



Comparative Study of Butterfly Diversity across Four Habitats in Cuncolim, Goa, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: <https://doi.org/10.56557/upjoz/2024/v45i194499>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://prh.mbimph.com/review-history/4123>

Original Research Article

Received: 22/07/2024

Accepted: 26/09/2024

Published: 30/09/2024

ABSTRACT

Biodiversity describes the variety and richness of life on Earth. The diversity of life on Earth is essential for healthy functioning and it boosts ecosystem productivity. Without wide range of animals, plants and microorganisms we cannot have the healthy ecosystems on which we are relying. Monitoring of biodiversity is of prime importance because biodiversity is the marker of ecosystem stability. Butterflies provide variety of ecological services and are very important component of biodiversity in different natural ecosystems. Several studies are reported from different parts of the state, mainly from wildlife sanctuaries, sacred grooves, Plateaus, and well-known tourist destinations of Goa. Present study is focused on collecting preliminary information on diversity of butterflies from four unexplored selected habitats of Cuncolim area at the foothills of

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Cite as: Dessai, Vidhi, Pradosh Velip, Viniksha Shetkar Dessai, Dhanashri Kesarlekar, Divya Angadi, Vaibhavi Dessai, and Kulkarni Rajender Rao. 2024. "Comparative Study of Butterfly Diversity across Four Habitats in Cuncolim, Goa, India". UTTAR PRADESH JOURNAL OF ZOOLOGY 45 (19):56-69. <https://doi.org/10.56557/upjoz/2024/v45i194499>.

Western Ghats in Goa. The Pollard Walk and visual count methods were employed. Total number of butterfly species during the survey at Forest is 316, Rivulet is 264, Seven temple is 222, and Plant nursery is 230. From the present survey it is observed that the Nymphalidae is the richest family (51%) followed by Pieridae (17%), Lycaenidae and Paipilionidae, both with (15%) each and Hesperidae with (2%). Relative abundance of site 1(Forest) is 30.62, site 2 (Rivulet) is 25.58 site 3 (Seven temple) is 21.51 and site 4 (Plant nursery) is 22.28. Observations from this study clearly indicate the impact of anthropogenic activities on butterfly diversity.

Keywords: *Butterfly diversity; biodiversity; wildlife sanctuaries; plateaus.*

1. INTRODUCTION

India is one of the World's mega bio diverse countries. India with its diversified ecosystem ranging from the snow-clad temperate forest in the Himalayas to the tropical wet evergreen forests of the Western Ghats, it has a rich butterfly fauna. The butterfly fauna of the southern part of the Indian peninsula is very rich and diverse compared to other parts of the peninsula due to availability of diverse habitats, a wide range of altitudinal gradients and associated microscopic regimes. Goa is the smallest state on the southwestern coast of India. Goa forms part of the Western Ghats and falls in transition zone between the northern and southern Western Ghats. It is India's smallest state by area and fourth smallest by population, with rich biodiversity. Goa for most of the year, has a hot and humid climate. Goa is unique as far as its floral and faunal composition is concerned since it falls in the transition zone between the northern and southern Western Ghats.

Lepidoptera are the second largest order of arthropods and are most easily identified, thus making them very useful for biodiversity survey, [1]. Butterflies are excellent indicator of a healthy environment. A garden that attracts butterflies, which in turn attract bees, spiders, lizards, mice, birds and other animals as they are food source thus an important member of the food chain. They are important component of biodiversity in different natural ecosystem and have significantly delicate and intricate links in the food web. The adult forms provide crucial ecological functioning, pollination service whereas larval forms as primary consumers and also as the prey to the organism at high trophic level, performing dual roles as pollinators and energy transferors [2]. There are about 200,000 known species of Lepidoptera approximately, of which about 10% are butterflies. The main true butterfly families are Papilionidae (swallowtail butterflies), Pieridae (yellow -white butterflies), Lycaenidae

(gossamer-winged butterflies), Riodinidae (metalmark butterflies), Libytheidae (snout butterflies), and Nymphalidae (brush-footed butterflies) [3]. India harbored total number of 1504 butterfly species accounting 8.74% of the world's butterflies. The Indian peninsula and Western Ghats have 351 and 334 species respectively [4]. Butterflies provide many vital economically important services within terrestrial ecosystem such as nutrients recycling, soil formation, food resources and pollination. They are excellent indicators to assess the ecological conditions and environmental modifications [5] including the wetlands ecosystem [6]. They are habitat specific and highly vulnerable to habitat deterioration [7].

Different ecosystems support different species of butterflies [8]. Like any other organisms specific abiotic and biotic factors such as climatic conditions, temperature and wind exposure affect the availability of host and larval plants and habitat quality [9], food and vegetation [10,11], topographic features [12], are some of the few most important parameters to determine composition of butterflies in a community. Butterflies depict reflection of human disturbance and habitat features [13] with greater sensitivity than many other taxonomic groups [14].

It is found that any minor change in their natural habitat due to anthropogenic factors can lead to their migration or local population extinction [15]. Butterflies act as good biological indicators of environmental quality [16,17] and are highly sensible to availability of larval host plants and environmental factors [18]. Anthropogenic factors including the loss of milkweed resources for larvae due to genetically modified crops, pesticides and fertilizers [19], loss of nectar resources from flowering plants, degraded forest habitats due to commercially motivated deforestation and other economic activities have threatening effects, especially on the migrating butterflies like Monarch Butterflies (*Danaus plexippus*) [20].

Butterflies of Goa are well documented by Sharma & Borkar [21] enumerated 251 species, while Rangnekar & Dharwadkar [22] added three more species to the state, that is Black-vein Sergeant (*Athyma ranga*, Moore), White-banded Awl [*Hasora taminatus* (Hubner)] and *Psoolos fuligo* (Mabille), which takes tally to 254 species. Diversity, abundance and habitats association of butterfly species in Bondla Wildlife Sanctuary of Goa, was studied by Borkar and Komarpant [23], three different habitat types, within the Sanctuary viz. Forests, orchards and formal gardens are reported 91 butterfly species belonging to 66 genera, 14 subfamilies and 5 families. Rangnekar [27] in photographic guide dealt with common butterfly species of Goa, though he did not mention the total number of species. Goa is estimated to harbor about 100 sacred grooves, each reflecting unique micro climatic conditions with diverse flora and fauna. An attempt was made to study the butterfly fauna and reported 33 butterfly species from four sacred groves of Goa, viz, Nirankarachi Rai, Alvaknichi Rai, Mharinginichi Rai, and Azobachi Rai. Presence of Endemic and Threatened species, viz, Southern Birdwing (*Triodes minos*) and Malabar Tree Nymph (*Idea malabarica*) indicates the services of the Sacred groves for the butterflies and their conservation [24]. A checklist of butterflies Insecta: Lepidoptera from Taleigao Plateau Goa, India was prepared by Bowalkar et al. [25].

The emphasis of butterfly diversity lies on the collections of primary data of the local butterfly species at selected areas. It is noted that increase in human activities would result in decreased butterfly species, in which the rich, rare and specialized species were the most affected [3]. In spite of availability of vast literature on the diversity of butterflies in Goa [25,26], (Sania et al. 2023)[35], no reports are available from Cuncolim, hence we have selected this area for the present investigation. This study will update with the comprehensive list of butterfly species as the baseline information for monitoring and planning various environmental activities in future.

2. METHODOLOGY

Cuncolim is a town situated in the Salcete district of South Goa, located at 150 10'38. 28" N and 73 0 59'38.112" E. With lush greenery and surrounded by Western Ghats. The town has 12 bunds or water gathering centers which is unique traditional irrigation. Cuncolim also has an

industrial estate. It offers a tropical monsoon climate and generally humid and warm throughout the year. Cuncolim is home to the Nayaband Lake, small waterfalls and the Molanguinim Cave.

Four sampling sites in Cuncolim were selected on the basis of ecological, geographical and demographical aspects representing diversified habitats influencing butterfly dynamics.

1. Forest: It is located in Veroda village in Cuncolim, an outskirts of Cuncolim town. The ward is surrounded by the Chandreshwar Mountain and covered with thick and dense vegetation. Underneath, the forest floor is covered in a thick layer of ferns, shrubs etc. Many wild animals like leopards, peacocks, birds and butterflies visit the site in search of food and water.
2. Rivulet: The rivulet is called as Pairabund, it is one of the 12 bunds (water gathering centers) of Cuncolim. They are Mhal, Shetcar, Naik, Mangro, Shet, Tombddo, Porob, Sidakalo, Lokakalo, Bandekar, Rounom and Becklo It forms a diverse and lush ecosystem. Different types of trees and plants are present at this site.
3. Seven temple: It is also known as Saat devla or saatdeore in Konkani in Talwada Veroda, it is a temple of lord Shiva. The temple is surrounded with sparse greenery such as small bushes or patches of grass. Trees are limited giving the area a more open feel.
4. Plant nursery: It is situated 2 kms away from Cuncolim bus stand and opposite to NH17 highway. Wide variety of plants ranging from ornamental to flowering plants like marigolds, chrysanthemums, cosmos, gomphrenas, dahlias, lantanas and other aromatic fragrant plants, cactuses and succulents, bonsai varieties, fruit bearing plants are present.

The field survey of butterflies was carried out every Thursday from mid-July to January 2024. A total 28 visits were made during active biological hours of butterfly species that is; between 8 am to 12 pm and 4 pm to 5 pm during normal climatic conditions with no strong wind and no heavy rain by random observations through the four selected sites based on habitats present in the study area. Pollard Walk method is used in which a band of 5 meter of land on both the sides of a trail are recorded and observed, with slow and steady walking. This method allows easy monitoring of butterfly species without harming

them. The butterflies were documented by employing visual count method. Photographs of the butterflies were taken for the purpose of identification. Key characters used in identification of butterfly species were color patterns, shape, and size and wing venation. Butterflies were identified in the field itself with the help of standard reference books such as photographic guides, Butterflies of Goa by Rangnekar [27], Butterflies of India by Isaac Kehimkar, [36]

The relative abundance of butterflies was calculated using the formula.

$$\text{Relative Abundance} = \frac{\text{Total number of individual species}}{\text{Total individuals of all the Species recorded}} \times 100$$

3. RESULTS

A preliminary study on diversity of butterflies at Cuncolim, Goa was conducted over a period of seven months from third week of July 2023 till last week of January 2024. Number of butterflies observed during the study period is presented in Table 1. Common grass yellow (128), Peacock pansy (72), Grey Pansy (67), were most common throughout the study period with maximum number of sightings among all. Common pierrot (10), and Common castor (9) were least sighted among all. The relative abundance of Common grass yellow is 12.5 followed by Grey pansy i.e. 6.4 and Peacock pansy i.e. 6.9. The relative abundance of Common pierrot is 0.96 and Common castor is 0.87. (Table 2). The highest relative abundance is shown by Common grass yellow, followed by Grey pansy and Peacock pansy. Whereas Common pierrot and Common castor had lesser relative abundance of all. During the survey period maximum number of butterflies were seen on 23 November 2023 -57 butterflies were observed. This is due to favorable climatic conditions which may be

favoring migration patterns. It is also possible that local weather conditions, environmental factors and food availability may influence the presence or absence of butterfly populations in a particular area. And least number of butterflies were observed on 25 January 2024 i.e. 10. January is characterized by colder temperatures which can limit butterfly activity. Also limited food sources can contribute to decreased abundance of butterflies in January. Maximum sightings were noted in Forest due thick vegetation. Forest has diverse range of habitat and provide different ecological niches for different species of butterfly, leading to high diversity of butterfly species. Overall, the combination of different habitat, water, the geographical environment and greenery contributes to high diversity. Compared to Forest, Rivulet has more human interference and disturbances hence, less number of butterflies were sighted at Rivulet than Forest. Whereas in Seven temple and Plant nursery, observed very few butterfly species because these sites are influenced by vehicular traffic and human activities. Since, they also have very little vegetation, its impact is visible on butterfly species diversity as the butterflies require specific host plants for their caterpillar to feed on, as well as nectar source for adults to feed on. The total butterfly abundance and relative abundance of each site at four different habitats during the survey period i.e. Forest, Rivulet, seven temple, Plant nursery is presented in (Table 3). Family wise percentage distribution of butterfly species in the study area is presented in Fig 1. From the present survey it is observed that the Nymphalidae is the richest family that dominated in the study area and is comprised of 21 species (51%) followed by Pieridae with 7 species (17%), Lycaenidae and Papilionidae, both with 6 species (15%) each and Hesperidae with only 1 species (2%). Numerical abundance of butterfly species in different sites of study area is presented in Fig 2.

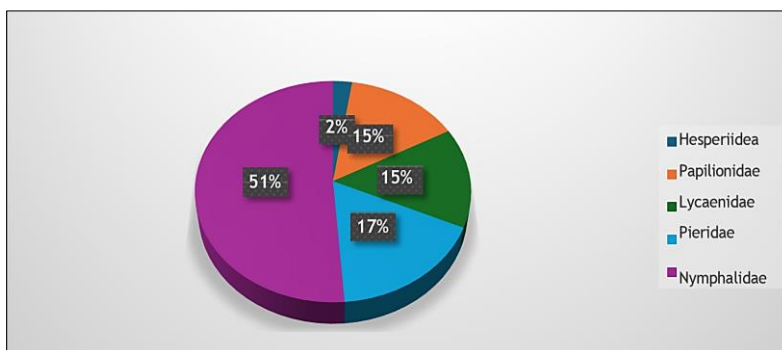


Fig. 1. Family wise percentage distribution of butterfly species (Cuncolim)

Photographs of Butterflies recorded during the study

Photographs 1:

Family: Pieridae



1



2



3



4



5



6



7

- 1) *Eurema hecabe* 2) *Captopsilia pyranthe* 3) *Catopsilia pomona* 4) *Pareronia valeria*
5) *Leptosia nina* 6) *Cepora nerissa* 7) *Delias eucharis*

Photographs 2

Family: Nymphalidae



8



9



10



11



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19

8) *Melanitis leda* 9) *Danaus chrysippus* 10) *Tanaecia lepidea* 11) *Acraea violae* 12) *Junonia iphita* 13) *Euthalia aconthea* 14) *Danaus genutia* 15) *Junonia lemonias* 16) *Mycalesis perseus* 17) *Ypthima huebneri* 18) *Ariadne merione* 19) *Orsotriaena medus*



20



21



22



23



24



25



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27



28

20) *Junonia almana* 21) *Elymnias caudata* 22) *Phalanta phalanta* 23) *Ypthima baldus* 24) *Neptis hylas* 25) *Parantica aglea* 26) *Hypolimnus bolina* 27) *Junonia atlites* 28) *Euploea core*

Photographs 3

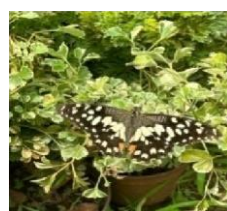
Family: Papilionidae



29



30



31



32



33



34

29) *Papilio dravidarum* 30) *Papilio polytes* 31) *Papilio demoleus* 32) *Pachliopta aristolochiae*
33) *Pachliopta hecetar* 34) *Graphium agamemnon*

Photographs 4:

Family: Lycaenidae



35



36



37



38



39



40

35) *Castalius rosimon* 36) *Jamides celeno* 37) *Talica niseus* 38) *Surendra quercetorum* 39)
Curetis thetis 40) *Zizeeria karsandra*

Photographs 5

Family: Hesperiiidae



41

41) *Ancistroides folus*

Table 1. Number of butterflies observed during the study period (Cuncolim)

Sr. No.	Scientific Name	Common Name	Jul-23		Aug-23					Sep-23				Oct-23				Nov-23				Dec-23				Jan-24				
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
			Survey No																											
1	<i>Eurema hecabe</i>	Common grass yellow	10		5	8	9	4	4	6	5	4	7	4	4	7	4	4	3	5	6	5	4	4	5	3	1	2	2	3
2	<i>Catopsilia pyranthe</i>	Mottled emigrant	1									1			1	1		7	1		1		1	1	1	2			1	
3	<i>Catopsilia pomona</i>	Common emigrant			1		1	1		2	1	2	1	1		1			1	1	1		2							
4	<i>Pareronia valeria</i>	Common wanderer	1	1			2		1	1		3			1	1	1									1				
5	<i>Leptosia nina</i>	Psyche	5	2	2	3	1	2	2	3		1	1	1	2			1		2	3	1		1						
6	<i>Cepora nerissa</i>	Common gull	1		1		1		1		1		2		2	2		1		1	1			1		2		1		
7	<i>Delias eucharis</i>	Common jezebel	1	1			1		1			1	1		1		2	1			1	1		1		1		1		
8	<i>Melanitis leda</i>	Common evening brown			1	1	1	2	2	1	2	1	2	1	1	2	1	1		2	1								2	
9	<i>Danaus chrysippus</i>	Plain tiger	1	1		1		1		1			1			1			1			1		1		2		1		
10	<i>Tanaecia lepidea</i>	Grey count	1		2	1	1	2	2	1	1	2	2	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	
11	<i>Acrearea violae</i>	Tawny coster		1		3	1	1	1	1	2	1		1	1		1		1		1	1		1	1					
12	<i>Junonia iphita</i>	Chocolate pansy	2	3	4		3	3	2	2	3	3	4	3	4	3	4	3	3	4	3		2							
13	<i>Euthalia aconthea</i>	Common baron		2		2	1	1	1	2	2		1	1	1	1	1	1	2	1	1	1	2	1	1	2	1	1	1	
14	<i>Danaus genutia</i>	Striped tiger	2	1	1	2	1		1	2				1	1	1	1	1		3	2			2						
15	<i>Junonia lemonias</i>	Lemon pansy	1	2	1		3	2	3	2	3	2	2	3	3	3	3	3	2	3	4	2							1	
16	<i>Mycalesis perseus</i>	Common bush brown				1		1	1	1	2			1		1	1	1			1		1					1		
17	<i>Ypthima huebneri</i>	Common four ring		1		1		2	1	1		1		1		1	1	1		1			1	1			1	1		
18	<i>Ariadne merione</i>	Common castor	1	2										1					1			1	1					2		
19	<i>Orsotriaena medus</i>	Medus brown	1		1		1		2		1		1	1		1		1	1		1			1	1					

Table 2. Numerical abundance and relative abundance of butterflies in the study period (Cuncolim)

Sr. No.	Family	Scientific Name	Common Name	Numerical Abundance	Relative Abundance
1	Pieridae	<i>Eurema hecabe</i>	Common grass yellow	128	12.4
2		<i>Catopsilia pyranthe</i>	Mottled emigrant	19	1.8
3		<i>Catopsilia pomona</i>	Common emigrant	16	1.5
4		<i>Pareronia valeria</i>	Common wanderer	13	1.25
5		<i>Leptosia nina</i>	Psyche	33	3.19
6		<i>Cepora nerissa</i>	Common gull	18	1.74
7		<i>Delias eucharis</i>	Common jezebel	15	1.45
8	Nymphalidae	<i>Melanitis leda</i>	Common evening brown	24	2.32
9		<i>Danaus chrysippus</i>	Plain tiger	13	1.25
10		<i>Tanaecia lepidea</i>	Grey count	30	2.9
11		<i>Acraea violae</i>	Tawny castor	19	1.84
12		<i>Junonia iphita</i>	Chocolate pansy	58	3.1
13		<i>Euthalia aconthea</i>	Common baron	32	3.1
14		<i>Danaus genutia</i>	Striped tiger	22	2.13
15		<i>Junonia lemonias</i>	Lemon pansy	48	4.65
16		<i>Mycalasis perseus</i>	Common bush brown	13	1.25
17		<i>Ypthima huebneri</i>	Common four ring	16	1.55
18		<i>Ariadne merione</i>	Common castor	9	0.87
19		<i>Orsotriaena medus</i>	Medus brown	14	1.35
20		<i>Junonia almana</i>	Peacock pansy	72	6.97
21		<i>Elymnias caudata</i>	Southern palmfly	13	1.25
22		<i>Phalanta phalanta</i>	Common leopard	14	1.35
23		<i>Ypthima baldus</i>	Common five ring	16	1.5
24		<i>Neptis hylas</i>	Common sailer	14	1.35
25		<i>Parantica aglea</i>	Glassy tiger	21	2
26		<i>Hypolimnus bolina</i>	Great eggfly	25	2.4
27		<i>Junonia atlites</i>	Grey pansy	67	6.4
28	<i>Euploea core</i>	Common Indian crow	24	2.3	
29	Papilionidae	<i>Papilio dravidarum</i>	Malabar raven	15	1.4
30		<i>Papilio polytes</i>	Common mormon	19	1.84
31		<i>Papilio demoleus</i>	Lime butterfly	22	2.13
32		<i>Pachliopta aristolochiae</i>	Common rose	17	1.64
33		<i>Pachliopta hecetar</i>	Crimson rose	14	1.35
34	Lycaenidae	<i>Graphium agamemnon</i>	Tailed jay	11	1
35		<i>Castalius rosimon</i>	Common pierrot	10	0.96
36		<i>Jamides celeno</i>	Common cerulean	14	1.3
37		<i>Talicauda nyseus</i>	Red pierrot	28	2.7
38		<i>Surendra quercetorum</i>	Common acacia blue	19	1.84
39		<i>Curetis thetis</i>	Indian sunbeam	11	1
40		<i>Zizeeria karsandra</i>	Dark grass blue	22	2.13
41	Hesperiidae	<i>Ancistroides folus</i>	Grass demon	24	2.32

Table 3. Total number of butterfly abundance at four different sites of Cuncolim during the study period

Survey No	Forest	Rivulet	Seven Temple	Plant Nursery	Total
1	10	6	9	15	40
2	13	10	4	8	35
3	11	5	12	8	36
4	13	12	10	12	47
5	20	15	6	12	53
6	10	12	12	6	40
7	16	14	8	13	51
8	17	11	12	10	50
9	18	5	9	8	40
10	7	16	13	8	44
11	13	9	8	16	46
12	9	17	15	11	52
13	14	8	10	8	40
14	17	15	8	10	50
15	12	14	5	11	42
16	12	11	15	10	48
17	16	10	8	7	41
18	15	13	8	9	45
19	19	16	12	10	57
20	10	8	4	11	33
21	5	10	5	5	25
22	4	6	9	5	24
23	16	4	3	3	26
24	5	9	2	4	20
25	2	2	5	3	12
26	1	1	8	2	12
27	8	1	1	3	13
28	3	4	1	2	10
Numerical Abundance	316	264	222	230	1032
Relative Abundance	30.62	25.58	21.51	22.28	

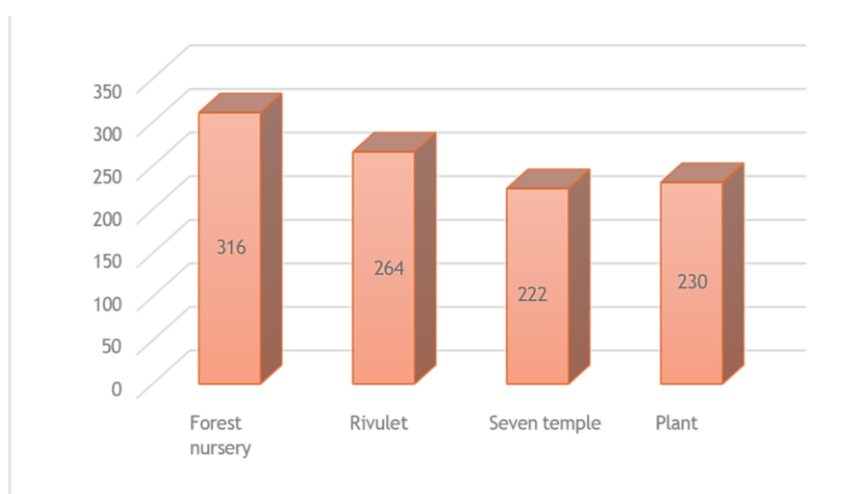


Fig. 2. Numerical abundance of butterfly species in different sites of study

4. DISCUSSION

Butterflies are not only beautiful creatures but also play a crucial role in the ecosystem. They act as pollinating agents to ensure the

continuation of many plant species. Additionally, butterflies are an essential part of food chain, serving as a food source for birds, small mammals and other insects. Their existence indicates the quality and health of an ecosystem,

as they are highly sensitive to environmental variations. Overall butterflies are vital for maintaining biodiversity and the balance of nature.

The diversity and abundance of different butterfly species in any habitat is correlated with the availability of host plants. Majority of butterfly species are choosy, and each species show its own particular requirements in relation to habitats, temperature, relative humidity, larval food plants and adult food sources (Sharma M. et al., 2013), [21]. However, butterfly diversity is directly dependent on distribution of their host plants and availability of nectar [28,29], seasonal variations [23]. Anthropogenic events like construction of highways, influx of tourist, grazing pressure, use of pesticides and change in land use pattern are mainly responsible for both butterfly and plant diversity loss. Cattle grazing affected the diversity and abundance of butterfly from family Lycaenidae as they largely feed on grasses [3].

During the study period 41 species were observed in Cuncolim. The family Nymphalidae was dominant, (Fig .1), as it is the largest family of butterfly. One of the reasons for its dominance might be the availability of their larval host plants. A similar pattern of dominance was observed by [34] During the study period it was observed that Common grass yellow, was most common. Similar findings were observed by Regier et al. [30].

Butterflies needs to warm its body before being able to take on a flight. Several butterflies were seen basking in most of the present survey sites in the bright sunshine such as Grey pansy, Peacock pansy, Chocolate pansy, Plain tiger, Common five ring, Blue tiger, Common mormon, Common sailer and Common baron. Some butterflies were seen sun basking using underside of their wings such as Common Indian crow, Euploe core, Psyche, Common pierrot to absorb heat, in the present investigation. This is called as lateral basking. Similar observations were recorded by Kevan and Shorthouss [31]. Euploe core, Dark grass blue was seen feeding on plant species of Amaranthaceae family in Cuncolim study area.

Some species require, over ripened fruit to feed on. Such as Common baron, Gaudy baron and long banded was seen feeding on *Manilkara zapota* (Sapodilla). (Chickoo fruit); Common evening brown was seen feeding on rotten

jackfruit. Butterflies are particularly fond of rotten fruits and vegetables [4]. Some butterflies were seen showing mating behaviour – *Talica niseus* (Red pierrot) and *Castalius rosimon* (Common pierrot) of Lycaenidae family; *Aeromachus pygmaeus* (Pygmy scrub hopper) of Hesperidae family; *Junonia atlites* (Grey pansy) and *Ypthima huebneri* (Common four ring) of Nymphalidae family; *Eurema hecabe* (Common grass yellow) of Pieridae family. Similar observations were reported by Freitas et al. [32].

During our study period sexual dimorphism observed in few instances. Differences in appearance of both male and female Common baron (*Euthalia aconthea*) were reported in Cuncolim. The male is dark brown with a row of small white spots on forewing while the female is paler having greenish sheath and has a band on its forewing in colour. It is in good accordance with the observations of Butterflies of Goa by Rangnekar [27].

Biodiversity is not stable and highly dynamic and keeps on changing due to various biotic and abiotic factors interaction. Population dynamics of butterflies is directly correlated with the availability of host plants and suitable environmental conditions such as humidity, wind velocity, temperature, rainfall etc. [9]. Periodic studies on butterfly diversity give valuable insights of environmental modifications [33].

5. CONCLUSION

Cuncolim area shows a smaller number of butterflies due to various factors such as habitat loss due to urbanization, agricultural practices and climate change. Cuncolim town has an industrial estate which contributes to pollution. This can in turn decline butterfly species. Present investigation is a preliminary in nature as impact of vegetation, human activities, competition among the different species are not directly assessed due to various constraints. Considerable information gathered from the present study and it serve as a useful checklist for various environmental related activities in the Cuncolim area.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image

generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENTS

Authors are grateful to Prof. Joydeep Bhattacharjee, Principal, Government College of Arts, science and Commerce, Quepem, Goa for his support and encouragement.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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