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Comparative evaluation of butterfly fauna at two selected sites of Junagadh and first occurrence of two new species of butterflies at Junagadh, Gujarat, India

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Abstract
The present study was conducted at two selected sites of Junagadh, Gujarat, India. The survey was conducted from July 2021 to February 2022 using pollard walk method on fixed transects at both sites. A total of 5,754 individuals of butterflies representing 44 Genera and 66 Species belonging to five families were recorded from the study sites. *Pelopidas sinensis* and *Potanthus confucius* belonging to family Hesperiidae were recorded first time from Junagadh, Gujarat. Industrial study site has less diversity of butterflies as compared to Baliyavad Dam site, due to lack of floral resources. This study helps in the conservation of butterflies by giving proper attention to plantation in the Industrial zones.

Keywords: diversity, abundance, industrial zone, first record

Introduction
Butterflies are regarded as "Dancing Flowers" because of their marvellous complexion, configuration, and elegant/dignified flight display delectation to everyone. Lepidoptera is commonly considered an excellent indication of ecosystem health in a variety of places around the world (Rosenberg, 1986; Beccaloni and Gaston, 1995; New *et al*., 1995; Oostermeijier and Van Swaay, 1998) [35, 2, 29, 30]. Butterflies are effective ecological models because they are very responsive to changes in local weather patterns, attributes of habitat as well as seasonal trends, and vegetation fragmentation. Butterflies have a well-defined taxonomic classification, as well as a well-defined life cycle and biology (Nelson and Anderson, 1994; Wood and Gillman, 1998) [28, 49, 49]. Around 273,000 species of Lepidoptera [butterflies (28,000) and moths (245,000)] have been identified in the world today, accounting for one-quarter of all known species (Emmel 2012; Nair *et al*. 2014; MCLB 2021) [9, 27, 23]. There are over 28,000 species of butterflies worldwide, with roughly 80% of them found in tropical areas (Ghazanfar *et al*., 2016) [12]. Indian subcontinents comprise about 1,800 species and subspecies of butterflies (Kunte *et al*., 2018) [20]. Gujarat State is home to a total of 193 species of Butterflies (Parasharya and Jani, 2007) [32]. The life cycle of butterfly consists of four stages namely eggs, larva, pupa, and adult (Shekahda et. al., 2021).
Global biodiversity is being threatened by urbanization, the industrial revolution, and agriculture expansion which is eliminating natural and seminatural ecosystems and increasing anthropogenic disturbances such as habitat degradation, which is reducing plant species, lowering water quality, and increasing air and soil pollution. (McKinney 2002; Garg *et al*. 2009; Singh *et al*. 2009; Lintott *et al*. 2014) [24, 11, 41, 21]. These problems will bring biodiversity to a halt. Butterflies respond to such shifts in the environment by drastically reducing their diversity since they are so reliant on plants. Dunn, (2005) [8]. estimated that around 44,000 insect species have already gone extinct due to human pressures, although only 70 are documented. The increase in the human population and advances in technology have directly affected the ecosystems, making many lepidopterans unable to adapt to these changes (Brattstrom *et al*. 2008) [5]. Appropriate management solutions for urban or industrial environments require a thorough awareness of all taxa of interest, as well as their habitat needs (Sidat and Bhatt, 2020) [39]. While there have been recent butterfly studies in various Indian cities and semi-urban locations, (Sarma *et al*. 2012; Kaneria *et al*. 2013; Kumar 2013; Arya *et al*. 2014; Thangapandian *et al*. 2014; Mukherjee *et al*. 2016; Bhatt and Nagar 2017) [36, 15, 18, 14, 43, 26, 4]. includes in parks and university campuses, it's possible that there haven't been many works done in and surrounding industrial regions.
Previously this type of study had been done by several authors (Gohel and Raval, 2019; Khodbhaya and Raval, 2020; Shekahda et. al., 2021) [13, 17, 38]. at different locations of Junagadh. We carried out this study for the comparative assessment of Butterfly richness at the agroforest site as well as at industrial site and discussion on; (I) what are the different types of butterfly diversity are there? (II) why/how butterfly richness and abundance differs at both sites?

Materials and Methods

Study Site and Habitat description

First study site, the Baliyavad Dam (Agroforest site) was located in Baliyavad Village (21°36'00''N and 70°33'11''E) (Figure.1). It is situated 18km away from the Junagadh, which is both district and sub-district headquarter of Baliyavad village. The area is spread over 0.83 km^2. This site has rich plant diversity and distinct with different types of Vegetative landscapes *viz*; Open Scrubland, Open Grass Land, Herbaceous Land, Dense Scrubland and Trees, as well as the peripheral agro-fields, including crop rotations all over the years *viz*; vegetable plants, commercially important flower plants, and different grain as well as pulse plants. On the southern side of this site, there is dense forest landscapes border (part of the foot-hills of Girnar Wildlife Sanctuary) which includes Forest plantation during all seasons. The major vegetation cover of this study site includes *viz*; *Acacia nilotica*, *Acacia senegal*, *Ailanthus excelsa*, *Alternanthera sessilis*, *Calotropis gigantea*, *Calotropis procera*, *Capparis sepiaria*, *Cassia auriculata*, *Cassia uniflora*, *Clerodendrum multiflorum*, *Cynodon dactylon*, *Ficus religiosa*, *Lantana camara*, *Ziziphus xylopyra*, *Ziziphus nummularia*, and *Heliotropium ellipticum*.

The second study site (Industrial site) was the G.I.D.C.-1 (21° 33' 11.52'' N and 70° 27' 46.08'' E) (Figure.1). The G.I.D.C-1 spread over 0.32 km^2 geographical area. The habitats of this site comprise the majority of the industrial buildings (including Textile Companies, Agro Industries, Food Processing Units (Industries), and Newspaper Industries as well as Warehouses of grains and pulses, etc.) and have fewer vegetation landscapes as compared to the first study site. This study site is covered with urban and suburban landscapes as well as near to the rail tracks. Vegetation covers includes *viz*; herbs, shrubs, grasses, and fewer trees. Major plantation of this site includes *viz*; *Calotropis procera*, *Bougainvillea spectabilis*, *Cynodon dactylon*, *Tridax procumbens*, *Ficus religiosa*, *Pergularia daemia*, *Tephrosia purpurea*, and *Casia fistula*.

Data Collection, Sampling Design, and Identification

The present study was conducted from July 2021 to February 2022 (i.e., Monsoon [July-August-September], Post Monsoon [October-November], and Winter [December- January-February]). The field surveys were conducted from 09:00 AM to 12:00 PM (Nair *et al*., 2014) during the monsoon season and from 10:00 AM to 01:00 PM during the winter season, when the butterflies are more active and were basking. The sites were surveyed four times a month at Agroforest site and once in a month at Industrial site. A total of 35 visits were made during entire study period.

At both the study sites, a total of 8 transects were fixed for the assessments of butterflies. For Butterfly monitoring, the transect count or "Pollard walk method" was used (Pollard, 1977). Observations were made on fixed transect which were 50-200 m long and 5 m wide (2.5 m in right and left side of each transect). Initially, the butterflies were identified in the field by visual observation. But in difficult cases, we either photographed the specimen by using a Camera (Nikon Coolpix P900) or caught the butterflies by using Sweep Insect Net for identification and later on released the butterflies in nature unharmed. For identification, we followed the standard identification keys Evans WH (1932) [10]; Wynter and Blyth (1957) [50].

Statistical Analysis and Status Assessment

To determine the Diversity Indices, we used Past Software 4.03 for data analysis. The diversity indices such as Dominance_D, Shannon-Weiner Index (H), Berger-Parker Dominance, Simpson Diversity Index (1-D), Margalef Index, Brillouin Index, Menhinick Index and Sorensen's Index were calculated by using the equations given by Shannon and Weiner (1949) [37], Berger and Parker (1970) [3], Simpson (1949) [40], Margalef (1958) [22], Brillouin (1956) [6], Menhinick (1964) [25], and Sorensen (1948) [42]. To avoid the biased result, we calculated the diversity indices by comparing only one visit of both the study sites. We also measured the population status (Frequency, Density, and Abundance) of butterflies for both study sites.

For local status assessment, we categorized the butterflies as VC- Very common (>100 sightings), C- Common (51-100 sightings), NR- Not rare (16-50 sightings), R- Rare (2-15 sightings), and VR- Very rare (<2 sightings) (Tiple *et al*., 2006; 2007) [45, 46].

Result and Discussion

Result

Diversity and Threat Status

In the present study we recorded a total of 5,754 individuals of butterflies from 44 Genera and 66 Species belonging to five families from both the study sites *viz*; Agroforest site and Industrial site (Table.1).

Out of 66 species, 2 species *Pelopidas sinensis* and *Potanthus confucius* belonging to family Hesperiidae, were recorded first time at Junagadh, Gujarat. The records of both the species were not included in available peer reviewed research papers from Gujarat. Therefore, these both species recorded first time at Junagadh, Gujarat (Table.1).

At present study, 20 species out of 66 species were categorized as LC- Least concern under IUCN red list index, while 46 species were still remained unranked in IUCN red list categories. 7 species out of 66 species of butterflies were categorized under Indian Wild-life Protection Act,1972. Two species *viz*; *Hypolimnas misippus* (also recorded under Schedule-II category) and *Castalius rosimon* were recorded under Schedule-I category. While 3 species *viz*; *Cepora nerissa*, *Prosotas nora*, and *Euchrysops cnejus* were recorded under Schedule-II

category and 2 species *viz*; *Appias libythea* and *Pelopidas sinensis* were recorded under Schedule -IV category (Table.1). The species were listed under IUCN red list and WPA, 1972 categories, has to be conserve.

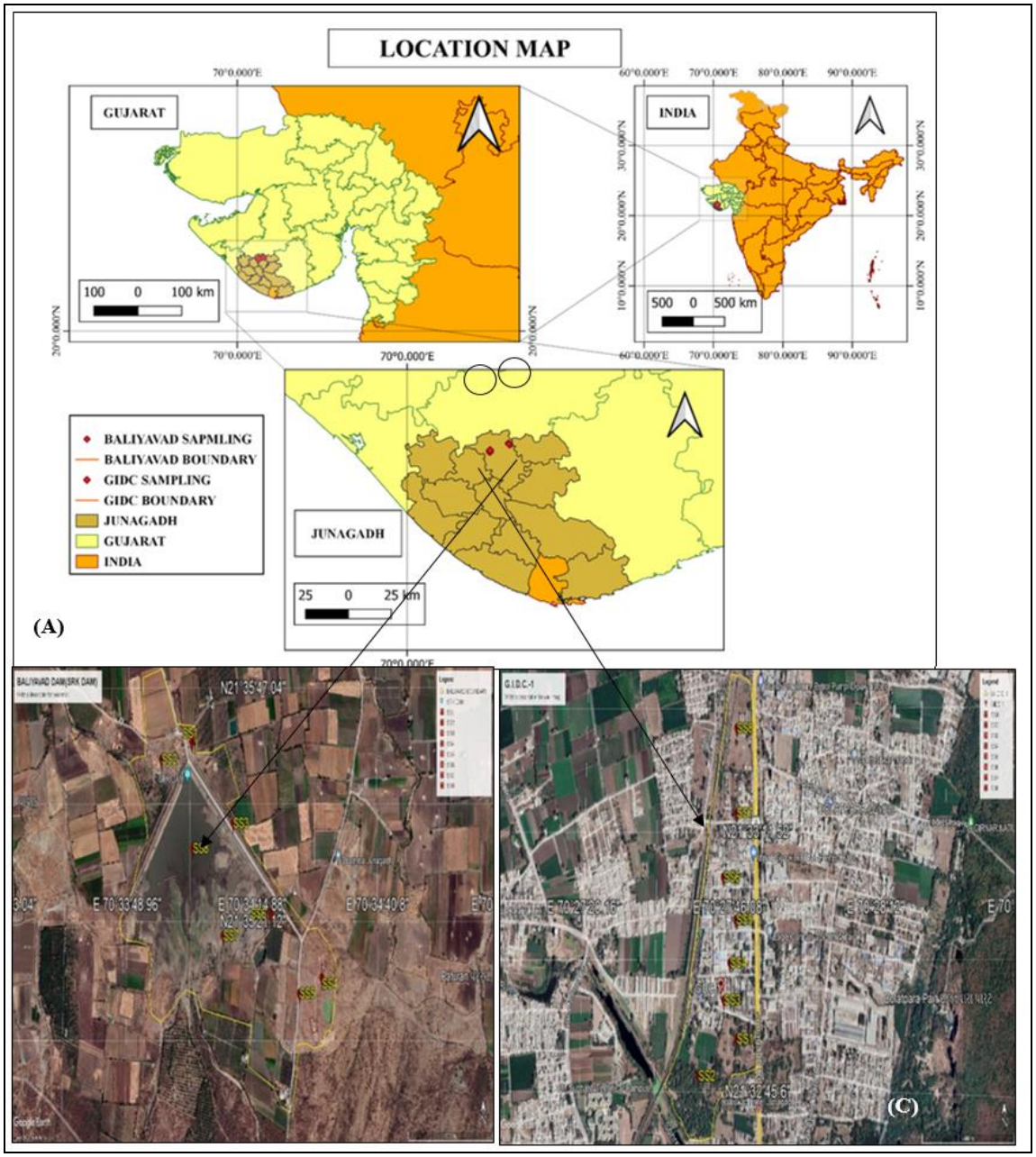

Fig 1: Study area and Sampling locations. A. Location of Junagadh followed by Gujarat and India B. Site 1 Location of Baliyavad Dam (Agroforest site) and sampling locations of survey C. Site 2 Location of G.I.D.C.-1 (Industrial site) and sampling locations of survey. (Image sources: QGIS-Software 3.16, BING Satellite, DIVA-GIS, Google Earth pro); Haribal (2002) [14]; Kehimkar (2008) [16]; and Kunte *et al*., (2018) [20]. In the present study, all the scientific names of Butterflies were followed by using Varshney (1983) and http://www.ifoundbutterflies.org.

Table 1: Checklist of butterflies recorded from both the study sites (Baliyavad Dam and G.I.D.C.-1 Industrial area).

Sr. No.	Common Name	Scientific Name/Authority	IUCN Status	WPA, 1972 Status
Family: Papilionidae (4)				
1.	Lime Swallowtail	*Papilio demoleus* (Linnaeus, 1758)	-	-
2.	Tailed Jay	*Graphium agamemnon* (Linnaeus, 1758)	-	-
3.	Common Mormon	*Papilio polytes* (Cramer, 1775)	LC	-
4.	Common Rose	*Pachliopta aristolochiae* (Fabricius,1775)	LC	-
Family: Pieridae (17)				
5.	Common Grass Yellow	*Eurema hecabe* (Linnaeus, 1758)	-	-
6.	Small Grass Yellow	*Eurema brigitta* (Stoll, 1780)	LC	-

7.	Spotless Grass Yellow	*Eurema laeta* (Boisduval, 1836)	-	-
8.	One-spot Grass Yellow	*Eurema andersonii* (Moore, 1886)	LC	-
9.	Three-spot Grass Yellow	*Eurema blanda* (Boisduval, 1836)	-	-
10.	Common Gull	*Cepora nerissa* (Fabricius, 1775)	-	Schedule-II
11.	Pioneer	*Belenois aurota* (Fabricius, 1793)	LC	-
12.	Crimson-tip	*Colotis danae* (Fabricius, 1775)	LC	-
13.	Little Orange-tip	*Colotis etrida* (Boisduval, 1836)	-	-
14.	Plain Orange-tip	*Colotis aurora* (Cramer, 1780)	-	-
15.	White Orange-tip	*Ixias marianne* (Cramer, 1779)	-	-
16.	Yellow Orange-tip	*Ixias pyrene (*Linnaeus, 1764)	-	-
17.	Lemon Emigrant	*Catopsilia pomona* (Fabricius, 1775)	-	-
18.	Mottled Emigrant	*Catopsilia pyranthe* (Linnaeus, 1758)	-	-
19.	Large Salmon Arab	*Colotis fausta* (Olivier, 1804)	LC	-
20.	Small Salmon Arab	*Colotis amata* (Fabricius, 1775)	-	-
21.	Western Striped Albatross	*Appias libythea* (Fabricius, 1775)	-	Schedule-IV
Family: Nymphalidae (15)				
22.	Angled Castor	*Ariadne ariadne* (Linnaeus, 1763)	-	-
23.	Blue Pansy	*Junonia orithya* (Linnaeus, 1758)	LC	-
24.	Yellow Pansy	*Junonia hierta* (Fabricius, 1798)	LC	-
25.	Lemon Pansy	*Junonia lemonias* (Linnaeus, 1758)	-	-
26.	Peacock Pansy	*Junonia almana* (Linnaeus, 1758)	-	-
27.	Blue Tiger	*Tirumala limniace* (Cramer, 1775)	LC	-
28.	Plain Tiger	*Danaus chrysippus* (Linnaeus, 1758)	LC	-
29.	Striped Tiger	*Danaus genutia* (Cramer, 1779)	-	-
30.	Common Leopard	*Phalanta phalantha* (Drury, 1773)	LC	-
31.	Common Three-ring	*Ypthima asterope* (Moore, 1884)	-	-
32.	Danaid Eggfly	*Hypolimnas misippus* (Linnaeus, 1764)	LC	Schedule-I & II
33.	Great Eggfly	*Hypolimnas bolina* (Linnaeus, 1758)	-	-
34.	Joker	*Byblia ilithyia* (Drury, 1773)	LC	-
35.	Tawny Coster	*Acraea terpsicore* (Linnaeus, 1758)	-	-
36.	Painted Lady	*Vanessa cardui* (Linnaeus, 1758)	LC	-
Family: Lycaenidae (23)				
37.	Zebra Blue	*Leptotes plinius* (Fabricius, 1793)	-	-
38.	Black-spotted Grass Jewel	*Freyeria putli* (Kollar, 1844)	-	-
39.	Bright Babul Blue	*Azanus ubaldus* (Stoll, 1782)	LC	-
40.	Dull Babul Blue	*Azanus uranus* (Butler, 1886)	-	-
41.	Common Lineblue	*Prosotas nora* (Felder, 1860)	-	Schedule-II
42.	Common Pierrot	*Castalius rosimon* (Fabricius, 1775)	-	Schedule-I
43.	Common Silverline	*Spindasis vulcanus* (Fabricius, 1775)	-	-
44.	Dark Grass Blue	*Zizeeria karsandra* (Moore, 1865)	LC	-
45.	Forget-me-not	*Catochrysops strabo* (Fabricius, 1793)	-	-
46.	Gram Blue	*Euchrysops cnejus* (Fabricius, 1798)	-	Schedule-II
47.	Common Red Flash	*Rapala iarbus* (Fabricius, 1787)	-	-
48.	Tiny Grass Blue	*Zizula hylax* (Fabricius, 1775)	LC	-
49.	Lesser Grass Blue	*Zizina otis* (Fabricius, 1787)	LC	-
50.	Lime Blue	*Chilades lajus* (Stoll, 1780)	-	-
51.	Apefly	*Spalgis epius* (Westwood, 1851)	-	-
52.	Plains Cupid	*Chilades pandava* (Horsfield, 1829)	-	-
53.	Small Cupid	*Chilades parrhasius* (Fabricius, 1793)	-	-
54.	Plumbeous Silverline	*Spindasis schistacea* (Moore, 1881)	-	-
55.	Common Shot Silverline	*Spindasis ictis* (Hewitson, 1865)	-	-
56.	Striped Pierrot	*Tarucus nara* (Kollar, 1848)	-	-
57.	Indian Sunbeam	*Curetis thetis* (Drury, 1773)	-	-
58.	African Babul Blue	*Azanus jesous* (Guérin-Méneville, 1849)	LC	-
59.	Tailless Lineblue	*Prosotas dubiosa* (Semper, 1879)	-	-
Family: Hesperiidae (7)				
60.	Rice Swift	*Borbo cinnara* (Wallace, 1866)	-	-
61.	Lesser Rice Swift	*Borbo bevani* (Moore, 1878)	-	-
62.	Chinese Branded Swift	*Pelopidas sinensis* (Mabille, 1877)	-	Schedule-IV
63.	Small Branded Swift	*Pelopidas mathias* (Fabricius, 1798)	-	-
64.	Chinese Dart	*Potanthus confucius* (Felder, 1862)	-	-

65.	Pale Palm-Dart	*Telicota colon* (Fabricius, 1775)	-	-
66.	Asian Grizzled Skipper	*Spialia galba* (Fabricius, 1793)	-	-

Note: "-"sign denotes unranked status in IUCN red list and WPA, 1972 categories.

Species Richness and Study site status

A total of 44 Genera and 66 Species were recorded from Site-1. At Site-1, the family Lycaenidae was highest with 23(34.8%) species followed by Pieridae 17(25.7%) species, Nymphalidae 15(22.7%) species, Hesperiidae 7(10.6%) species, and the family Papilionidae was lowest with only 4(6%) species. Only 8 Genera and 11 species were recorded from Site-2. At Site-2, the family Pieridae was highest with 6(54.5%) species followed by Nymphalidae 2(18.1%) species, Papilionidae 2(18.1%) species, Lycaenidae 1(9%) species and family Hesperiidae with zero (0%) species (Table.2 and Figure.2 and 3).

Table 2: Percentage and numbers of Genus and Species according to five families for both sites.

Sr. No.	Family	Genus		Species		Genus (%)		Species (%)	
		Site.1	Site.2	Site.1	Site.2	Site.1	Site.2	Site.1	Site.2
1.	Papilionidae	3	2	4	2	6.8	25.0	6.0	18.1
2.	Pieridae	7	3	17	6	15.9	37.5	25.7	54.5
3.	Nymphalidae	10	2	15	2	22.7	25.0	22.7	18.1
4.	Lycaenidae	19	1	23	1	43.1	12.5	34.8	9.0
5.	Hesperiidae	5	0	7	0	11.3	0.0	10.6	0.0

Note: "Site.1" and "Site.2" sign denotes Agroforest site and Industrial sites respectively.

At Agroforest site, the status of individuals of different species was highest as compared to Industrial site. At Agroforest site, we analysed that about 25 species recorded under R- Rare status, 16 species recorded under VC- Very common status, 14 species recorded under NR- Not rare status, 7 species recorded under VR- Very rare status, and 4 species recorded under C- Common status. Where at Industrial site, 6 species recorded under NR- Not rare status, 3 species recorded under R- Rare status, 1 species recorded under VR- Very rare status, and 1 species recorded under C- Common status (Table.3).

Table 3: Comparison of Agroforest site and Industrial site.

Sr. No.	Scientific Name	Agroforest site		Industrial site	
		Presence/Absence	Site Status	Presence/Absence	Site Status
1.	*Papilio demoleus*	+	NR	-	*
2.	*Graphium agamemnon*	+	VR	+	VR
3.	*Papilio polytes*	+	R	+	R
4.	*Pachliopta aristolochiae*	+	R	-	*
5.	*Eurema hecabe*	+	VC	+	NR
6.	*Eurema brigitta*	+	VC	+	NR
7.	*Eurema laeta*	+	VC	+	NR
8.	*Eurema andersonii*	+	R	-	*
9.	*Eurema blanda*	+	VR	-	*
10.	*Cepora nerissa*	+	R	-	*
11.	*Belenois aurota*	+	NR	-	*
12.	*Colotis danae*	+	C	-	*
13.	*Colotis etrida*	+	VC	+	R
14.	*Colotis aurora*	+	VC	-	*
15.	*Ixias marianne*	+	R	-	*
16.	*Ixias pyrene*	+	NR	-	*
17.	*Catopsilia pomona*	+	VC	+	NR
18.	*Catopsilia pyranthe*	+	VC	+	NR
19.	*Colotis fausta*	+	VC	-	*
20.	*Colotis amata*	+	R	-	*
21.	*Appias libythea*	+	NR	-	*
22.	*Ariadne ariadne*	+	VC	-	*
23.	*Junonia orithya*	+	C	-	*
24.	*Junonia hierta*	+	R	-	*
25.	*Junonia lemonias*	+	NR	-	*
26.	*Junonia almana*	+	R	-	*
27.	*Tirumala limniace*	+	NR	-	*
28.	*Danaus chrysippus*	+	VC	+	C
29.	*Danaus genutia*	+	R	-	*

30.	*Phalanta phalantha*	+	VR	-	*
31.	*Ypthima asterope*	+	NR	-	*
32.	*Hypolimnas misippus*	+	VC	+	R
33.	*Hypolimnas bolina*	+	C	-	*
34.	*Byblia ilithyia*	+	VC	-	*
35.	*Acraea terpsicore*	+	R	-	*
36.	*Vanessa cardui*	+	VR	-	*
37.	*Leptotes plinius*	+	NR	-	*
38.	*Freyeria putli*	+	C	-	*
39.	*Azanus ubaldus*	+	R	-	*
40.	*Azanus uranus*	+	R	-	*
41.	*Prosotas nora*	+	NR	-	*
42.	*Castalius rosimon*	+	R	-	*
43.	*Spindasis vulcanus*	+	R	-	*
44.	*Zizeeria karsandra*	+	VC	-	*
45.	*Catochrysops strabo*	+	R	-	*
46.	*Euchrysops cnejus*	+	NR	-	*
47.	*Rapala airbus*	+	NR	-	*
48.	*Zizula hylax*	+	NR	-	*
49.	*Zizina otis*	+	VC	+	NR
50.	*Chilades lajus*	+	R	-	*
51.	*Spalgis epius*	+	VR	-	*
52.	*Chilades pandava*	+	NR	-	*
53.	*Chilades parrhasius*	+	NR	-	*
54.	*Spindasis schistacea*	+	R	-	*
55.	*Spindasis ictis*	+	VR	-	*
56.	*Tarucus nara*	+	VC	-	*
57.	*Curetis thetis*	+	R	-	*
58.	*Azanus jesous*	+	R	-	*
59.	*Prosotas dubiosa*	+	VC	-	*
60.	*Borbo cinnara*	+	R	-	*
61.	*Borbo bevani*	+	R	-	*
62.	*Pelopidas sinensis*	+	VR	-	*
63.	*Pelopidas mathias*	+	R	-	*
64.	*Potanthus confucius*	+	R	-	*
65.	*Telicota colon*	+	R	-	*
66.	*Spialia galba*	+	R	-	*

Note: "*" sign denotes no records of those species, "+" sign denotes Presence and "–" sign denotes Absence

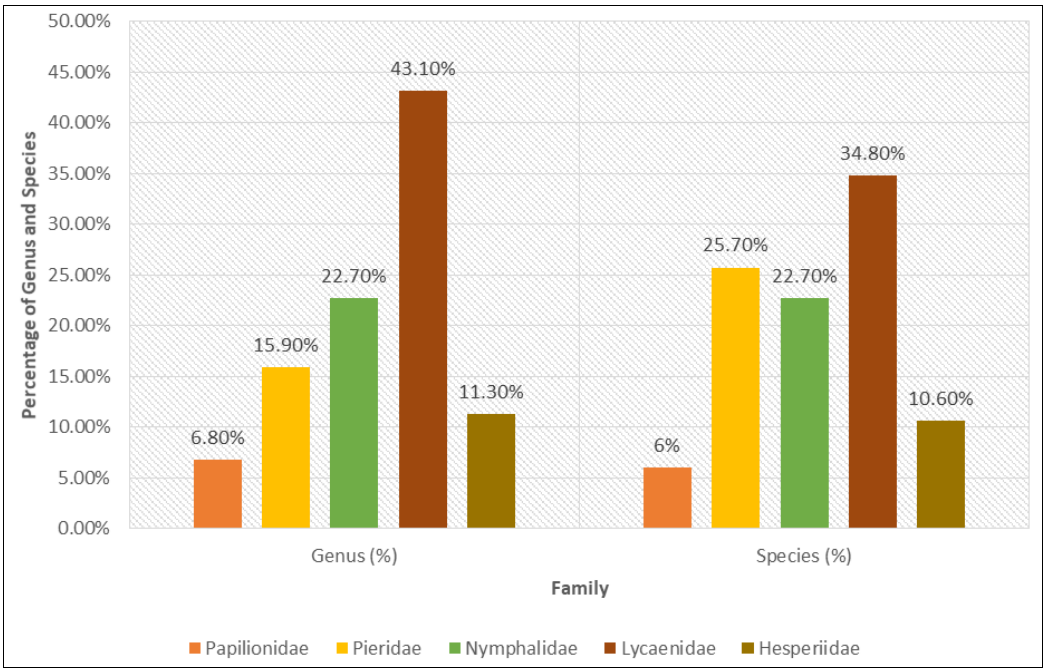

Fig 2: Genus-species percentage for Agroforest site

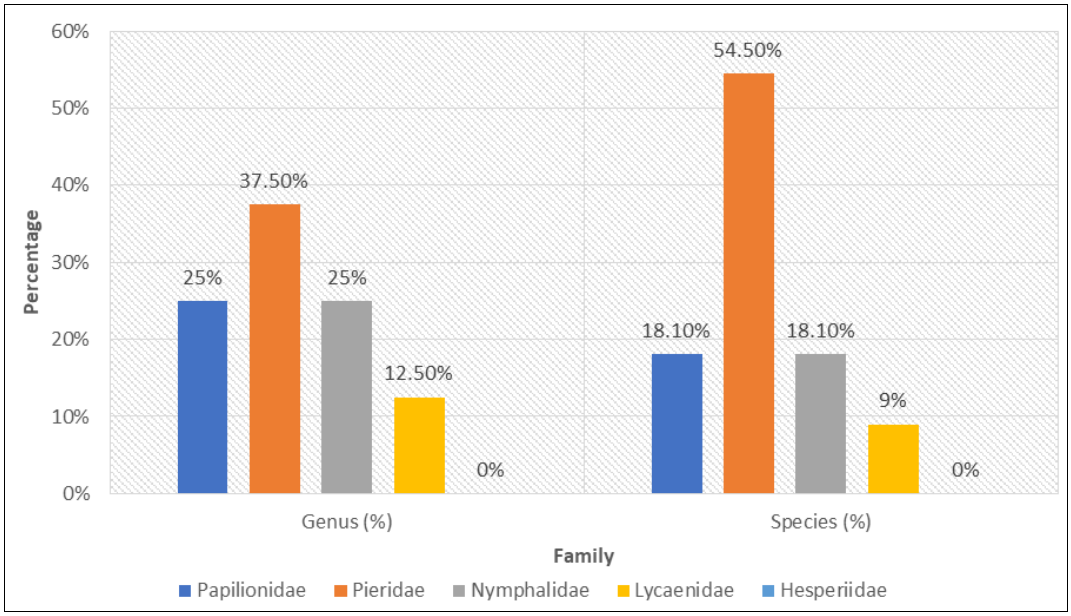

Fig 3: Genus-species percentage for Industrial site

At Agroforest site, highest number of species were recorded in September (56) followed by October (45) and lowest number of species were recorded in July and February (24). At Industrial site, Highest number of species were recorded in August (10) and lowest number of species were recorded in October (3). Agroforest site comprises of 66 species and Industrial site comprises of 11 species, which indicate higher diversity of butterfly present at Agroforest site (Figure.4).

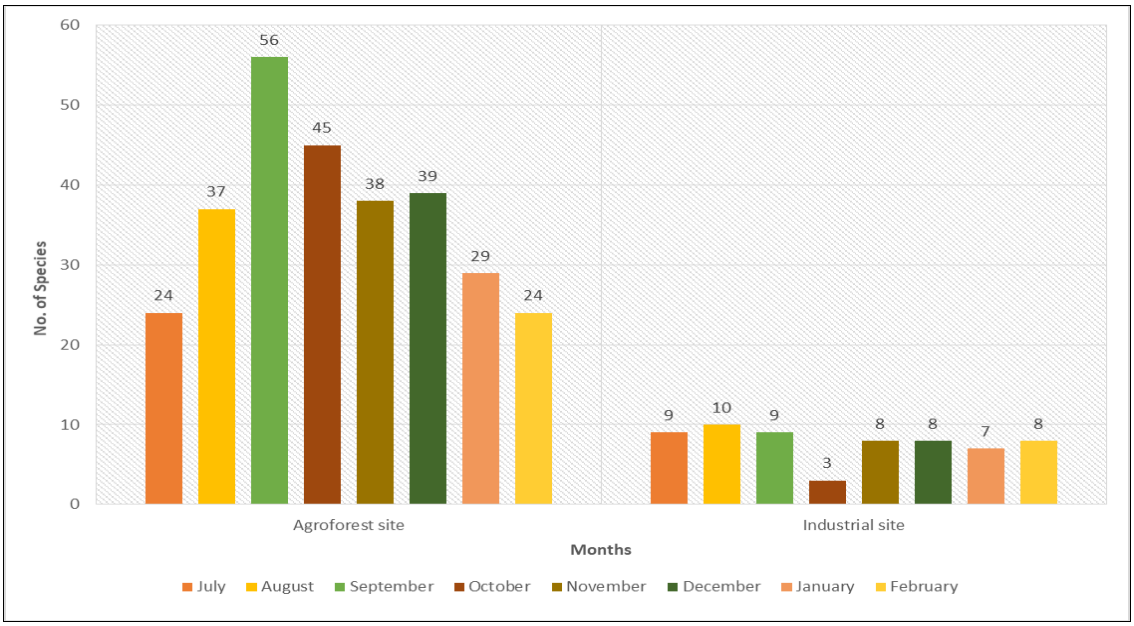

Fig 4: Month-wise diversity of butterflies (July 2021 to February 2022)

Population Status

Population status includes the Species frequency, density and abundance of both the study sites (Table. 4).

Table 4: The Population Status of both the study sites.

Sr. No.	Species Name	Agroforest site			Industrial site		
		Frequency (%)	Density	Abundance	Frequency (%)	Density	Abundance
1.	*Papilio demoleus*	50 %	1	2	*	*	*
2.	*Graphium agamemnon*	62.5 %	4.8	7.8	12.5 %	0.12	1
3.	*Papilio polytes*	12.5 %	0.12	1	25 %	0.25	1
4.	*Pachliopta aristolochiae*	12.5 %	0.25	2	*	*	*
5.	*Eurema hecabe*	100 %	82.7	82.7	100 %	6.2	6.2
6.	*Eurema brigitta*	100 %	35.1	35.1	87.5 %	2.7	3.1

7.	*Eurema laeta*	100 %	34.6	34.6	75 %	2.6	3.5
8.	*Eurema andersonii*	12.5 %	0.37	3	*	*	*
9.	*Eurema blanda*	12.5 %	0.12	1	*	*	*
10.	*Cepora nerissa*	50 %	1.8	3.7	*	*	*
11.	*Belenois aurota*	75 %	3.6	4.8	*	*	*
12.	*Colotis danae*	100 %	7	7	*	*	*
13.	*Colotis etrida*	100 %	22.3	22.3	62.5 %	1.1	1.8
14.	*Colotis aurora*	75 %	16.8	22.5	*	*	*
15.	*Ixias marianne*	75 %	1.8	2.5	*	*	*
16.	*Ixias pyrene*	37.5 %	2.3	6.3	*	*	*
17.	*Catopsilia pomona*	100 %	83.6	83.6	100 %	4.3	4.3
18.	*Catopsilia pyranthe*	100 %	13.5	13.5	87.5 %	2.2	2.5
19.	*Colotis fausta*	75 %	21.2	28.3	*	*	*
20.	*Colotis amata*	37.5 %	1.2	3.3	*	*	*
21.	*Appias libythea*	62.5 %	4.1	6.6	*	*	*
22.	*Ariadne ariadne*	87.5 %	42.1	48.1	*	*	*
23.	*Junonia orithya*	100 %	8.6	8.6	*	*	*
24.	*Junonia hierta*	62.5 %	1.1	1.8	*	*	*
25.	*Junonia lemonias*	87.5 %	5	5.7	*	*	*
26.	*Junonia almana*	37.5 %	0.62	1.6	*	*	*
27.	*Tirumala limniace*	50 %	2.1	4.2	*	*	*
28.	*Danaus chrysippus*	100 %	47.6	47.6	100 %	6.5	6.5
29.	*Danaus genutia*	75 %	1.8	2.5	*	*	*
30.	*Phalanta phalantha*	12.5 %	0.12	1	*	*	*
31.	*Ypthima asterope*	50 %	5.3	10.7	*	*	*
32.	*Hypolimnas misippus*	75 %	28.7	38.3	37.5 %	1.1	3
33.	*Hypolimnas bolina*	50 %	7.1	14.2	*	*	*
34.	*Byblia ilithyia*	62.5 %	28.2	45.2	*	*	*
35.	*Acraea terpsicore*	25 %	0.25	1	*	*	*
36.	*Vanessa cardui*	12.5 %	0.12	1	*	*	*
37.	*Leptotes plinius*	87.5 %	4.3	5	*	*	*
38.	*Freyeria putli*	37.5 %	10.6	28.3	*	*	*
39.	*Azanus ubaldus*	37.5 %	1.6	4.3	*	*	*
40.	*Azanus uranus*	12.5 %	0.25	2	*	*	*
41.	*Prosotas nora*	50 %	5.1	10.2	*	*	*
42.	*Castalius rosimon*	50 %	0.5	1	*	*	*
43.	*Spindasis vulcanus*	37.5 %	1.1	3	*	*	*
44.	*Zizeeria karsandra*	87.5 %	27.3	31.2	*	*	*
45.	*Catochrysops strabo*	50 %	0.62	1.2	*	*	*
46.	*Euchrysops cnejus*	75 %	2.2	3	*	*	*
47.	*Rapala airbus*	25 %	2.2	9	*	*	*
48.	*Zizula hylax*	62.5 %	4.6	7.4	*	*	*
49.	*Zizina otis*	100 %	27.2	27.2	87.5 %	3.1	3.5
50.	*Chilades lajus*	37.5 %	0.87	2.3	*	*	*
51.	*Spalgis epius*	12.5 %	0.12	1	*	*	*
52.	*Chilades pandava*	62.5 %	2.3	3.8	*	*	*
53.	*Chilades parrhasius*	87.5 %	5.7	6.5	*	*	*
54.	*Spindasis schistacea*	25 %	0.37	1.5	*	*	*
55.	*Spindasis ictis*	12.5 %	0.12	1	*	*	*
56.	*Tarucus nara*	100 %	31.2	31.2	*	*	*
57.	*Curetis thetis*	50 %	1.2	2.5	*	*	*
58.	*Azanus jesous*	37.5 %	1.8	5	*	*	*
59.	*Prosotas dubiosa*	75 %	35.1	46.8	*	*	*
60.	*Borbo cinnara*	25 %	1	4	*	*	*
61.	*Borbo bevani*	12.5 %	0.25	2	*	*	*
62.	*Pelopidas sinensis*	12.5 %	0.12	1	*	*	*
63.	*Pelopidas mathias*	37.5 %	1	2.6	*	*	*
64.	*Potanthus confucius*	37.5 %	0.37	1	*	*	*
65.	*Telicota colon*	12.5 %	0.25	2	*	*	*
66.	*Spialia galba*	25 %	0.5	2	*	*	*

Note: “*” sign denotes no record of those species.

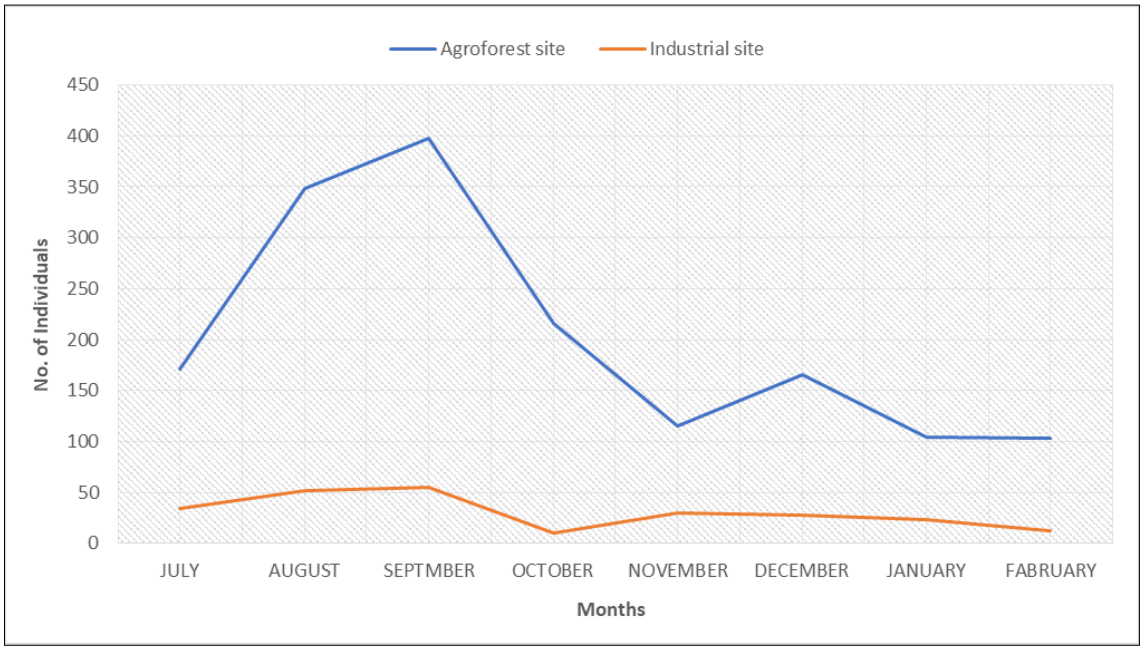

Fig 5: Population mean status of butterflies at Agroforest site and Industrial site

Highest number of individuals were recorded in September 2021 from both study site. While lowest number of individuals were recorded in February 2021 from both the study site. That means, the weather variables affected both study site equally. Highest number of individuals were observed in September, which indicate that butterflies were abundant in Monsoon season and lowest number of individuals were observed in February, which indicate that butterflies were least abundant in Winter Season (Figure.5).

Comparative analysis

The calculated diversity indices indicate that there was variation in the diversity of the butterflies at both the sites. Agroforest site, indicates good diversity as compared to Industrial site. For Agroforest site, the Dominance index was 0.059, Simpson_1-D index was 0.94, Shannon_H index was 3.16, Margalef index was 7.88, Berger-Parker dominance was 0.12, Brillouin index was 3.11, and Menhinick index was 1.42, and which suggested favourable diversity of butterflies at this site (Table.5).

Table 5: Diversity indices for study site 1 and 2

Sr. No.	Diversity Indices	Site-1	Site-2
1.	Dominance	0.05997	0.1599
2.	Simpson_1-D	0.94	0.8401
3.	Shannon_H	3.163	1.905
4.	Margalef	7.884	1.295
5.	Berger-Parker	0.1288	0.2332
6.	Brillouin	3.114	1.847
7.	Menhinick	1.423	0.5357
8.	Sorensen's Similarity	0.2857	

Note: Site-1 and Site-2 indicates both study sites (Agroforest site and Industrial site).

For Industrial site, the Dominance index was 0.15, Simpson_1-D index was 0.84, Shannon_H index was 1.90, Margalef index was 1.29, Berger-Parker index was 0.23, Brillouin index was 1.847, and Menhinick index was 0.5357, which suggested poor diversity at this site. The Sorensen's Similarity Index suggested that the species overlap was less while comparing species of both study site (Table.5).

Occurrence of Two New Species belongs to Family Hesperiidae

1. Chinese Branded Swift; *Pelopidas sinensis* (Mabille, 1877) (Figure.6)

The species *Pelopidas sinensis* was recorded first time at Baliyavad Dam, Baliyavad Village, Junagadh, Gujarat, India during Winter season of 2022 (8 February, 2022). The specimen was observed, while foraging on the flower of *Pithecellobium dulce* Plant species. This species was earlier reported globally at Shanghai, Nankow, Ningpo, and Kiukiang (Evans, 1932) [10].

The distribution of this species reported from Northern India (Uttarakhand and Sikkim) to Eastern India (Assam), and also reported at Nepal Province no. 4 (Kaski Dist.) (Kunte *et al*., 2018) [20]. But there were no records of this species in Gujarat state. The *Pelopidas sinensis* species have not include any sub-species in India.

Fig 6: *Pelopidas sinensis*

During our study, this species was found in less dense vegetation, which included *Accacia mellifera, Acacia leucophloea, Accacia nilotica, Alternanthera sessilis, Azadirachta indica, Capparis sepiaria, Cassia uniflora, Clerodendrum multiflorum,* and *Dichrostachys cinerea*. Species morphology includes; Above dark brown, single upper cell spot upf; brand incomplete and obscure, in two parts and lower part may be absent. Below much darker and overland ochreous scales (Evans, 1932) [10].

Fig 7: *Potanthus confucius*

2. Chinese Dart; *Potanthus confucius* (C. & R. Felder, 1862) (Figure.7)

The species *Potanthus confucius* was recorded first time at Baliyavad Dam, Baliyavad Village, Junagadh, Gujarat, India during Monsoon season of 2021 (12 September, 2021). The specimen was observed, while basking on leaf of *Ipomea spp.* Plant.

Potanthus confucius is found in India, Sri Lanka, Myanmar, Cambodia, Laos, Thailand, Malaysia, China, and Taiwan globally. In India, there are three sub-species of *Potanthus confucius* were reported *viz*; First one *P. confucius diana* (Evans, 1932) [10], which was reported from Maharashtra to Kerala. Second one *P. confucius dushta* (Fruhstorfer, 1911), which was reported from Sikkim to N.E. India. Third one *P. confucius nina* (Evans, 1932) [10], which was reported in Andaman and Nicobar Islands (Varshney and Smetacek, 2015) [48]. But we could able to identify this specimen up to species level. During our study, this species was found in open grass land type habitat with vegetative plantation such as *Ipomea spp., Tridax procumbens, Acanthospermum*

hispidum, Calotropis procera, Coldemia procumbens, Cynodon dactylon, Derris indica, Heliotropium ellipticum, and Parthenium hysterophorus.

This species usually found in disturbed grassy habitats and are active sun- loving little butterfly. *P. confucius* is tiny skipper butterfly with a wingspan about 18-22 mm, and morphology of this skipper includes; the upper side of both fore & hind wings have a pattern of yellowish- orange markings on a dark brown ground colour in wonderful contrast, while the undersides are a shade lighter. The yellowish- orange markings on the male are more pronounced while those of the female less distinct (Sources: learnaboutbutterflies.com; jaycjay.com).

Discussion

In current study, we recorded a total of 5,754 individuals of butterflies represented 44 genera and 66 species belonging to five families from both the study sites. Parallel finding was made by Raval *et al*., 2020, who recorded 1,052 individuals of butterflies represented 38 species. At Agroforest site, we recorded 66 species of butterflies. It because of the Agroforest site was dominant with preferable food resources which are necessary for butterflies. Unlike Agroforest site, the Industrial site has lesser variation in flowering as well as non- flowering plants, which indicates habitat destruction at this site. Due to this reason, we recorded only 11 species of butterflies from Industrial site. Previously, this type of study had been done by Pahari *et al*., 2018, whose study recorded lowest number of butterflies species (37) from industrial area. Kunte, 2000; Thomas, 2005; Bonebrake *et al*., 2010 [19, 44, 7]. have described that human disturbance like habitat loss and pollution can be affected butterflies' diversity. 11 species that were recorded from Industrial site (G.I.D.C.-1) may be considered as more tolerant to pollution and 55 species out of 66 species, which were only restricted to the Agroforest site (Baliyavad Dam) considered as more sensitive to pollution. That's why, if any changes are occurs in abundance of plants diversity through habitat fragmentation and expansion of urban or industrial landscapes leads the alteration in species composition. Ultimately, the proper attention towards the habitat conservation at industrial site is necessary.

In terms of family wise composition, family Lycaenidae was the highest with 23 species at Agroforest site. Where at Industrial site, the family Lycaenidae was the lowest with only 1 species. The difference between numbers of species recorded from this family can be corelated with difference in abundance of larval host plants present at both sites. Another reason behind the lowest number of species recorded from family Lycaenidae at Industrial site is that the species of this family mostly prefer less disturbed area as in Agroforest site. Family Papilionidae represented poorly at Agroforest site. where at Industrial site, Family Pieridae represented highest species richness.

The maximum species richness observed in the month of August, September and October, that indicates the Monsoon season stands favourable for butterfly diversity. The species richness drastically decreased in the month of December, January and February due to the flowers of plants become marcescent. The maximum number of individuals were recorded in month of September and minimum number of individuals were recorded in month of February at both study sites. But numbers of individuals recorded at Agroforest site were much higher than at Industrial site. An analysis of Month wise distribution of butterflies indicates that the weather variables affected both study sites equally. Usually, specific butterfly species are dominant and appeared in particular season and may or may not be observed in other seasons. Therefore, the species observed in summer season were not recorded in our study.

11 species recorded more frequently and abundantly throughout the study period. Among this, three species *E. hecabe, C. pomona, D. chrysippus* were detected at both study site. While eight species *T. nara, J. orithya, E. brigitta, E. laeta, C. pyranthe, C. danae, C. etrida,* and *Z. otis* detected only at Agroforest site.

The dominance index (D) and Berger- Parker Dominance was found to be lower at Agroforest site (0.059, 0.12) as compared to the Industrial site (0.15, 0.23), which suggests good diversity at Agroforest site. There was slight difference in Simpson index (1-D), while comparing distribution pattern of both the study sites. The diversity (H=3.16 and K=7.88) indices was higher at Agroforest site. The species richness (D=1.42) was found to be higher at Agroforest site than at Industrial site (0.53). The Sorensen's index analysis (β= 0.2857) indicates that the similarity in species were less while comparing the number of species present at both sites.

It clearly suggests that the agroforest site represents better habitats and provide enough food resources for butterflies. Where industrial site represents intolerant ecological condition for butterfly community.

Conclusion

In our study, we concluded that the area with good vegetation, enough resources of nectar and larval host plants represented good and favourable diversity of butterflies. As the butterflies rely on the plants, butterflies need better habitats with enough plants resources to continue their life cycle without any disturbance. Therefore, Agroforest site (Baliyavad Dam) represented good butterfly diversity. But nowadays, expansion of urban and industrial landscapes as well as excessive resources utilization and fragmentation of habitats cause demolition of butterfly species or causing local extinction and further also responsible for global extinction of this groups. Therefore, Industrial site (G.I.D.C.-1) represented poor butterfly diversity. As the butterflies are good pollinators and play a vital role in food chain, it is being necessary to conserve this tiny insect. By conserving this groups, we will secured our entire Ecosystem. For conservation of butterflies, we have to introduce suitable larval and nectar host plants for butterflies in Gardens, surroundings to Home, Urban parks, Industrial area and needs to avoid excessive plant utilization for commercial purposes.

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