i>Colotis amata</i> Fabricius, 1775	√	√	√
14		Crimson Tip	<i>Colotis danae</i> Fabricius, 1775	-	-	√
15		Small Orange Tip	<i>Colotis etrida</i> Boisduval, 1836	√	√	√
16		Common Jezebel	<i>Delias eucharis</i> Drury, 1773	√	√	√
17		Small Grass Yellow	<i>Eurema brigitta</i> Stoll, 1780	√	√	√
18		Common Grass Yellow	<i>Eurema hecabe</i> Linnaeus, 1758	√	√	√
19		White Orange Tip	<i>Ixias marianne</i> Cramer, 1779	√	√	√
20		Yellow Orange Tip	<i>Ixias pyrene</i> Linnaeus, 1764	√	√	√
21		Psyche	<i>Leptostia nina</i> Fabricius, 1793	√	-	√
22	Common Wanderer	<i>Pareronia hippia</i> Fabricius, 1787	-	-	√	
23	Nymphalidae	Tawny Coster	<i>Acraea terpsicore</i> Linnaeus, 1758	√	√	√
24		Angled Castor	<i>Ariadne ariadne</i> Linnaeus, 1763	√	√	√
25		Common Castor	<i>Ariadne merione</i> Cramer, 1777	√	√	√
26		Common Nawab	<i>Charaxes athamas</i> Drury, 1770	-	√	√
27		Black Rajah	<i>Charaxes solon</i> Fabricius, 1793	√	-	√
28		Painted Lady	<i>Vanessa cardui</i> Linnaeus, 1758	√	-	√
29		Plain Tiger	<i>Danaus chrysippus</i> Linnaeus, 1758	√	√	√
30		Striped Tiger	<i>Danaus genutia</i> Cramer, 1779	√	-	√
31		Common Indian Crow	<i>Euploea core</i> Cramer, 1780	√	√	√
32		Common Baron	<i>Euthalia aconthea</i> Cramer, 1777	√	-	-
33		Great Eggfly	<i>Hypolimnas bolina</i> Linnaeus, 1758	√	-	√
34		Danaid Eggfly	<i>Hypolimnas misippus</i> Linnaeus, 1764	-	√	√
35		Peacock Pansy	<i>Junonia almana</i> Linnaeus, 1758	√	√	√
36		Grey Pansy	<i>Junonia atlites</i> Linnaeus, 1763	-	-	√
37		Yellow Pansy	<i>Junonia hierta</i> Fabricius, 1798	√	-	-
38		Chocolate Pansy	<i>Junonia iphita</i> Cramer, 1779	√	-	√
39		Lemon Pansy	<i>Junonia lemonias</i> Linnaeus, 1758	√	√	√
40	Blue Pansy	<i>Junonia orithya</i> Linnaeus, 1758	√	-	-	
41	Common Evening Brown	<i>Melanitis leda</i> Linnaeus, 1758	√	-	√	
42	Common Bushbrown	<i>Mycalesis perseus</i> Fabricius, 1775	-	√	√	
43	Common Sailer	<i>Neptis hylas</i> Linnaeus, 1758	√	-	-	

Sr.no	Family	Common Name	Scientific Name	Pre Monsoon	Monsoon	Post Monsoon
44		Glassy Tiger	<i>Parantica aglea</i> Stoll, 1782	-	-	√
45		Common Leopard	<i>Phalanta phalantha</i> Drury, 1773	√	-	√
46		Baronet	<i>Symphaedra nais</i> Forster, 1771	√	-	√
47		Blue Tiger	<i>Tirumala limniace</i> Cramer, 1775	-	√	√
48		Common Five-ring	<i>Ypthima baldus</i> Fabricius, 1775	√	-	√
49		Common Four-ring	<i>Ypthima huebneri</i> Kirby, 1871	√	-	√
50		Plum Judy	<i>Abisara echerius</i> Stoll, 1790	√	√	√
51		Angled Pierrot	<i>Caleta decidia</i> Hewitson, 1876	-	√	√
52		Common Pierrot	<i>Castalius rosimon</i> Fabricius, 1775	√	√	√
53		Forget-Me-Not	<i>Catochrysops strabo</i> Fabricius, 1793	-	√	√
54		Lime Blue	<i>Chilades lajus</i> Stoll, 1780	√	√	√
55		Plains Cupid	<i>Chilades pandava</i> Horsfield, 1829	-	√	√
56		Angled Sunbeam	<i>Curetis dentate</i> Moore, 1879	-	√	√
57		Indian Sunbeam	<i>Curetis thetis</i> Drury, 1773	√	-	√
58	Lycaenidae	Gram Blue	<i>Euchrysops cnejus</i> Fabricius, 1798	√	√	√
59		Indian Cupid	<i>Everes lacturnus</i> Godart, 1824	√	√	√
60		Common Cerulean	<i>Jamides celeno</i> Cramer, 1775	√	-	√
61		Zebra Blue	<i>Leptotes plinius</i> Fabricius, 1793	√	√	√
62		Pale Grass Blue	<i>Pseudozizeeria maha</i> Kollar, 1848	√	√	√
63		Red Pierrot	<i>Talicauda nyseus</i> Guerin- Meneville, 1843	√	√	√
64		Stripped Pierrot	<i>Tarucus nara</i> Kollar, 1848	√	√	√
65		Dark Grass Blue	<i>Zizeeria karsandra</i> Moore, 1865	√	√	√
66		Lesser Grass Blue	<i>Zizina otis</i> Fabricius, 1787	√	√	√
67		Tiny Grass Blue	<i>Zizula hylax</i> Fabricius, 1775	√	√	√
68	Hesperiidae	Brown Awl	<i>Badamia exclamationis</i> Fabricius, 1775	-	√	√
69		Rice Swift	<i>Borbo cinnara</i> Wallace, 1866	-	-	√
70		Dark Palm-Dart	<i>Telicota bambusae</i> Moore, 1878	-	√	√

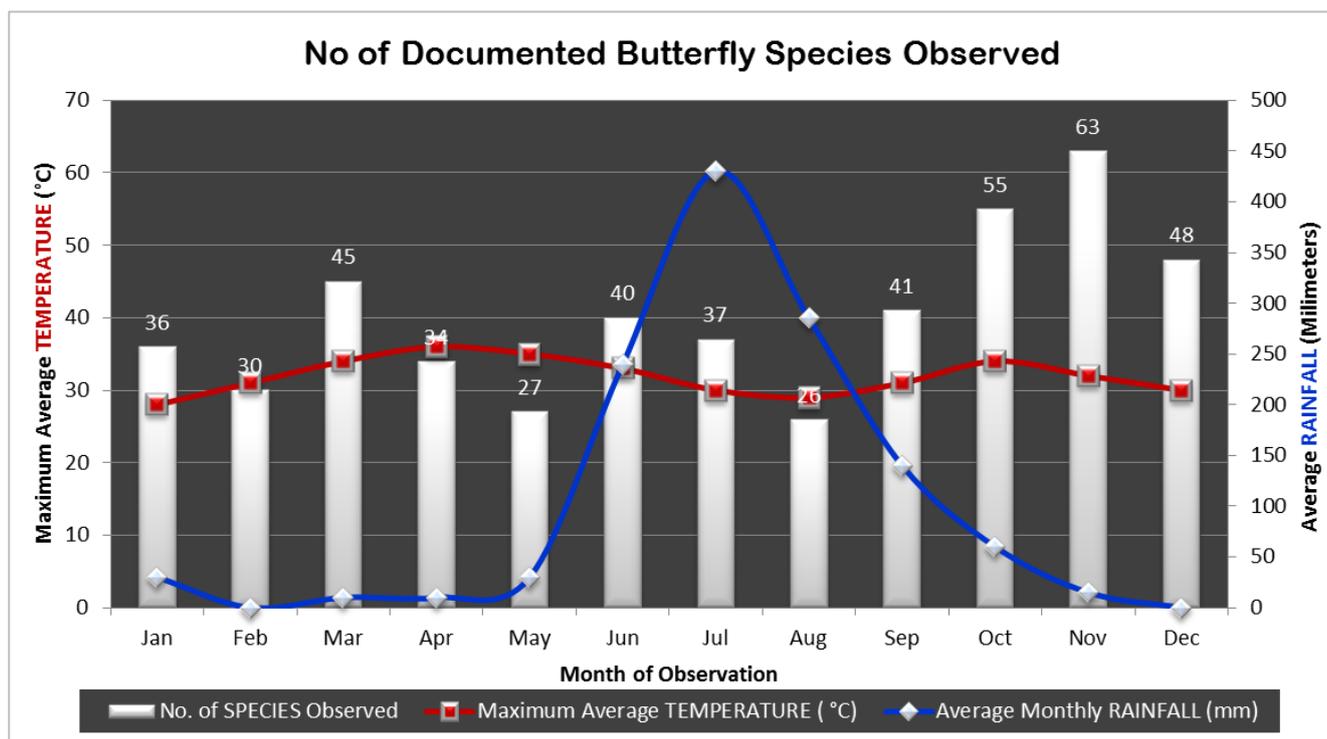


Fig. 4: Seasonal Distribution of Documented Species of Butterflies from Waghai Botanical Garden of The Dangs

In Botanical Garden of Waghai, average maximum temperature ranges from 33°C to 36°C in summer, which is best suitable for existence of butterflies; but as compared to other seasons, number of species observed during pre-monsoon months of April, May & June in summer were comparatively less as compared to other seasons.

During monsoon season, very high total average rainfall of approx.850 mm was observed in Waghai. This supports excellent quality and quantity of larval food plants for the caterpillars and nectar rich flower source for adults. Significant amount of rainfall makes the soil rich in nutrients & fertile for plants growth. Thus,

as compared to all other seasons, highest numbers of butterfly species were observed in post monsoon months of October & November i.e. 55 & 63 species respectively.

Low visibility of butterfly species is mainly due to the heavy rainfalls and high humidity levels in the atmosphere. January being the coldest month of the year, also observed lower number of butterfly species due to sudden drop in temperatures.

Seasonal studies have also been conducted on papilionid butterflies in Assam of Northeast India and showed that rainfall and season showed variation in papilionid abundance and confirmed with the study that strong seasonality is observed in the South

Asian butterfly assemblages (Barua et al., 2010). Team of researchers from Gauhati University conducted the seasonal studies of Nymphalidae butterflies in Rani Garbhanga Reserve Forest of Assam and observed total of 109 species of butterflies and combined it with the respective geographical distribution and seasonal abundance (Saikia et al., 2010).

Regarding other fragmented habitats, studies have also been conducted in various university campuses around India. Group of authors conducted the studies on the butterfly diversity in Manasgangotri campus of Mysore University and explored a total of 86 species of butterflies (Sarjan et al., 2014) and also observed large congregations of *Catopsilia* sp., *Euploea core*, *Tirumala limniace*, etc. during the study period.

Previously, studies on diversity of butterflies were carried out in fragmented habitats and have raised the voice of conservation of species along with its habitats. Duo authors from Singapore showed from their studies that the quantity of larval hosts plants and isolation form the forests are considered to the major determinants of butterfly richness in urban parks (Koh & Sodhi, 2004). The authors also suggested that vegetation of such habitats with their larval host plants can elevate the conservation value of these butterflies.

4. Conclusion

In Habitat Preference study conducted within Waghai Botanical Garden, a total of 70 butterfly species belonging to 5 families were revealed mostly abundant within evergreen plots, medicinal plots & moist deciduous plots due to availability of food plants & nectar resources. While, during Seasonal Diversity studies, highest numbers of butterfly species were found in post-monsoon season as compared to winter, pre-monsoon and monsoon season.

During post monsoon season in the month of October- November, temperature range varies between 32-34°C in Waghai, which is best suitable for existence of butterflies. Moreover high total average rainfall of around 850 mm in Waghai during monsoon provided excellent quality and superior quantity of larval food plants for the caterpillars as well as nectar rich flower source for adult butterflies in post-monsoon season. Thus from entire study, it can be concluded that apart from preferred habitat for butterflies, favourable temperature and adequate rainfall are the major life guarding factors for the existence of diverse butterfly species.

Acknowledgement

One of the authors, Suchi Gandhi is thankful to UGC-RFSMS fellowship scheme, New Delhi for the financial assistance to carry out the required study.

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