3.

Results & Discussion

CHAPTER III

3. RESULTS AND DISCUSSION

Studies on species diversity, habitat preference and seasonal distribution appear to be straight and simple but was indeed challenging when it comes to Rhopalocerans. State of Gujarat is indeed a paradise for lepidopteron and when it comes to selected habitats, the flora and fauna was indeed amazing and was not less than an adventurous roller coaster ride.

But the time has come to observe, collect the required data and interpret the hazards of changing time with respect to pesticide usage (immense), urbanization (extensive), pollution (vehicular, release from oil and gas fields) and shrinking of green spaces including the public parks. Such a careless attitude of the overgrowing and over-occupied human population is a matter of concern. Hence, it's an essential research to know the diversity, habitat preference in varied seasons of one of the most marvellous creatures inhabiting the Earth- Butterflies! My research shows that there is definitely scope to increase the population of butterflies in India. Multiple studies have shown and observed the decline in pollination- important link in plant-insect inter-relationship due to pesticides in agricultural fields. A collaborative team of authors studied the impact of pesticides specifically- fenitrothion, on pollinators like bumble bees and butterfly species. Moreover, adding on to it, they said fenetrothion is more toxic than other normally used pesticides and suggested to propose for in depth studies on the effect of quality, quantity and time of pesticide application on pollinators (Brittain et al., 2010).

Certain other studies have also said that habitat fragmentation has dreadfully affected the plant- pollinator interrelationship. Couple of decades back, two biologists (Rathcke & Jules, 1993) said that with the loss of one mutual partner of in a pollinator-plant relationship, would cause the succeeding extinctions. They further suggested that such studies on plant pollinator mutualisms will be effective in strategic planning of the habitat management & conservation.

3.1 Species Diversity

Species diversity studies of rhopalocerans along with its habitat preference and seasonal distribution was carried out for a period of three years. The selected fragmented habitats were: Urban residential, Agricultural landscapes, Industrial Vicinity, Botanical Garden and Hill Station. A total of 72 species belonging to 5 families and 51 genera in all the selected fragmented habitats in Gujarat was observed (Table 12). Members of family Nymphalidae were found to be maximum i.e. 27 species belonging to 17 genera. Family Lycaenidae comprises of 20 species belonging to 18 genera, followed by 15 butterfly species from Pieridae, 7 species of Papilionidae and 3 species of family Hesperiidae.

Numerous studies have been carried out with respect to species diversity and habitat preference around the globe while discussing out in terms of fragmented habitats. Duo authors from Brazil studied the diversity of butterflies in an urban area of Port Alegre of Brazil and revealed the importance of regional urban environmental conditions necessary for butterfly existence. Along with it, they also concluded that during winters, certain scattered areas with high vegetation cover showed high butterfly diversity (Ruszczyk & Mellender de Araujo, 1992). Multiple studies have been carried out in various fragmented habitats in India. In 2014, study on butterfly abundance and diversity was conducted in some urban habitats of Jhansi and revealed a total of 38 butterfly species belonging to 29 genera and 6 families, wherein family Nymphalidae was dominant (Kumar, 2014). Research team in 2012 from Tamilnadu carried out studies on the butterfly diversity in different habitats like forest area, river bank and crop area. Their study revealed a total of 92 butterfly species from 65 genera and 5 families (Parandhaman et al., 2012).

Studies have also been conducted within different habitats in the sanctuaries. Research team from Tripura carried out studies on variation in butterfly diversity and species richness in different habitats of Trishna Wildlife Sanctuary of Tripura and recorded a total of 59 species belonging to 5 families and 48 genera. The study also revealed that moist deciduous forest showed maximum butterfly species diversity whereas the exotic grassland showed the minimum. The research team also suggested that exotic grassland pour in the negative impact on the butterfly species composition (Majumder et al., 2012).

Along with the species diversity, present study also focused on the habitat preference and seasonal distribution of butterflies in selected fragmented habitats of Gujarat.

Table 12: List of documented species of butterflies in selected fragmented habitats of Gujarat

Sr. no	Family	Common name	Scientific Names
1	Papilionidae	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758
2		Common Jay	*Graphium doson* Felder & Felder, 1864
3		Spot Swordtail	*Graphium nomius* Esper, 1785
4		Common Rose	*Pachliopta aristolochiae* Fabricius, 1775
5		Crimson Rose	*Pachliopta hector* Linnaeus, 1758
6		Lime Butterfly	*Papilio demoleus* Linnaeus, 1758
7		Common Mormon	*Papilio polytes* Linnaeus, 1758
8	Pieridae	Western Striped Albatross	*Appias libythea* Fabricius, 1775
9		Pioneer	*Belenois aurota* Fabricius, 1793
10		Common Emigrant	*Catopsilia pomona* Fabricius, 1775
11		Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758
12		Common Gull	*Cepora nerissa* Fabricius, 1775
13		Small Salmon Arab	*Colotis amata* Fabricius, 1775
14		Crimson Tip	*Colotis danae* Fabricius, 1775
15		Small Orange Tip	*Colotis etrida* Boisduval, 1836
16		Common Jezebel	*Delias eucharis* Drury, 1773
17		Small Grass Yellow	*Eurema brigitta* Stoll, 1780
18		Common Grass Yellow	*Eurema hecabe* Linnaeus, 1758
19		White Orange Tip	*Ixias marianne* Cramer, 1779
20		Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764
21		Psyche	*Leptosia nina* Fabricius, 1793
22		Common Wanderer	*Pareronia hippia* Fabricius, 1787
23	Nymphalidae	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758
24		Angled Castor	*Ariadne ariadne* Linnaeus, 1763
25		Common Castor	*Ariadne merione* Cramer, 1777
26		Common Nawab	*Charaxes athamas* Drury, 1770
27		Black Rajah	*Charaxes solon* Fabricius, 1793
28		Painted Lady	*Vanessa cardui* Linnaeus, 1758
29		Plain Tiger	*Danaus chrysippus* Linnaeus, 1758
30		Striped Tiger	*Danaus genutia* Cramer, 1779
31		Common Indian Crow	*Euploea core* Cramer, 1780
32		Common Baron	*Euthalia aconthea* Cramer, 1777
33		Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758
34		Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764

Sr.	Family	Common name	Scientific Names
35		Peacock Pansy	*Junonia almana* Linnaeus, 1758
36		Grey Pansy	*Junonia atlites* Linnaeus, 1763
37		Yellow Pansy	*Junonia hierta* Fabricius, 1798
38		Chocolate Pansy	*Junonia iphita* Cramer, 1779
39		Lemon Pansy	*Junonia lemonias* Linnaeus, 1758
40		Blue Pansy	*Junonia orithya* Linnaeus, 1758
41		Common Evening Brown	*Melanitis leda* Linnaeus, 1758
42		Common Bushbrown	*Mycalesis perseus* Fabricius, 1775
43		Common Sailer	*Neptis hylas* Linnaeus, 1758
44		Glassy Tiger	*Parantica aglea* Stoll, 1782
45		Common Leopard	*Phalanta phalantha* Drury, 1773
46		Baronet	*Symphaedra nais* Forster, 1771
47		Blue Tiger	*Tirumala limniace* Cramer, 1775
48		Common Five-ring	*Ypthima baldus* Fabricius, 1775
49		Common Four-ring	*Ypthima huebneri* Kirby, 1871
50	Lycaenidae	Plum Judy	*Abisara echerius* Stoll, 1790
51		Angled Pierrot	*Caleta decidia* Hewitson, 1876
52		Common Pierrot	*Castalius rosimon* Fabricius, 1775
53		Forget-Me-Not	*Catochrysops strabo* Fabricius, 1793
54		Lime Blue	*Chilades lajus* Stoll, 1780
55		Plains Cupid	*Chilades pandava* Horsfield, 1829
56		Angled Sunbeam	*Curetis acuta* Moore, 1877
57		Indian Sunbeam	*Curetis thetis* Drury, 1773
58		Gram Blue	*Euchrysops cnejus* Fabricius, 1798
59		Indian Cupid	*Everes lacturnus* Godart, 1824
60		Common Cerulean	*Jamides celeno* Cramer, 1775
61		Pea Blue	*Lampides boeticus* Linnaeus, 1767
62		Zebra Blue	*Leptotes plinius* Fabricius, 1793
63		Pale Grass Blue	*Pseudozizeeria maha* Kollar, 1848
64		Common Silverline	*Spindasis vulcanus* Fabricius, 1775
65		Red Pierrot	*Talicada nyseus* Guerin- Meneville, 1843
66		Stripped Pierrot	*Tarucus nara* Kollar, 1848
67		Dark Grass Blue	*Zizeeria karsandra* Moore, 1865
68		Lesser Grass Blue	*Zizina otis* Fabricius, 1787
69		Tiny Grass Blue	*Zizula hylax* Fabricius, 1775
70	Hesperiidae	Brown Awl	*Badamia exclamationis* Fabricius, 1775
71		Rice Swift	*Borbo cinnara* Wallace, 1866
72		Dark Palm-Dart	*Telicota bambusae* Moore, 1878

During the research study period, the butterflies were photographed on fields. Documented butterfly species from the selected fragmented habitats are shown from Figure 21- 98.

Family: Papilionidae

Figure 21: Lime Butterfly *Papilio demoleus* Linnaeus, 1758

Figure 22: Common Jay *Graphium doson* Felder & Felder, 1864

Family: Papilionidae

Figure 23: Common Mormon *Papilio polytes* Linnaeus, 1758

Figure 24: Spot Swordtail *Graphium nomius* Esper, 1785

Family: Papilionidae

Figure 25: Tailed Jay *Graphium agamemnon* Linnaeus, 1758 on *Ixora coccinea*

Figure 26: Lime Butterfly *Papilio demoleus* Linnaeus, 1758 basking on the grass blade

Family: Pieridae

Figure 27: Common Jezebel *Delias eucharis* Drury, 1773 on *Jatropha integerrima*

Figure 28: Common Wanderer *Pareronia hippia* Fabricius, 1787

Family: Pieridae

Figure 29: Common Emigrant *Catopsilia pomona* Fabricius, 1775 on *Lantana camara*

Figure 30: Common Grass yellow *Eurema hecabe* Linnaeus, 1758 on grass blade

Family: Pieridae

Figure 31:Common Gull *Cepora nerissa* Fabricius, 1775

Figure 32: Common Gull *Cepora nerissa* Fabricius, 1775

Family: Pieridae

Figure 33: Mottled Emigrant *Catopsilia pyranthe* Linnaeus, 1758 on *Jatropha integerrima*

Figure 34: Pioneer *Belenois aurota* Fabricius, 1793 on dry grass

Family: Pieridae

Figure 35: Small Grass Yellow *Eurema brigitta* Stoll, 1780

Figure 36: Crimson Tip *Colotis danae* Fabricius, 1775

Family: Pieridae

Figure 37: White Orange Tip *Ixias marianne* Cramer, 1779

Figure 38: Small Salmon Arab *Colotis amata* Fabricius, 1775

Family: Nymphalidae

Figure 39: Black Rajah *Charaxes solon* Fabricius, 1793 feeding on *Lantana camara*

Figure 40: Black Rajah *Charaxes solon* Fabricius, 1793 on rotten *Musa paradisiaca*

Family: Nymphalidae

Figure 41: Blue Tiger *Tirumala limniace* Cramer, 1775

Figure 42: Group of Nymphalids sucking plant sap

Family: Nymphalidae

Figure 43: Plain Tiger *Danaus chrysippus* Linnaeus, 1758

Figure 44: Stripped Tiger *Danaus genutia* Cramer, 1779

Family: Nymphalidae

Figure 45: Baronet *Symphaedra nais* Forster, 1771 (upper side)

Figure 46: Baronet *Symphaedra nais* Forster, 1771 (underside)

Family: Nymphalidae

Figure 47: Common Evening Brown *Melanitis leda* Linnaeus, 1758

Figure 48: Common Sailer *Neptis hylas* Linnaeus, 1758

Family: Nymphalidae

Figure 49: Caterpillar of Common Baron *Euthalia aconthea* Cramer, 1777

Figure 50: Adult Common Baron *Euthalia aconthea* Cramer, 1777

Family: Nymphalidae

Figure 51: Common Castor *Ariadne merione* Cramer, 1777 on *Ricinus communis*

Figure 52: Tawny Castor *Acraea terpsicore* Linnaeus, 1758

Family: Nymphalidae

Figure 53: Common Nawab *Charaxes athamas* Drury, 1770

Figure 54:Common Bush Brown *Mycalesis perseus* Fabricius, 1775

Family: Nymphalidae

Figure 55: Peacock Pansy *Junonia almana* Linnaeus, 1758 feeding on *Lantana camara*

Figure 56: Peacock Pansy *Junonia almana* Linnaeus, 1758

Family: Nymphalidae

Figure 57: Grey Pansy *Junonia atlites* Linnaeus, 1763 on *Lantana camara*

Figure 58: Lemon Pansy *Junonia lemonias* Linnaeus, 1758

Family: Nymphalidae

Figure 59: Yellow Pansy *Junonia hierta* Fabricius, 1798

Figure 60: Blue Pansy *Junonia orithya* Linnaeus, 1758

Family: Nymphalidae

Figure 61: Chocolate Pansy *Junonia iphita* Cramer, 1779 on *Lantana camara*

Figure 62: Chocolate Pansy *Junonia iphita* Cramer, 1779

Family: Nymphalidae

Figure 63: Common Five-ring *Ypthima baldus* Fabricius, 1775

Figure 64: Common Four-ring *Ypthima huebneri* Kirby, 1871

Family: Nymphalidae

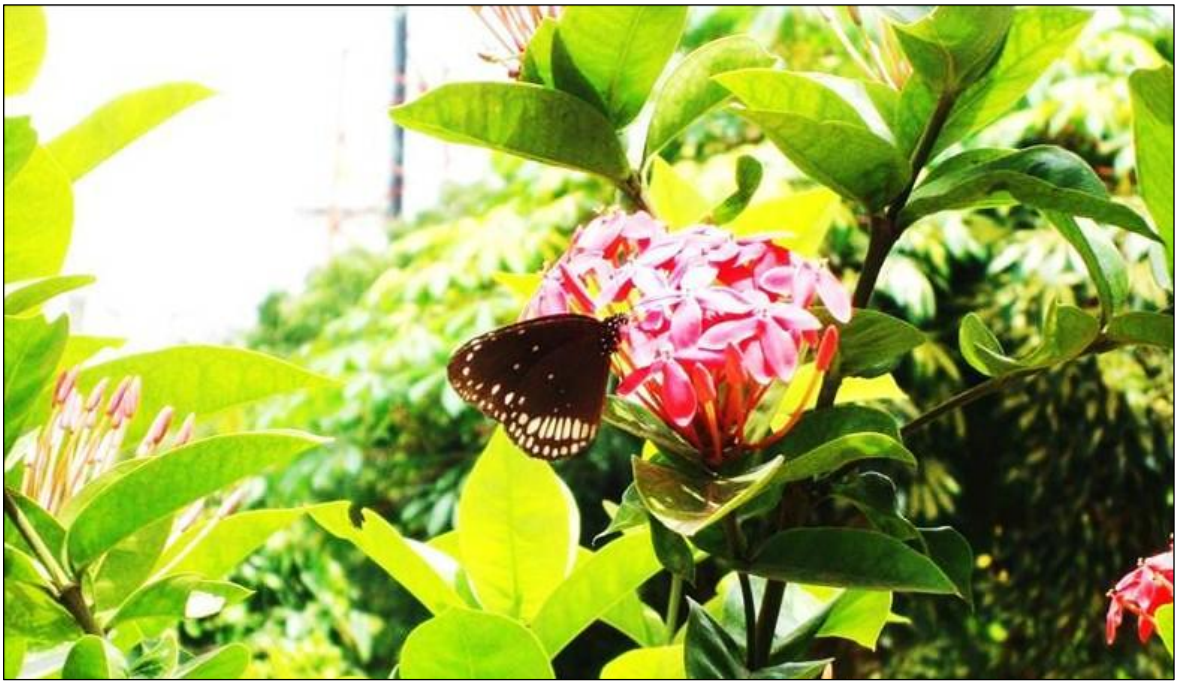


Figure 65: Common Indian Crow *Euploea core* Cramer, 1780 on *Ixora coccinea*

Figure 66: Matting Pair of Indian Common Crow *Euploea core* Cramer, 1780

Family: Nymphalidae

Figure 67: Common Leopard *Phalanta phalantha* Drury, 1773 on *Alternanthera pungent*

Figure 68: Common Leopard *Phalanta phalantha* Drury, 1773

Family: Nymphalidae

Figure 69: Danaid Eggfly *Hypolimnas misippus* Linnaeus, 1764 on *Lantana camara*

Figure 70: Great Eggfly *Hypolimnas bolina* Linnaeus, 1758 on *Ixora coccinea*

Family: Nymphalidae

Figure 71: Great Eggfly *Hypolimnas bolina* Linnaeus, 1758 on *Allium cepa*

Figure 72: Great Eggfly *Hypolimnas bolina* Linnaeus, 1758 on *Lantana camara*

Family: Nymphalidae

Figure 73: Painted Lady *Cynthia cardui* Linnaeus, 1758 on *Lantana camara*

Figure 74: Painted Lady *Cynthia cardui* Linnaeus, 1758 on *Alternanthera pungent*

Family: Lycaenidae

Figure 75: Angled Pierrot *Caleta decidia* Hewitson, 1876

Figure 76: Angled Sunbeam *Curetis acuta* Moore, 1877

Family: Lycaenidae

Figure 77: Common Cerulean *Jamides celeno* Cramer, 1775

Figure 78: Common Pierrot *Castalius rosimon* Fabricius, 1775 on *Tridax procumbens*

Family: Lycaenidae

Figure 79: Common Silverline *Spindasis vulcanus* Fabricius, 1775

Figure 80: Indian Sunbeam *Curetis thetis* Drury, 1773 on *Lantana camara*

Family: Lycaenidae

Figure 81: Plum Judy *Abisara echerius* Stoll, 1790

Figure 82: Red Pierrot *Talicada nyseus* Guerin- Meneville, 1843 on *Bryophyllum*

Family: Lycaenidae

Figure 83: Mating Pair of Zebra Blue *Leptotes plinius* Fabricius, 1793

Figure 84: Mating Pair of Forget-Me-Not *Catochrysops strabo* Fabricius, 1793

Family: Lycaenidae

Figure 85: Lime Blue *Chilades lajus* Stoll, 1780

Figure 86: Plains cupid *Chilades pandava* Horsfield, 1829

Family: Lycaenidae

Figure 87: Gram Blue *Euchrysops cnejus* Fabricius, 1798

Figure 88: Pale Grass Blue *Pseudozizeeria maha* Kollar, 1848

Family: Lycaenidae

Figure 89: Lesser Grass Blue *Zizina otis* Fabricius, 1787 on *Alternanthera pungens*

Figure 90: Tiny Grass Blue *Zizula hylax* Fabricius, 1775

Family: Lycaenidae

Figure 91: Indian Cupid *Everes lacturnus* Godart, 1824

Figure 92: Forget-me-got *Catochrysops strabo* Fabricius, 1793

Family: Lycaenidae

Figure 93: Tiny Grass Blue *Zizula hylax* Fabricius, 1775 on dry leaf

Figure 94: Lesser Grass Blue *Zizina otis* Fabricius, 1787

Family: Lycaenidae

Figure 95: Stripped Pierrot *Tarucus nara* Kollar, 1848

Figure 96: Pea Blue *Lampides boeticus* Linnaeus, 1767

Family: Hesperiidae

Figure 97: Dark Palm Dart *Telicota bambusae* Moore, 1878

Figure 98: Rice Swift *Borbo cinnara* Wallace, 1866

Alpha diversity values were calculated to study the species diversity in the selected fragmented habitats of Gujarat

Table 13: Alpha diversity of Rhopaloceran species in various habitats of Gujarat

Habitats and diversity indices	**Urban Residential (Vadodara)**	**Agricultural Landscapes (Chhani-Vadodara)**	**Industrial Vicinity (Ankleshwar-Bharuch)**	**Waghai Botanical Garden (Waghai-The Dangs)**	**Saputara Hill Station (The Dangs)**
Shannon Weiner Diversity	3.46	3.29	3.22	3.99	3.94
Pielou's Evenness Index	0.74	0.81	0.86	0.77	0.79

From Table 13, it is clearly indicated that Waghai Botanical Garden shows the highest species diversity as compared to that of other fragmented habitats of Gujarat. Saputara hill station show slightly less diversity as compared to that of the botanical garden.

Industrial vicinity shows the least species diversity as compared to all the fragmented habitats of Gujarat. Owing to the wild vegetation, species diversity between urban residential, agricultural landscapes as well as industrial vicinity is much lower as compared to that of the habitats of botanical garden and hill station.

But the evenness of species was more in industrial vicinity of Ankleshwar as compared to that of other habitats. This indicates that with not much being diverse in its habitat, the species are evenly distributed and not much variation is observed. Comparing the evenness values of botanical garden and hill station, the evenness values more or less are same but tend to show certain variation amongst species.

3.2 Habitat Preference

Since last decade, researchers have indulged not only in pure studies of butterfly diversity but also have incorporated other associating components like habitat preference, host plant inter-relationship, etc. Few years back, collaborative team of researchers conducted study of patterns in butterfly communities in heterogenous landscapes of Department of atomic energy (DAE) like scrub jungle, riparian area, garden area, sandy area and monoculture. The team revealed a total of 55 butterfly species across these 5 habitats of which scrub jungle and garden habitats showed the maximum number of butterfly species (Ramesh et al., 2010).

Collaborative team of authors from Arunachal Pradesh carried out studies on butterfly diversity in Dihang Dibang Biosphere Reserve in Eastern Himalayas and listed a total of 134 species of butterflies belonging to 8 families and 81 genera (Borang et al., 2008). An extensive study on butterfly diversity was carried out in Garo Hills of Meghalaya in North-eastern India and recorded a total of 298 species of butterflies and findings suggested the significance of the Garo Hills for butterfly conservation and hence the work can be considered as baseline studies in that particular hotspot (Kunte et al., 2012).

During the entire study period, along with the Rhopaloceran diversity, studies on habitat preference were also carried out. The selected major fragmented habitats were further sub-divided into multiple sub habitats.

3.2.1 Urban Residential

In the present study, habitat preference studies were carried out in sub habitats of urban residential of Vadodara. A total of 43 butterfly species were recorded belonging to 5 families and 29 genera (Table 14). Members of family Nymphalidae were found to be maximum with 15 species, followed by family Pieridae with 12 species. 8 species were found from Family Lycaenidae, followed by 6 species from family Papilionidae and the least being from Family Hesperiidae i.e. 3 species

Table 14: Habitat Preference of documented species of butterflies in sub-habitats of Urban Residential- Vadodara City

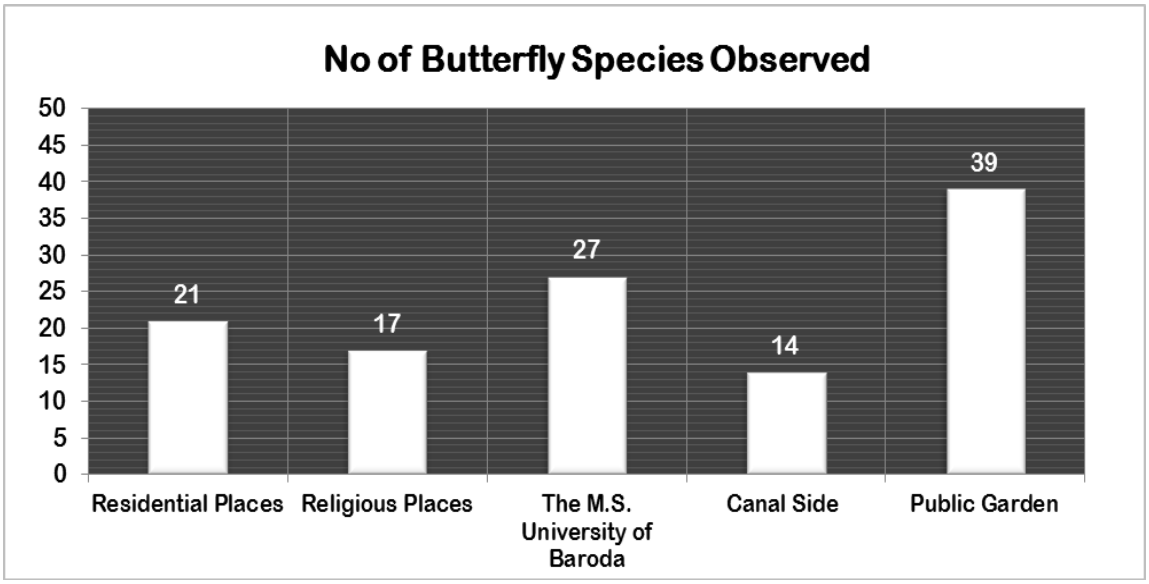
Sr No.	Area	No of Butterfly Species Observed
1	**Residential Places**	21
2	**Religious Places**	17
3	**The M.S. University of Baroda**	27
4	**Canal side**	14
5	**Public Garden**	39

Urbanization and development are one the most prominent factors in decreasing the green and open spaces. It's always good to hear that Banyan city –Vadodara comes up with establishing new fly-overs, high rise buildings and shopping complexes. This toasts for strong infrastructure that aids in changing the shape of Vadodara.

In one sense, Vadodara is a developing city but as the same time it's losing its green space too. Once known for large number of Banyan trees, Vadodara now shows finite count of Banyan trees. Such loss of open spaces greatly affects the diversity depending on it namely butterflies.

Along with imposing only the dark side of it, there are new ventures coming up when it comes to construct new residential areas in and around Vadodara. Barodians have now started to accept the eco-friendly lifestyle. Moreover, (McKinney, 2002) suggested that the impacts of urbanization on the native species can be improved by educating the human population about the impacts which in turn can greatly improve the species conservation in all ecosystems.

Hence, looking to it closely, people want to be near Nature. Thus, observations in urban areas of Vadodara states good number of plant cultivation and in-built gardens that in turn serves as host plants or nectar resources like *Ixora coccinea*, *Cassia fistula*, etc. for butterflies. On a positive note, such nectar rich plantations must be encouraged to attract more number of butterflies hereby helps in elevating its population too.



Graph 1: Habitat Preference of documented species of butterflies in sub- habitats of Urban Residential- Vadodara City

In Public garden of Sayajibaug, due to maximum number of palms & other nectar rich & larval food source plants, highest numbers of butterfly species i.e. 39 were found. While within the university campus of the M.S University of Baroda, more numbers of flowering plants in partition gardens, but the numbers of species which were observed were comparatively less due to crowded educational infrastructure.

Due to availability of nectar resources & larval food plants in private gardens developed with person interest within bungalows & tenements, considerable numbers of species i.e. 21 were found (Graph 1). While in the case of religious places, very less numbers of nectar rich source plants were found which was responsible for less numbers of butterfly species. Moreover instead of green cover, surrounding flooring was maximally covered with marbles & ceramics. Along the road side of Narmada canal, least numbers of species i.e. 14 were found in open vegetative plots as it was devoid of any larval food plants.

Various species of plants at selected sub habitats support the butterfly diversity. *Ixora coccinea*, *Lantana camara* serve as nectar resources for butterflies like *Hypolimnas bolina*, *Graphium agamemnon*, etc. to thrive in such urban residentials. List of plants utilized by butterflies are given in Table 3. Religious places show presence of Bael *Aegle marmelos* which serve as the food plant for Papilionids. Majority of times, canal side

areas show the presence of *Calotropis* sp. which serve as host plant for Plain tiger *Danaus chrysippus.* With the limited availability of plant resources in urban residential, it was observed during the study that *Jatropha integerrima* served as an alternative nectar resource for butterflies like *Catopsilia pomona*, *Catopsilia pyranthe*, *Delias eucharis* and *Graphium agamemnon* rely on *Jatropha integerrima* species for nectar. Such diversity and species richness studies on butterflies was also carried out in the home garden habitat and its vicinity in Puttalam district in Sri Lanka (Karunarathna et al., 2012) and revealed a total of 66 butterfly species from 5 families and suggested to conduct more such detailed studies on butterflies in managed landscapes which can be useful in the conservation of butterfly fauna.

With the advent of urbanization, diversity of plant resources has been adversely affected and hence limited resources are made available to the native species and other pollinators. It is said that urban biotic homogenization is a huge challenge to conservation as plays a leading role in the loss of native species and also the Nature's awareness amongst the human inhabitants in such urban areas (McKinney, 2006). With the present study, observations in urban areas aims and suggests that creating compassion in planting nectar resources and host plants can bring up the butterfly species population. Similar idea can be worked upon on different developing cities of Gujarat like Surat and other parts of the world. Along with the species diversity, butterfly species abundance was also observed which is clearly mentioned in Table 15.

Table 15: Butterfly species abundance in the urban residentials of Vadodara city

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758	VC
2	Common Jay	*Graphium doson* Felder & Felder, 1864	VC
3	Common Rose	*Pachliopta aristolochiae* Fabricius, 1775	C
4	Crimson Rose	*Pachliopta hector* Linnaeus, 1758	C
5	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	VC
6	Common Mormon	*Papilio polytes* Linnaeus, 1758	C
Family Pieridae			

Sr.no	Common name	Scientific Name	Abundance
7	Western Striped Albatross	*Appias libythea* Fabricius, 1775	C
8	Pioneer	*Belenois aurota* Fabricius, 1793	C
9	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	VC
10	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758	VC
11	Common Gull	*Cepora nerissa* Fabricius, 1775	C
12	Small Salmon Arab	*Colotis amata* Fabricius, 1775	VC
13	Crimson Tip	*Colotis danae* Fabricius, 1775	C
14	Common Jezebel	*Delias eucharis* Drury, 1773	C
15	Small Grass Yellow	*Eurema brigitta* Stoll, 1780	VC
16	Common Grass Yellow	*Eurema hecabe* Linnaeus, 1758	VC
17	White Orange Tip	*Ixias marianne* Cramer, 1779	C
18	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	C
Family Nymphalidae			
19	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758	C
20	Angled Castor	*Ariadne ariadne* Linnaeus, 1763	C
21	Common Castor	*Ariadne merione* Cramer, 1777	C
22	Black Rajah	*Charaxes solon* Fabricius, 1793	C
23	Plain Tiger	*Danaus chrysippus* Linnaeus, 1758	VC
24	Striped Tiger	*Danaus genutia* Cramer, 1779	R
25	Common Indian Crow	*Euploea core* Cramer, 1780	VC
26	Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758	VC
27	Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764	C
28	Peacock Pansy	*Junonia almana* Linnaeus, 1758	R
29	Grey Pansy	*Junonia atlites* Linnaeus, 1763	R
30	Yellow Pansy	*Junonia hierta* Fabricius, 1798	R
31	Lemon Pansy	*Junonia lemonias* Linnaeus, 1758	C
32	Blue Pansy	*Junonia orithya* Linnaeus, 1758	R
33	Common Evening Brown	*Melanitis leda* Linnaeus, 1758	C
Family Lycaenidae			
34	Angled Pierrot	*Caleta decidia* Hewitson, 1876	C
35	Common Pierrot	*Castalius rosimon* Fabricius, 1775	C
36	Plains Cupid	*Chilades pandava* Horsfield, 1829	C
37	Indian Sunbeam	*Curetis thetis* Drury, 1773	R
38	Zebra Blue	*Leptotes plinius* Fabricius, 1793	C
39	Common Silverline	*Spindasis vulcanus* Fabricius, 1775	R
40	Stripped Pierrot	*Tarucus nara* Kollar, 1848	C
41	Lesser Grass Blue	*Zizina otis* Fabricius, 1787	C
Family Hesperiidae			
42	Brown Awl	*Badamia exclamationis* Fabricius, 1775	R
43	Rice Swift	*Borbo cinnara* Wallace, 1866	R

3.2.2 Agricultural Landscapes

Table 16: Habitat Preference of documented species of butterflies in sub- habitats of Agricultural Landscapes- Chhani in Vadodara district

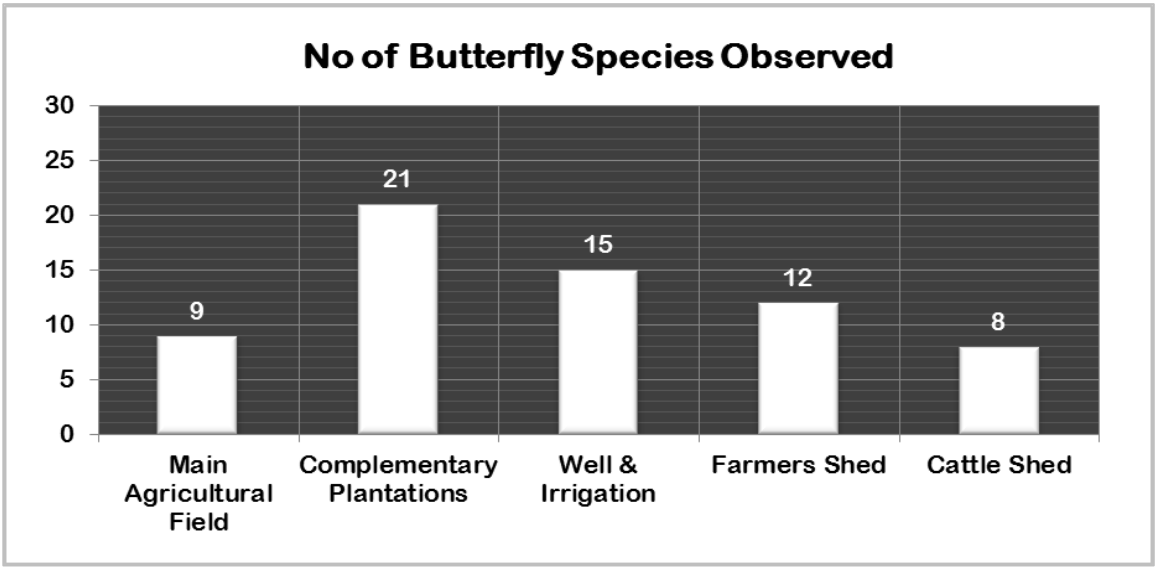
Sr No	Area	No of Butterfly Species Observed
1	**Main Agricultural Field**	9
2	**Complementary Plantations**	21
3	**Well & Irrigation**	15
4	**Farmers Shed**	12
5	**Cattle Shed**	8

Within the agricultural landscape of Chhani, sub habitats were selected to study the occurrence of butterfly species. Amongst all the studied sub- habitats from the agricultural landscapes, area which occupies the complementary plantations showed maximum butterfly species richness i.e. 21 species (Table 16).

Areas occupying the well and irrigation system for sufficient water access to the main agricultural fields showed the presence of 15 species which was fair enough from the number of species presence exhibited by the main agricultural fields i.e. 9 species. Whereas totally different sub-habitats like the farmer's shed and cattle shed showed the presence of 12 and 8 butterfly species respectively.

Agricultural fields of Chhani showed great variety of cultivating and edible crops (Table 4). Along with the edible crop cultivation, Chhani agricultural fields also harbour complementary plantations given in the form of list in Table 5. Such complementary plantations serve as host plants for various butterflies like *Graphium doson* and *Graphium agamemnon*. It's one of the most fertile fragmented habitats that own good quality soil as it cultivates variety of edible crucifer and leguminous crops.

Other factors like temperature and rainfall also adds on to the crop yield though at times also face extreme temperatures in pre monsoon months of May and mid-June.



Graph 2: Habitat Preference of documented species of butterflies in sub-habitats of Agricultural Landscapes- Chhani in Vadodara district

Complementary plantations, which were grown along with main crop, showed highest numbers of butterfly species i.e. 21 (Chart 2), as plants in this complementary plantation serves as a host for various butterfly species. Moreover it was devoid of any chemical pesticide & weedicide application. While, due to availability of humid area around well & water irrigation system, considerable numbers of butterfly species were found to get relieve from excessive hot temperature from surrounding

very less numbers of butterfly species i.e. 9 were found in the main agricultural field, owing to direct hazardous pesticide & weedicide application and considerable farming & grazing activities,. While only shed loving species & species which feed on cattle dung found in the resting areas for farmers & cattle.

There are certain species like Grass yellows which mud puddle near human inhabitation and hence show the presence near the farmer's shed and there are shade loving butterflies like *Melanitis leda,* also known as Common Evening Brown which can temporally land in such places.

Nymphalid butterflies like *Charaxes solon* feed on cow dungs, rotten fruits and also nectar resources. Besides providing shed for the cattle, Cattle shed also serve the feeding purpose for these butterflies and hence tend to show fair number of species richness.

Duo authors from Karnataka (Santhosh & Basavarajappa, 2015) conducted a field survey to record butterfly diversity in different agro-horticultural ecosystems of Chamarajanagar district in Karnataka and observed a total of 95 species belonging to 5 families.

Recently, duo authors carried out the studies on the butterfly diversity in agricultural fields of Howrah district, West Bengal and reported a total of 29 butterfly species belonging to 5 families (Dwari & Mondal, 2015). Moreover, the authors concluded that with the presence of good number of butterfly species, it reveals the good health of the agricultural fields as they serve butterflies with host plants and pollinating grounds.

Despite of naturally managed abiotic factors, this fragmented landscape somewhat fails in holding of large butterfly diversity as compared to that of habitats of mountain range and botanical gardens of The Dangs. Pesticide application is what ruins the entire game. Farmers at Chhani tend to spray pesticides and weedicides to protect their crops from infestation of insect pests.

Application of pesticides has definitely brought down the butterfly population and exhibits detour from cultivated crops to complementary plantations. Hence, with the minimal use of chemical and synthetic pesticides, there can be elevation in population of butterflies. Increase in butterfly population also is achieved by application of botanicals and invasion by the bio-control agents which do not affect the non-target insect pests.

Crop cultivation tends to get affected during elevated temperatures in summers and post monsoon months of October and November which increases the damage of crops due to insect pest invasions.

During the present study, agricultural landscapes of Chhani were selected as one the fragmented habitats of Gujarat. A total of 33 butterfly species belonging to 4 families and 23 genera were documented from the agricultural landscape of Chhani. Members of Family Nymphalidae were found to be maximum i.e. 12 species followed by the members of family Pieridae i.e. 11 species and 5 species of family Lycaenidae were observed (Table 17).

Table 17: Butterfly species abundance in agricultural landscapes of Chhani -Vadodara district

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758	VC
2	Common Jay	*Graphium doson* Felder & Felder, 1864	C
3	Common Rose	*Pachliopta aristolochiae* Fabricius, 1775	R
4	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	C
5	Common Mormon	*Papilio polytes* Linnaeus, 1758	VC
Family Pieridae			
6	Pioneer	*Belenois aurota* Fabricius, 1793	VC
7	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	VC
8	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758	VC
9	Common Gull	*Cepora nerissa* Fabricius, 1775	VC
10	Small Salmon Arab	*Colotis amata* Fabricius, 1775	C
11	Crimson Tip	*Colotis danae* Fabricius, 1775	C
12	Common Jezebel	*Delias eucharis* Drury, 1773	C
13	Small Grass Yellow	*Eurema brigitta* Stoll, 1780	VC
14	Common Grass Yellow	*Eurema hecabe* Linnaeus, 1758	VC
15	White Orange Tip	*Ixias marianne* Cramer, 1779	C
16	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	C
Family Nymphalidae			
17	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758	C
18	Angled Castor	*Ariadne ariadne* Linnaeus, 1763	VC
19	Common Castor	*Ariadne merione* Cramer, 1777	VC
20	Black Rajah	*Charaxes solon* Fabricius, 1793	C
21	Plain Tiger	*Danaus chrysippus* Linnaeus, 1758	VC
22	Common Indian Crow	*Euploea core* Cramer, 1780	VC
23	Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758	R
24	Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764	R
25	Peacock Pansy	*Junonia almana* Linnaeus, 1758	R
26	Lemon Pansy	*Junonia lemonias* Linnaeus, 1758	C
27	Blue Pansy	*Junonia orithya* Linnaeus, 1758	R
28	Common Evening Brown	*Melanitis leda* Linnaeus, 1758	C
Family Lycaenidae			
29	Common Pierrot	*Castalius rosimon* Fabricius, 1775	R
30	Plains Cupid	*Chilades pandava* Horsfield, 1829	C
31	Indian Sunbeam	*Curetis thetis* Drury, 1773	R
32	Zebra Blue	*Leptotes plinius* Fabricius, 1793	C
33	Common Silverline	*Spindasis vulcanus* Fabricius, 1775	R

3.2.3 Industrial Vicinity

Table 18: Habitat Preference of documented species of butterflies in sub- habitats of Industrial Vicinity - Ankleshwar GIDC in Bharuch district

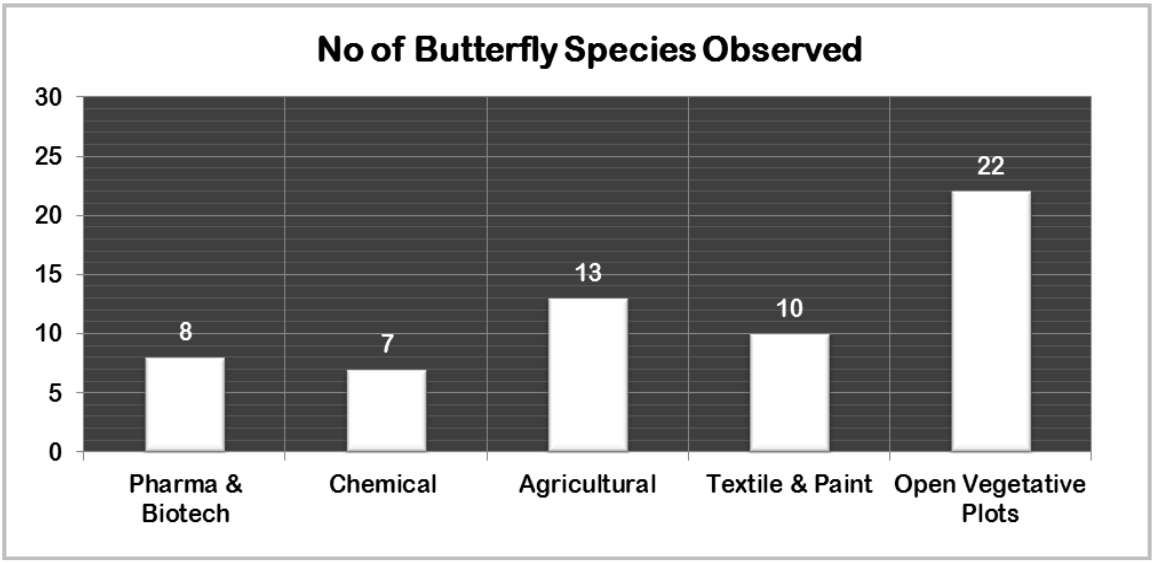
Sr No.	Area	No of Butterfly Species Observed
1	**Pharma & Biotech**	8
2	**Chemical**	7
3	**Agricultural**	13
4	**Textile & Paint**	10
5	**Open Vegetative Plots**	22

The present study was carried out in the industrial vicinity of Ankleshwar in Bharuch district. A total of 29 butterfly species were recorded belonging to 4 families and 21 genera. Family Pieridae showed the maximum number of species i.e. 11 species, followed by family Nymphalidae with 7 species. Family Lycaenidae with 7 species and 4 species from family Papilionidae were also observed during the study (Table 19)

Study in industrial vicinity of Ankleshwar was further divided to sub-habitats involving the surrounding vicinity's of major chemical, agricultural, textile and paint industries and other being the open vegetative plots.

As shown in Table 18, In the Industrial Vicinity of Ankleshwar, Open Vegetative plots in Ankleshwar GIDC showed highest numbers of butterfly species i.e. 22, as it served as a natural host plot with unwanted & essential plants collectively those in a particular area. While due to improper waste management, soil get polluted during manufacturing process of fertilizers & paints in the agricultural, textile & paint industry, only considerable numbers of butterfly species were found i.e. 13 & 10 as shown in Graph 3.

Owing to significant air pollution during chemical synthesis process of synthetic hazardous reagents, chemicals & drug substances; least numbers of butterfly species were observed along with Pharmaceuticals, Biotech & Chemical industries.



Graph 3: Habitat Preference of documented species of butterflies in sub- habitats of Industrial Vicinity - Ankleshwar GIDC in Bharuch district

Gas fields and Oil fields based at Ankleshwar have its release directly blend with the surrounding atmosphere. Hence, pollution in air makes difficult for the local civilians to breathe in fresh air. Owing to the butterfly studies, a total of 29 species were observed.

Though industrial growth is required for country's economy, such industrial tasks should be planned with proper norms. Visual observations of canopy flying butterflies like Common jezebel and migrants did not show large richness as compared to other fragmented habitats. Hence, the species richness in industrial area was observed to be greatly affected. No doubt the in between open plots at Ankleshwar did hold some low flying butterflies like the yellows due to presence of weeds.

Table 19: Butterfly species abundance in the industrial vicinity of Ankleshwar GIDC in Bharuch district

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758	VC
2	Common Jay	*Graphium doson* Felder & Felder, 1864	VC
3	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	VC
4	Common Mormon	*Papilio polytes* Linnaeus, 1758	C
Family Pieridae			
5	Pioneer	*Belenois aurota* Fabricius, 1793	VC
6	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	VC

7	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758	VC
8	Common Gull	*Cepora nerissa* Fabricius, 1775	C
9	Small Salmon Arab	*Colotis amata* Fabricius, 1775	VC
10	Crimson Tip	*Colotis danae* Fabricius, 1775	C
11	Common Jezebel	*Delias eucharis* Drury, 1773	C
12	Small Grass Yellow	*Eurema brigitta* Stoll, 1780	C
13	Common Grass Yellow	*Eurema hecabe* Linnaeus, 1758	VC
14	White Orange Tip	*Ixias marianne* Cramer, 1779	C
15	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	C
Family Nymphalidae			
16	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758	C
17	Plain Tiger	*Danaus chrysippus* Linnaeus, 1758	VC
18	Common Indian Crow	*Euploea core* Cramer, 1780	VC
19	Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758	C
20	Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764	VC
21	Lemon Pansy	*Junonia lemonias* Linnaeus, 1758	VC
22	Blue Tiger	*Tirumala limniace* Cramer, 1775	R
Family Lycaenidae			
23	Common Pierrot	*Castalius rosimon* Fabricius, 1775	C
24	Lime Blue	*Chilades lajus* Stoll, 1780	R
25	Plains Cupid	*Chilades pandava* Horsfield, 1829	C
26	Gram Blue	*Euchrysops cnejus* Fabricius, 1798	C
27	Pea Blue	*Lampides boeticus* Linnaeus, 1767	C
28	Zebra Blue	*Leptotes plinius* Fabricius, 1793	R
29	Tiny Grass Blue	*Zizula hylax* Fabricius, 1775	C

3.2.4 Botanical Garden

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.

19 butterfly species were observed from Dang and Bamboo plot whereas 13 species was observed from scrub thorn and health forest (Table 20). Graphical comparison between numbers of butterfly species observed is depicted from Graph 4.

Table 20: Habitat Preference of documented species of butterflies in sub-habitats of Botanical Garden - Waghai Botanical Garden in The Dangs district

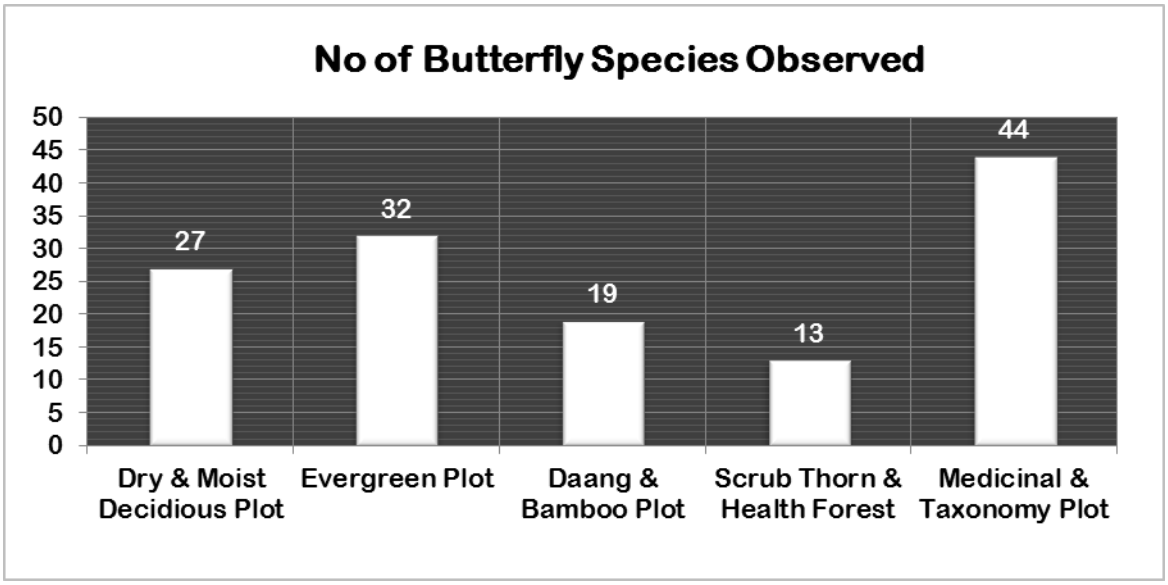
Sr. No	Area	No of Butterfly Species Observed
1	**Dry & Moist Deciduous Plot**	27
2	**Evergreen Plot**	32
3	**Dang & Bamboo Plot**	19
4	**Scrub Thorn & Health Forest**	13
5	**Medicinal & Taxonomy Plot**	44

As compared to other plots, highest numbers of butterfly species i.e. 44 species 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 the all fragments.

As compared to agricultural landscapes, botanical garden is devoid of any anthropological interference i.e. pesticide or weedicides application. Hence, keeping it at its nature's purity, such habitats harbour good butterfly diversity.

During the present study, Waghai Botanical Garden was also selected as one of the fragmented habitats, situated in The Dangs, Gujarat. A total of 70 species of butterflies belonging to 5 families and 49 genera were observed. 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 finally 3 species belonging to family Hesperiidae (Table 21).



Graph 4: Habitat Preference of documented species of butterflies in sub- habitats of Botanical Garden - Waghai Botanical Garden in The Dangs district

Table 21: Butterfly species abundance in Waghai Botanical Garden in The Dangs district

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758	VC
2	Common Jay	*Graphium doson* Felder & Felder, 1864	VC
3	Spot Swordtail	*Graphium nomius* Esper, 1785	C
4	Common Rose	*Pachliopta aristolochiae* Fabricius, 1775	C
5	Crimson Rose	*Pachliopta hector* Linnaeus, 1758	C
6	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	VC
7	Common Mormon	*Papilio polytes* Linnaeus, 1758	C
Family Pieridae			
8	Western Striped Albatross	*Appias libythea* Fabricius, 1775	R
9	Pioneer	*Belenois aurota* Fabricius, 1793	C
10	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	C
11	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758	C
12	Common Gull	*Cepora nerissa* Fabricius, 1775	C
13	Small Salmon Arab	*Colotis amata* Fabricius, 1775	R
14	Crimson Tip	*Colotis danae* Fabricius, 1775	C
15	Small Orange Tip	*Colotis etrida* Boisduval, 1836	C
16	Common Jezebel	*Delias eucharis* Drury, 1773	C
17	Small Grass Yellow	*Eurema brigitta* Stoll, 1780	VC
18	Common Grass	*Eurema hecabe* Linnaeus, 1758	VC

Sr.no	Common name	Scientific Name	Abundance
	Yellow		
19	White Orange Tip	*Ixias marianne* Cramer, 1779	C
20	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	C
21	Psyche	*Leptosia nina* Fabricius, 1793	C
22	Common Wanderer	*Pareronia hippia* Fabricius, 1787	R
Family Nymphalidae			
23	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758	C
24	Angled Castor	*Ariadne ariadne* Linnaeus, 1763	R
25	Common Castor	*Ariadne merione* Cramer, 1777	C
26	Common Nawab	*Charaxes athamas* Drury, 1770	R
27	Black Rajah	*Charaxes solon* Fabricius, 1793	R
28	Painted Lady	*Vanessa cardui* Linnaeus, 1758	R
29	Plain Tiger	*Danaus chrysippus* Linnaeus, 1758	VC
30	Striped Tiger	*Danaus genutia* Cramer, 1779	VC
31	Common Indian Crow	*Euploea core* Cramer, 1780	VC
32	Common Baron	*Euthalia aconthea* Cramer, 1777	R
33	Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758	C
34	Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764	C
35	Peacock Pansy	*Junonia almana* Linnaeus, 1758	C
36	Grey Pansy	*Junonia atlites* Linnaeus, 1763	C
37	Yellow Pansy	*Junonia hierta* Fabricius, 1798	C
38	Chocolate Pansy	*Junonia iphita* Cramer, 1779	C
39	Lemon Pansy	*Junonia lemonias* Linnaeus, 1758	VC
40	Blue Pansy	*Junonia orithya* Linnaeus, 1758	C
41	Common Evening Brown	*Melanitis leda* Linnaeus, 1758	VC
42	Common Bushbrown	*Mycalesis perseus* Fabricius, 1775	VC
43	Common Sailer	*Neptis hylas* Linnaeus, 1758	C
44	Glassy Tiger	*Parantica aglea* Stoll, 1782	VC
45	Common Leopard	*Phalanta phalantha* Drury, 1773	C
46	Baronet	*Symphaedra nais* Forster, 1771	C
47	Blue Tiger	*Tirumala limniace* Cramer, 1775	VC
48	Common Five-ring	*Ypthima baldus* Fabricius, 1775	C
49	Common Four-ring	*Ypthima huebneri* Kirby, 1871	C
Family Lycaenidae			
50	Plum Judy	*Abisara echerius* Stoll, 1790	R
51	Angled Pierrot	*Caleta decidia* Hewitson, 1876	C
52	Common Pierrot	*Castalius rosimon* Fabricius, 1775	C
53	Forget-Me-Not	*Catochrysops strabo* Fabricius, 1793	C
54	Lime Blue	*Chilades lajus* Stoll, 1780	C

55	Plains Cupid	*Chilades pandava* Horsfield, 1829	C
56	Angled Sunbeam	*Curetis dentate* Moore, 1879	R
57	Indian Sunbeam	*Curetis thetis* Drury, 1773	C
58	Gram Blue	*Euchrysops cnejus* Fabricius, 1798	C
59	Indian Cupid	*Everes lacturnus* Godart, 1824	C
60	Common Cerulean	*Jamides celeno* Cramer, 1775	R
61	Zebra Blue	*Leptotes plinius* Fabricius, 1793	C
62	Pale Grass Blue	*Pseudozizeeria maha* Kollar, 1848	C
63	Red Pierrot	*Talicada nyseus* Guerin- Meneville, 1843	C
64	Stripped Pierrot	*Tarucus nara* Kollar, 1848	C
65	Dark Grass Blue	*Zizeeria karsandra* Moore, 1865	C
66	Lesser Grass Blue	*Zizina otis* Fabricius, 1787	C
67	Tiny Grass Blue	*Zizula hylax* Fabricius, 1775	C
Family Hesperiidae			
68	Brown Awl	*Badamia exclamationis* Fabricius, 1775	R
69	Rice Swift	*Borbo cinnara* Wallace, 1866	R
70	Dark Palm Dart	*Telicota bambusae* Moore, 1878	R

3.2.5 Hill Station

No sooner, there is a green space and there are large numbers of past literatures throwing light on the sustained good population of butterflies. In the present work, maximum of 65 species were found in Saputara (Hill Station) belonging to 5 families and Saputara, also known as the Abode of Serpents, is the only hill station of Gujarat, situated in Dangs. Although visited by tourists moving towards Shirdi, but considered to still-undisturbed and less concrete structures (although on-rise).

The only hill station of Gujarat, Saputara was selected as fragmented habitat. Within Saputara, sub-habitats were selected which includes flat plateau, Ayurvedic gardens, Saputara lake view garden, Honey bee centre and roadside bamboo trees.

A total of 48 species were observed from Ayurvedic garden, followed by 34 species from flat plateau region, a total of 27 and 23 butterfly species were observed from the Saputara lake Garden and roadside bamboo trees respectively. Least number of butterfly species was observed from the honey bee centre i.e. 18 species (Table 22).

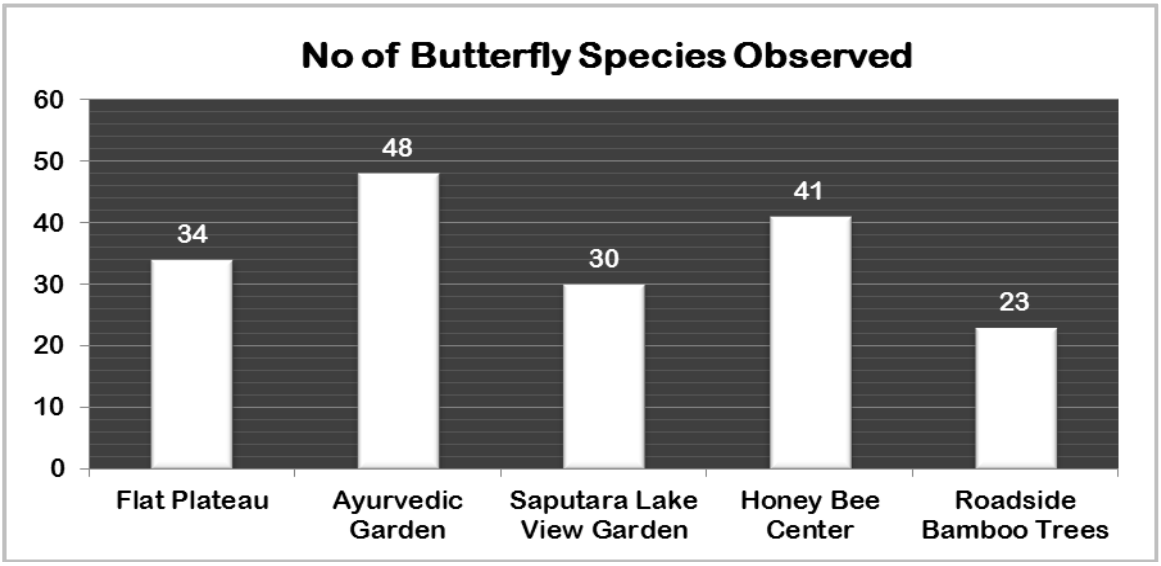
Table 22: Habitat Preference of documented species of butterflies in sub-habitats of Saputara Hill Station in The Dangs district

Sr No	Area	No of Butterfly Species Observed
1	**Flat Plateau**	34
2	**Ayurvedic Garden**	48
3	**Saputara Lake**	30
4	**Honeybee Center**	41
5	**Roadside Bamboo Trees**	23

Least numbers of butterfly species i.e. 23 were found in the dry woody grass of roadside bamboo trees due to less numbers of nectar resource & larval food plants. Due to availability of considerable numbers of nector resources, considerable nos. pf butterfly species i.e. 41, were found in in the center for honey bees apart from raring & breeding activities of honey bees.

Due to maximum availability of significant number of larval food source of Ayurveda plants & nectar rich flower sources in naturally grown vegetation plots in surrounding, maximum numbers of butterfly species were found in Ayurvedic garden i.e. 48.

Saputara – a consideration to make that it can serve as an ideal place for a butterfly park. This is the site where there is an established apiculture centre exists and an ayurvedic garden which harbours wide range of medicinal plants. The existence of blues, sulphurs, swallow tails, brush-footed nymphalids becomes a heart melting vision and pleasure to observe diversity, habitat and season point of view. Total of 65 butterfly species were observed belonging to 5 families and 46 genera. Maximum number of butterfly species was observed from family Nymphalidae i.e. 23 species, followed by 17 species from family Lycaenidae. 15 species were observed from family Pieridae followed by 7 species from Family Papilionidae and 3 species from family Hesperiidae (Table 23)



Graph 5: Habitat Preference of documented species of butterflies in sub-habitats of Saputara Hill Station in The Dangs district

Table 23: Butterfly species abundance at Saputara Hill Station in The Dangs district

Sr.no	Common name	Scientific Name	Abundance
Family Papilionidae			
1	Tailed Jay	*Graphium agamemnon* Linnaeus, 1758	VC
2	Common Jay	*Graphium doson* Felder & Felder, 1864	C
3	Spot Swordtail	*Graphium nomius* Esper, 1785	C
4	Common Rose	*Pachliopta aristolochiae* Fabricius, 1775	C
5	Crimson Rose	*Pachliopta hector* Linnaeus, 1758	R
6	Lime Butterfly	*Papilio demoleus* Linnaeus, 1758	VC
7	Common Mormon	*Papilio polytes* Linnaeus, 1758	VC
Family Pieridae			
8	Western Striped Albatross	*Appias libythea* Fabricius, 1775	C
9	Pioneer	*Belenois aurota* Fabricius, 1793	C
10	Common Emigrant	*Catopsilia pomona* Fabricius, 1775	VC
11	Mottled Emigrant	*Catopsilia pyranthe* Linnaeus, 1758	VC
12	Common Gull	*Cepora nerissa* Fabricius, 1775	VC
13	Small Salmon Arab	*Colotis amata* Fabricius, 1775	C
14	Crimson Tip	*Colotis danae* Fabricius, 1775	C
15	Small Orange Tip	*Colotis etrida* Boisduval, 1836	C
16	Common Jezebel	*Delias eucharis* Drury, 1773	VC

17	Small Grass Yellow	*Eurema brigitta* Stoll, 1780	VC
18	Common Grass Yellow	*Eurema hecabe* Linnaeus, 1758	VC
19	White Orange Tip	*Ixias marianne* Cramer, 1779	VC
20	Yellow Orange Tip	*Ixias pyrene* Linnaeus, 1764	VC
21	Psyche	*Leptosia nina* Fabricius, 1793	C
22	Common Wanderer	*Pareronia hippia* Fabricius, 1787	R
Family Nymphalidae			
23	Tawny Coster	*Acraea terpsicore* Linnaeus, 1758	C
24	Angled Castor	*Ariadne ariadne* Linnaeus, 1763	R
25	Common Castor	*Ariadne merione* Cramer, 1777	R
26	Black Rajah	*Charaxes solon* Fabricius, 1793	C
27	Painted Lady	*Vanessa cardui* Linnaeus, 1758	VC
28	Plain Tiger	*Danaus chrysippus* Linnaeus, 1758	C
29	Striped Tiger	*Danaus genutia* Cramer, 1779	C
30	Common Indian Crow	*Euploea core* Cramer, 1780	VC
31	Great Eggfly	*Hypolimnas bolina* Linnaeus, 1758	VC
32	Danaid Eggfly	*Hypolimnas misippus* Linnaeus, 1764	C
33	Peacock Pansy	*Junonia almana* Linnaeus, 1758	VC
34	Grey Pansy	*Junonia atlites* Linnaeus, 1763	C
35	Yellow Pansy	*Junonia hierta* Fabricius, 1798	VC
36	Chocolate Pansy	*Junonia iphita* Cramer, 1779	VC
37	Lemon Pansy	*Junonia lemonias* Linnaeus, 1758	VC
38	Blue Pansy	*Junonia orithya* Linnaeus, 1758	VC
39	Common Evening Brown	*Melanitis leda* Linnaeus, 1758	C
40	Glassy Tiger	*Parantica aglea* Stoll, 1782	R
41	Common Leopard	*Phalanta phalantha* Drury, 1773	C
42	Baronet	*Symphaedra nais* Forster, 1771	R
43	Blue Tiger	*Tirumala limniace* Cramer, 1775	R
44	Common Five-ring	*Ypthima baldus* Fabricius, 1775	C
45	Common Four-ring	*Ypthima huebneri* Kirby, 1871	C
Family Lycaenidae			
46	Plum Judy	*Abisara echerius* Stoll, 1790	R
47	Angled Pierrot	*Caleta decidia* Hewitson, 1876	C
48	Common Pierrot	*Castalius rosimon* Fabricius, 1775	C
49	Forget-Me-Not	*Catochrysops strabo* Fabricius, 1793	C
50	Lime Blue	*Chilades lajus* Stoll, 1780	C
51	Plains Cupid	*Chilades pandava* Horsfield, 1829	C
52	Indian Sunbeam	*Curetis thetis* Drury, 1773	R
53	Gram Blue	*Euchrysops cnejus* Fabricius, 1798	C
54	Indian Cupid	*Everes lacturnus* Godart, 1824	C

55	Common Cerulean	*Jamides celeno* Cramer, 1775	R
56	Zebra Blue	*Leptotes plinius* Fabricius, 1793	C
57	Pale Grass Blue	*Pseudozizeeria maha* Kollar, 1848	C
58	Red Pierrot	*Talicada nyseus* Guerin- Meneville, 1843	C
59	Stripped Pierrot	*Tarucus nara* Kollar, 1848	C
60	Dark Grass Blue	*Zizeeria karsandra* Moore, 1865	C
61	Lesser Grass Blue	*Zizina otis* Fabricius, 1787	C
62	Tiny Grass Blue	*Zizula hylax* Fabricius, 1775	C
Family Hesperiidae			
63	Brown Awl	*Badamia exclamationis* Fabricius, 1775	R
64	Rice Swift	*Borbo cinnara* Wallace, 1866	R
65	Dark Palm- Dart	*Telicota bambusae* Moore, 1878	R

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.

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 Manasagangotri 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.

Trio authors carried out studies on species richness and diversity of butterflies in and around Kumaun University in Nainital and revealed a total of 27 species from 8 families (Arya et al., 2014) of which members of family Pieridae were found to be dominant. Studies regarding abundance of butterfly species at Sarojini Naidu college campus was conducted and recorded total of 49 species from 5 families (Nair & Mitra, 2014).

The authors also focused on restoration of biodiversity in the campus and developing management strategies to support existence of butterflies.

Table 24: Beta diversity values showing community similarity

Sites	**UR**	**AL**	**IV**	**BG**	**HS**
UR	0.0	0.86	0.66	0.74	0.77
AL		0.0	0.77	0.62	0.65
IV			0.0	0.56	0.60
BG				0.0	0.96
HS					0.0

(where UR: Urban Residentials; AL: Agricultural Landscapes; IV: Industrial Vicinity; BG: Botanical Garden; HS: Hill Station)

From Table 24, it's clearly indicated that botanical garden of Waghai and Saputara hill station possess almost similar species whereas the least similarity of species is indicated between the industrial vicinity of Ankleshwar and botanical garden of Waghai.

Moreover, urban residentials of Vadodara and agricultural landscapes of Chhani also share almost similar species but with certain level of dis-similarity. This indicates that even certain level of urban development can affect the species diversity compared to that of the agricultural fields.

Studying the form of beta diversity helps to study the structure of species diversity in various habitats and thereby one can study the differentiating aspect of the species occurrence in that particular habitat.

3.3 Impact of Seasonal Variations

3.3.1 Urban Residential

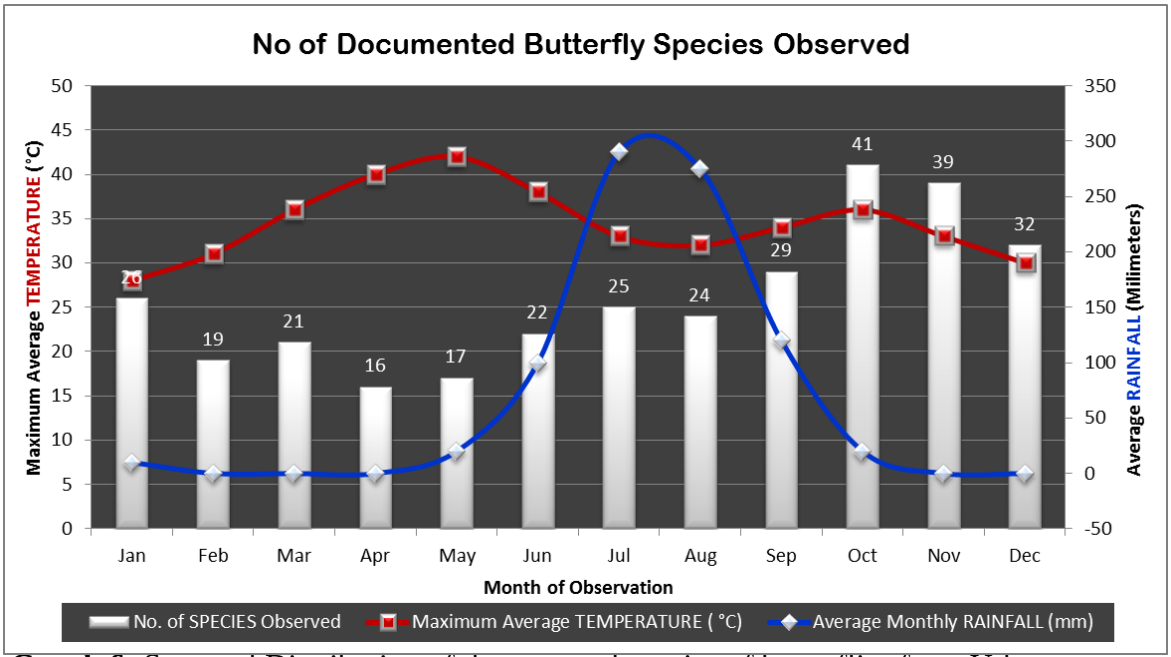
Table 25: Seasonal Distribution of documented species of butterflies from Urban Residentials of Vadodara City

Season	Month	No. of Species Observed	Maximum Average Temperature (°C)	Average Monthly Rainfall (mm)
Pre Monsoon	**Apr**	16	40	0
	May	17	42	20
	Jun	22	38	100
Monsoon	**Jul**	25	33	290
	Aug	24	32	275
	Sep	29	34	120
Post monsoon	**Oct**	41	36	20
	Nov	39	33	0
Winter	**Dec**	32	30	0
	Jan	26	28	10
	Feb	19	31	0
	Mar	21	36	0

Earlier, the seasons were categorised into winters, summers and rainy season. But looking onto the present climatic situations, the three seasons are now being depicted in form of winters, pre-monsoon (which was earlier known as summers), monsoon and post-monsoon. Today, the world is facing one of the major challenges i.e. prime causes and impacts of seasonal fluctuations on the surrounding biodiversity.

During the present study, a total of 43 different butterfly species were observed at urban residentials of Vadodara. Combined studies on species diversity, habitat preference and seasonal distributions of butterflies were carried out.

The present study reveals that with the dawn of winters starting from December, there is a gradual decrease in the number of butterfly species observed at the urban residential due to comparatively cool and dry weather.



Graph 6: Seasonal Distribution of documented species of butterflies from Urban Residentials of Vadodara City

In urban residential of Vadodara city, average maximum temperature ranges from 38°C to 44°C in the Pre-Monsoon season during summer. This High Temperature may hinder the development process of butterflies during their transformation from caterpillar to adult stage. Hence, as compared to all other seasons least numbers of butterfly species were observed during the pre-monsoon months of April, May & June.

While during monsoon season, total rainfall of July, August & September months ranges around 680 mm in Vadodara city. Considerable amount of rainfall supports considerable quantity of larval food plants for the butterfly caterpillars and nectar resource for adults. Thus, as compared to all other seasons, highest numbers of butterfly species were observed in post monsoon months of October & November i.e. 41 & 39 species respectively.

Monthly number of documented species of butterflies with corresponding maximum average temperature and average monthly rainfall is provided in Table 25.

Along with the list, graphical representation is also depicted in Graph 6. Detailed seasonal occurrence of butterfly species is provided in Appendix C1.

3.3.2 Agricultural Landscape

Table 26: Seasonal Distribution of documented species of butterflies from Agricultural Landscapes of Chhani of Vadodara District

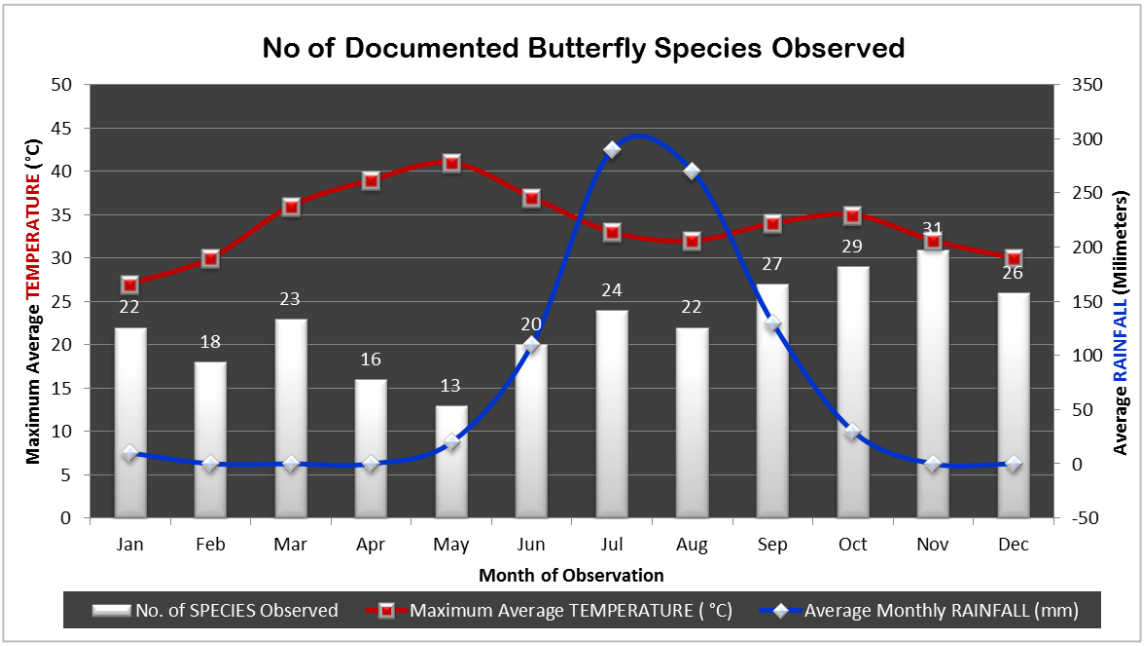
Season	Month	No. of Species Observed	Maximum Average Temperature (°C)	Average Monthly Rainfall (mm)
Pre Monsoon	**Apr**	16	39	0
	May	13	41	20
	Jun	20	37	110
Monsoon	**Jul**	24	33	290
	Aug	22	32	270
	Sep	27	34	130
Post monsoon	**Oct**	29	35	30
	Nov	31	32	0
Winter	**Dec**	26	30	0
	Jan	22	27	10
	Feb	18	30	0
	Mar	23	36	0

Monthly number of documented species of butterflies with corresponding maximum average temperature and average monthly rainfall is provided in Table 26. Along with the tabulated list, graphical representation is also depicted in Graph 7.

During the present study, a total of 33 different butterfly species were observed at agricultural landscapes of Chhani, Vadodara. Seasonal distribution of butterfly species existing in these agricultural landscapes was observed.

The present study reveals more or less the same seasonal trend as observed in the urban residential. The beginning of winters starting from December, decrease in the number of butterfly species was observed at the agricultural landscapes.

In agricultural landscapes of Chhani, average maximum temperature ranges from 36°C to 42°C in the Pre-Monsoon season during summer. This High Temperature may hinder the development process of butterflies during metamorphosis from caterpillar to adult stage. This condition is exaggerated by excessive use of chemical pesticides & weedicides.



Graph 7: Seasonal Distribution of documented species of butterflies from Agricultural Landscapes of Chhani of Vadodara District

Thus, as compared to all other seasons least numbers of butterfly species were observed during the summer.

However during July, August & September months of monsoon season, total rainfall ranges around 700 mm in Vadodara city. Substantial amount of rainfall supports substantial quantity of larval food plants for the butterfly caterpillars and nectar resource for adults.

Rain washes off all the chemical residues of synthetic pesticide & weedicide, which in consequence make the soil more nutrient-rich & fertile for variety of complementary plantation. Thus, as compared to all other seasons, highest numbers of butterfly species i.e. 29 & 33 species respectively were observed in October & November months of post monsoon.

Application of pesticides has gradually brought down the number of butterfly species observed in agricultural fields of Chhani as compared to the urban residentials of Vadodara which is devoid of such invasions of chemical substances.

Detailed seasonal occurrence of individual butterfly species is provided in Appendix C2.

3.3.3 Industrial Vicinity

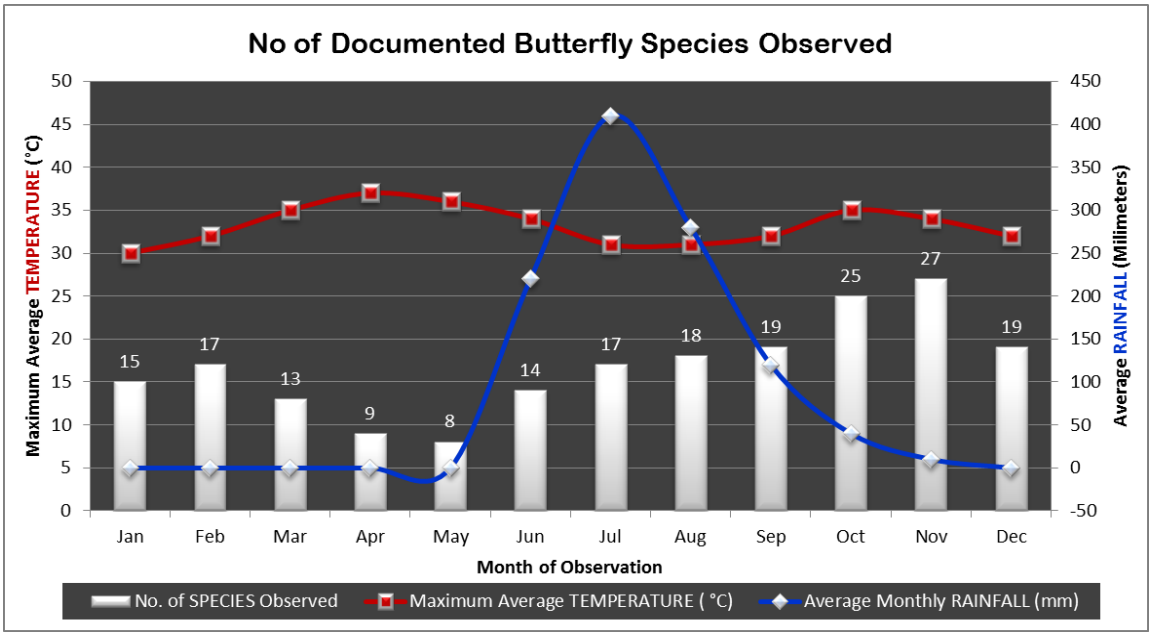
Table 27: Seasonal Distribution of documented species of butterflies from Industrial Vicinity of Ankleshwar of Bharuch District

Season	Month	No. of Species Observed	Maximum Average Temperature (°C)	Average Monthly Rainfall (mm)
Pre Monsoon	**Apr**	9	37	0
	May	8	36	0
	Jun	14	34	220
Monsoon	**Jul**	17	31	410
	Aug	18	31	280
	Sep	19	32	120
Post monsoon	**Oct**	25	35	40
	Nov	27	34	10
Winter	**Dec**	19	32	0
	Jan	15	30	0
	Feb	17	32	0
	Mar	13	35	0

From winters to pre-monsoon to monsoon, the beginning of pre- monsoon i.e. month March and the post monsoon months of October and November showed the gradual elevation in the number of butterfly species.

During summer, the average maximum temperature ranges from 33°C to 38°C in the critically polluted industrial vicinity of Ankleshwar GIDC, which is suitable for butterfly existence but due to water pollution, air pollution & soil infertility, numbers of butterfly species were found in industrial phase of Ankleshwar were very less.

During monsoon, considerable rainfall was observed around 800 mm in Ankleshwar GIDC, which is best suitable for considerable numbers of larval food plants during pre-monsoon season to grow for the butterfly caterpillars in vegetative plots along with GIDC phase. Thus, in the months of October & November, maximum numbers of butterfly species were observed. The low number of butterfly species existing in such vicinity of industries is an eye-opening example of impact of industrialization on biodiverse elements in surrounding environment.



Graph 8: Seasonal Distribution of documented species of butterflies from Industrial Vicinity of Ankleshwar of Bharuch District

During the present study, a total of 29 different butterfly species were observed at industrial vicinity of Ankleshwar in Bharuch district. Seasonal distribution of butterfly species existing in this industrial vicinity was observed.

Along with habitat fragmentation, pollution arising from the industries causes decline in butterfly populations. Only total of 29 species from industrial vicinity of Ankleshwar is the last on the score board as studied one of all 5 major fragmented habitats of Gujarat.

Nevertheless, visible good number of butterflies can be observed at open vegetative plots which are throbbing with naturally managed vegetation. Being at distant place from the main industrial zone, they have managed to adapt to survival strategies obtained from these open plots.

Monthly number of documented species of butterflies observed with corresponding maximum average temperature and average monthly rainfall is provided in Table 27. Along with the list, graphical representation is also depicted in Graph 8.

Detailed seasonal occurrence of butterfly species is provided in Appendix C3.

3.3.4 Botanical Garden

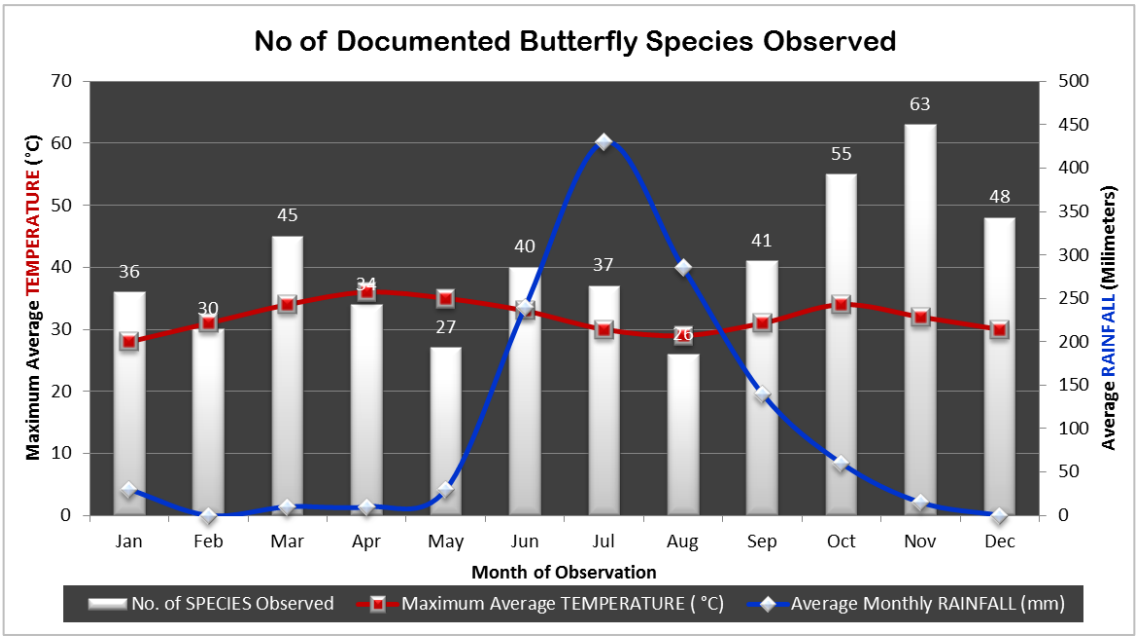
Table 28: Seasonal Distribution of documented species of butterflies from Waghai Botanical Garden of The Dangs District

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

During the present study, an excellent total of 70 species of butterflies were observed at Waghai Botanical Garden of The Dangs. Observations were taken on seasonal distribution of butterfly species in botanical garden.

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. Waghai Botanical Garden comprises of multiple plots of dry and moist deciduous plants, scrub forest, medicinal and taxonomy plot, etc.

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, nos. of species observed during pre-monsoon months of April, May & June in summer were comparatively less as compared to other seasons.



Graph 9: Seasonal Distribution of documented species of butterflies from Waghai Botanical Garden of The Dangs District

During monsoon, very high rainfall of around 850 mm was observed in Waghai, 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 butterflies species due to sudden drop in temperatures.

Along with such climatic situations, Waghai Botanical Garden showed the maximum number of butterfly diversity as compared to that of other selected fragmented habitats of Gujarat.

Monthly number of documented species of butterflies observed with corresponding maximum average temperature and average monthly rainfall is provided in Table 28. Along with the list, graphical representation is also depicted in Graph 9.

Detailed seasonal occurrence of butterfly species is provided in Appendix C4.

3.3.5 Hill Station

Habitat: Hill Station

Figure 99 : Saputara Hill Station in the month of August

Figure 100 : Construction development at Saputara Hill Station

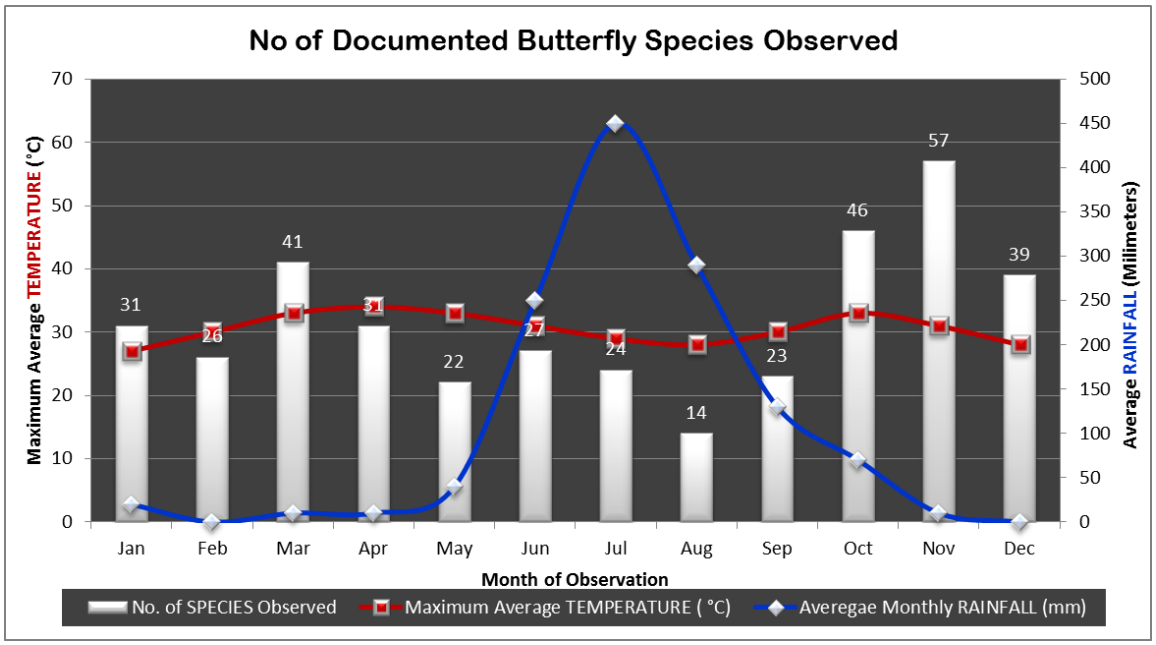
Table 29: Seasonal Distribution of documented species of butterflies from Saputara Hill Station of The Dangs District

Season	Month	No. of Species Observed	Maximum Average Temperature (°C)	Average Monthly Rainfall (mm)
Pre Monsoon	**Apr**	31	34	10
	May	22	33	40
	Jun	27	31	250
Monsoon	**Jul**	24	29	450
	Aug	14	28	290
	Sep	23	30	130
Post monsoon	**Oct**	46	33	70
	Nov	57	31	10
Winter	**Dec**	39	28	0
	Jan	31	27	20
	Feb	26	30	0
	Mar	41	33	10

The present study was carried out at the only hill station of Gujarat- Saputara. During the present study, a total of 65 species of butterflies were observed at Saputara. Observations were taken on seasonal distribution of butterfly species from Saputara. Monthly number of documented species of butterflies with corresponding maximum average temperature and average monthly rainfall is provided in Table 29. Along with the list, graphical representation is also depicted in Graph 10.

Saputara, the alone hill station of Gujarat, is famous tourist attraction. Along with that Saputara have Ayurvedic Garden, Honey bee rearing centre, Lake Garden and open plateau region.

The months of March, October and November showed the maximum number of butterfly diversity. Whereas the months of April to September, showed fluctuations in the presence of butterfly diversity. Moreover, Saputara is situated at an elevation of approx. 800 msl, the rainfalls are chilling and maximum humidity level. Moreover, during rains i.e. month of August, the visibility of the region becomes minimum (Figure 99). Hence, butterflies cannot remain active during such low temperatures.



Graph 10: Seasonal Distribution of documented species of butterflies from Saputara Hill Station of The Dangs District

In Saputara, a planned hill station of Gujarat, average maximum temperature ranges from 30°C to 35°C in summer, which is best suitable for existence of butterflies; but as compared to other seasons, numbers of species observed during pre-monsoon months of April, May & June in summer were comparatively less as compared to other seasons.

Highest rainfall of around 900 mm was observed in Saputara during monsoon season, which supports excellent quality and quantity of larval food plants for the caterpillars and nectar rich flower source for adults just after monsoon. Thus, as compared to all other seasons, highest numbers of butterfly species were observed in.post-monsoon season i.e. 46 & 67 species in October & November months respectively.

Detailed seasonal occurrence of butterfly species is provided in Appendix C5.

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 in 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).

In a nut shell, fragmented habitats have high tendency to bring up the butterfly diversity and richness owing to proper planning on the cultivation of nectar and host plant resources. Definitely, non can control the extreme abiotic situations but at least enhancing the biotic component with utmost input can bring great results. Hope this attempt on studying butterfly diversity in fragmented habitats will work out as baseline strategy to improvise the present scenario of high concrete components and low green spaces.